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COWICHAN VALLEY REGIONAL DISTRICT

South Cowichan Water Plan Study

A Preliminary Assessment of Water Supply & Needs within the South Cowichan Region

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SYNOPSIS

WorleyParsons and Westland Resource Group were jointly retained by the Cowichan Valley Regional District (CVRD) to undertake a preliminary water plan study of the South Cowichan region. This water plan study was designed to provide CVRD with the tools necessary to develop a water management framework for the region that will maintain its unique hydrological and ecological values while supporting appropriate kinds and scales of human activities.

The region that forms the subject of this report (the Study Area) consists of CVRD's Electoral Areas A and C in their entirety, and those parts of Electoral Areas B, D, and E that lie within the Shawnigan, Cowichan and Saanich Inlet watersheds. The Study Area covers 20,853 hectares of land, and is centred on latitude 48°38'N and longitude 123°36'W (UTM coordinates 5388132N 455163E, Zone 10).

The main objectives of this project were as follows:

- To compile a comprehensive summary of existing technical information relating to the region's current water resources and needs, including calculation of the area's existing water balance using available data and evaluation of interactions between its key components;
- To estimate future population growth, land use patterns, and water supply / demand for the next 30 years using projections based on past trends, with emphasis on the identification of key issues that could potentially result in water shortages within the region;
- To evaluate the effects of existing government policies and regulations on water use within the region; and
- To develop a Terms of Reference for CVRD that will facilitate the development of a comprehensive Water Management Plan for the region that will ensure the South Cowichan region's water supply is capable of meeting projected demand in a sustainable and ecologically sensitive fashion.

At the request of CVRD, water resource data collection and evaluation focused on defining the occurrence, distribution, development, and usage of groundwater within the Study Area.

The key findings of this study are presented below.

Water Uses and Needs

- The three watersheds in the South Cowichan area each support a diverse range of land uses and ecological habitats;
- More than 17,000 people currently live in the South Cowichan communities of Cobble Hill, Mill Bay, Malahat, Shawnigan Lake Village, and Cowichan Bay, and are contained within 7,477 housing units. The Shawnigan watershed contains the greatest number of housing units (3,992), followed by the Cowichan watershed (2,680 units), and the Saanich Inlet watershed (805 units). Provincial government estimates suggest that the number of housing units in South Cowichan could grow by 28% to 9,500 by 2036. If residential developments now being planned are built, the number of units

could potentially reach 13,700 by 2036. Depending on the extent of future development, the 2036 population could range from 22,000 to 32,000. It is important to recognize that global phenomena, such as climate change and economic fluctuations, increase the uncertainty associated with projections of future growth in the South Cowichan area;

- A variety of plans, regulations, and guidelines currently affects water and land use in the South Cowichan area. Ten provincial acts and four federal acts are relevant to water and watershed management in the Study Area, and community land use plans have been developed for all of its electoral areas. CVRD authority in water management is presently unclear since local governments' abilities to implement and enforce water use policies within their jurisdictions are limited by the present water governance structure in British Columbia;
- Uncontrolled water use for farming, cattle rearing, wineries, and new land development projects in the South Cowichan area will place increasing pressure on its existing water resources. The present estimated water demand for all land uses use within the South Cowichan area is estimated at 26 million m^3/yr. By 2036, these demands may grow to 34 million m^3/yr. With active water conservation measures and urban densification, total water demand in 2036 could remain the same as today's estimated consumption, as would the distribution of demand among future agricultural, residential, and other urban uses. Without conservation, the residential component could grow from 7 to 10 million m^3/yr, which highlights the importance of future land use decisions as part of a sound water management strategy;
- Agricultural activities account for a substantial proportion of current water use in the South Cowichan area (15 million m^3 for agricultural use, compared to 7 million m^3 for residential and 3 million m^3 for "other" urban uses). Detailed information is not presently available concerning the amounts of water used by different agricultural activities. Based on the disproportionate use of water by agricultural activities within the Study Area, prudent water management planning should carefully consider the value of conservation measures to ensure that an adequate supply of water is available for the region's other users, and should identify potential obstacles to attaining water use efficiencies;
- The South Cowichan area's five First Nations reserves and major non-governmental water users (primarily educational institutions) constitute a relatively small component of its overall water use, although their demand volumes in the Shawnigan and Cowichan watersheds exceed commercial and industrial consumption. Water use on First Nations reserves is currently fairly limited, but may grow significantly as their respective residential community plans and commercial developments are implemented;
- The relative proportion of current groundwater to surface water use within the Study Area is not currently known with precision, since regional groundwater extraction rates are not monitored with the same accuracy as surface water diversion rates;
- The hydrology and patterns of water use in the South Cowichan area could change substantially by the conversion of existing forest land to urban uses. More information on the likelihood of these conversions will be needed as the water planning process proceeds. Specific estimates water supply demand to service new forest-urban land conversion developments should be undertaken, as well as projections regarding the extent of potential modifications to the surface water and groundwater

hydrological regimes on the subject developments and their cumulative effects on downstream land parcels; and

- Many opportunities exist in the South Cowichan area for water conservation and demand reduction, although very little area-specific information on these topics is currently available. Future regional water planning should include the identification and implementation of such measures, which could be used to forecast future water use more accurately and determine the potential effects of urban growth on the area's groundwater and surface water resources.

Groundwater

- Government mapping has delineated 13 groundwater aquifers within the South Cowichan area. Surficial aquifers are mainly hosted by unconsolidated glaciofluvial and morainal sand and gravel deposits of the Vashon Drift and Capilano Sediments. Bedrock aquifers are hosted in discrete fracture zones within a wide range of consolidated bedrock lithologies and ages;
- There are very few regional-scale geologic cross-sections currently available for the South Cowichan area that demonstrate its aquifers' hydrostratigraphic settings or connectivity. Groundwater flow directions have been inferred from the presence of prospective recharge zone (upland locations) and discharge zones (rivers, streams, lakes and marine environment). Groundwater flow directions in surficial aquifers are expected to be largely topography driven, while flow in bedrock aquifers may also be subject to site-specific geologic controls (location and inter-connectivity of fracture zones);
- Surficial aquifers within the Study Area appear to be generally more productive than bedrock aquifers, but are highly variable from one aquifer to the next due to significant localized differences in media conductivity and stratigraphy;
- Government mapping suggests that bedrock aquifer productivities generally increase eastward within the Study Area, although this assertion appears to have been based on airlifted yields recorded at the time of well completion as opposed to evaluations of the region's hydrostratigraphic settings and structural geologic regimes. Given the comparatively large surface extent of the area's mapped bedrock aquifers and the currently inadequate level of understanding of their geological settings, significant opportunities may exist for increasing bedrock groundwater use. However, identifying productive bedrock groundwater zones (fractures) may prove to be technically challenging and costly;
- Total annual groundwater inflows from natural recharge within the South Cowichan area may range between 25 million m^3 and 110 million m^3, with a best estimate of about 45 million m^3. Based on this best estimate recharge value and assuming that roughly 50% of total water usage within the Study Area originates from groundwater sources, it is estimated that about 30% of annual groundwater inflows may be currently allocated for water use, with the remainder (70%) being available for discharge to streams, lakes, wetlands and the marine environment. A portion of irrigation and domestic water use is also expected to end up as groundwater return flow (artificial recharge). Taking uncertainty of recharge into account, the confidence in these estimated percentages is relatively low;

- Areas where surficial aquifers are unconfined and may permit relatively high groundwater recharge rates, or areas where bedrock aquifers outcrop at the land surface or are overlain by a thin soil veneer, are expected to be characterized by relatively high groundwater vulnerability to surface contamination. A collaborative vulnerability mapping project for the area is currently being completed by others (the "Vancouver Island Water Resources Vulnerability Mapping Project"), the findings from which should form an integral part of the future South Cowichan area water plan;
- Groundwater recharge may potentially increase due to climate change, leading to a possible positive impact on water supplies. The degree to which this will occur is dependent on local geological constraints (for example, low permeability tills or massive bedrock might locally limit groundwater infiltration). Climate change may negatively affect groundwater resources through increased evaporation in areas where shallow water table conditions exist;
- Long-term trends in water levels measured for MOE observation wells in the Cherry Point aquifer were correlated against precipitation records. Water levels in this aquifer have declined in recent years, which have been attributed to increased groundwater use. This study suggests that water level declines may be due to a combination of groundwater withdrawals and natural fluctuations, given that the 2000 to 2005 period was characterized by below-average annual precipitation. Shallow domestic wells in particular appear to be very sensitive to either natural or anthropogenically-induced declines in water table elevation, as evidenced by the need for deepening of some domestic wells in the Cherry Point aquifer. The analysis of well hydrographs for the Cherry Point aquifer seem to confirm that surficial groundwater systems within the South Cowichan area may be highly sensitive to climate variability; and
- This study revealed the hydrostratigraphic complexity of the region's groundwater aquifers, the current lack of quantitative information regarding these aquifers' development and usage, and the general sparseness of reliable data. Consequently, the understanding of the Study Area's groundwater resources at this time remains conceptual and largely qualitative in nature, which indicates the need for the development of an area-specific groundwater assessment to address current knowledge gaps. The development of a groundwater model for the region is recommended. This model could be used to distinguish between natural and anthropogenic pressures on groundwater flows, determine groundwater budgets on an aquifer-by-aquifer basis, support aquifer recharge zone and well-specific vulnerability assessments and protection strategies, and facilitate long-term water supply planning. Steps required to complete this new groundwater model development are outlined within this report.

Surface Water

- The British Columbia Ministry of Environment's (MOE's) climate models predict that the availability of water within South Cowichan by the year 2050 may be influenced by increases to the average air temperature by 2 to 3°C and annual precipitation by 20%, that summers will be hotter and drier while the winters will be wetter, and that the frequency of 24-hr precipitation events greater than 80mm will increase;

- Monthly water balance models were developed as part of this project to estimate the current and future volume of surface water within the South Cowichan region. These models were based on unit-area runoff estimates, precipitation, lake evaporation, surface water abstractions, and climate change scenarios.
- The results of this modelling for all scenarios (current and future) suggest that an overall net annual surplus of surface water can be expected, with a significant excess of surface water during the winter months (December through March) and a slight deficit during the late summer months and early fall (note that monthly surface water balance deficits do not necessarily indicate that creeks and rivers are dry during the summer months, but that dry weather flows are maintained by release of water stored in lakes and groundwater base flows).
- The present calculated water balance for the South Cowichan area shows an annual net surplus of approximately 135 million m^3, increasing to 160 million m^3 by 2036 as the result of drier summers, warmer temperatures, and increase demand. The 33% water efficiency goals set by British Columbia's 'Living Water Smart' water plan only have a slight impact on the overall water balance, increasing the 2036 annual net surplus by 4%, with the summer/early fall months still in deficit; and
- Summer low flows in Lower Shawnigan Creek are detrimental to aquatic system health and are due in part to having insufficient lake storage to support both domestic use and downstream needs in summer. Low flow issues are also apparent in many creeks and streams within the South Cowichan area, including Garnett Creek, Johns Creek, and Spectacle Creek. These issues may be linked to excessive surface water diversion, decreased groundwater base flow, and/or climate variability.

Knowledge Gaps and Issues Requiring Further Study

It is recommended that a phased approach be adopted to develop a Water Management Plan for the South Cowichan area, with major existing knowledge gaps being addressed as stand-alone studies prior to development of the Plan. Recommended studies to be conducted prior to development of the Water Management Plan include the following:

- The acquisition of more detailed current surface water and groundwater withdrawal data is necessary to allow a better understanding of potential demand versus supply issues. This will require co-operation from major water users (improvement districts, etc.) and involvement from CVRD;
- A comprehensive, area-specific groundwater resource evaluation should be completed, which will culminate in the development of a numerical model that will establish detailed water budgets on an aquifer-by-aquifer basis. The groundwater resource evaluation and model development should take into account findings from MOE's aquifer vulnerability mapping project currently being completed, and use the model to refine understanding of local aquifer vulnerabilities;
- A comprehensive, baseline surface water quality monitoring program should be undertaken. This program should include, at a minimum, the collection of surface water samples on a quarterly basis from the area's key streams, lakes and reservoirs over a 1 to 2 year period. Prospective sampling locations should be identified through consultation with regional directors to identify potential areas

of concern. Those locations for which the baseline program indicates possible water quality concerns could be incorporated in a longer-term monitoring program; and

- The potential effects of regional, national, and global pressures on population trend projections for the CVRD should be considered. Climate change could alter migration of people from areas experiencing water supply shortages or sea level increases. Economic upheavals and demographic shifts in Canadian society might also change housing choice and settlement patterns. The effects of such phenomena are difficult to anticipate and may increase the uncertainty in population trend projections for the CVRD.

Water Management Plan

Once the supplemental investigations and monitoring programs outlined above have been undertaken, a comprehensive Water Management Plan for the South Cowichan area can be developed to address issues raised by this preliminary study. Terms of Reference for the creation of this Water Management Plan are presented in this report.

Completion of this Water Management Plan should result in the following tangible benefits:

- Enhanced understanding of local water issues;
- A workable management structure for each of Study Area's three watersheds over a 30-year planning horizon that represents the interests of all stakeholders; and
- A sense of balance between the future water needs of agriculture, a growing population, and the ecosystems of the South Cowichan area.

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1. INTRODUCTION

1.1 Terms of Reference

WorleyParsons and Westland Resource Group were jointly retained by the Cowichan Valley Regional District (CVRD) to undertake a preliminary water plan study of the South Cowichan region. This water plan study is designed to provide CVRD with the tools necessary to develop a water management framework for the region that will maintain its unique hydrological and ecological values while supporting appropriate kinds and scales of human activities.

The main objectives of this project are as follows:

- To compile a comprehensive summary of existing technical information relating to the region's current water resources and needs, including calculation of the area's existing water balance using available data and evaluation of interactions between its key components;
- To estimate future population growth, land use patterns, and water supply / demand for the next 30 years using projects based on past trends, with emphasis on the identification of key issues that could potentially result in significant water shortages within the region;
- To evaluate the effects of existing government policies and regulations on water use within the region; and
- To develop a Terms of Reference for CVRD that will facilitate their eventual development of a comprehensive Water Management Plan for the region that will ensure the South Cowichan region's water supply is capable of meeting projected demand in a sustainable, ecologically sensitive fashion.

At the request of CVRD, water resource data collection and evaluation focused on defining the occurrence, distribution, development, and usage of groundwater within the Study Area.

Conclusions and recommendations presented herein are based on desktop reviews of publicly-available technical literature, private and public Internet websites, aerial photographs, and local regulatory / planning documents, as well as personal interviews with individuals familiar with the water resources and demands of the region. No intrusive investigations were conducted as part of this study.

1.2 Study Area Location

The South Cowichan region is situated near the south end of Vancouver Island along its east shore. The region that forms the subject of this report (the Study Area) consists of CVRD's Electoral Areas A and C in their entirety, and those parts of Electoral Areas B, D, and E that lie within the Shawnigan, Cowichan and Saanich Inlet watersheds (see Figure 1).

The Study Area covers 20,853 hectares of land, and is centred on latitude 48°38'N and longitude 123°36'W (UTM coordinates 5388132N 455163E, Zone 10).

1.3 Community Settings & Challenges

More than 17,000 people live in the rural communities of Mill Bay, Malahat, Shawnigan Lake, Cobble Hill, Cowichan Bay, and Cowichan Station. The region's temperate climate, high recreational and landscape value, and proximity to larger urban areas (Duncan and Victoria) make the South Cowichan region a highly desirable place for people to live, work, and enjoy recreational pursuits. Water use for farming, cattle rearing, wineries and growing development has already put pressure on the water resources of South Cowichan.

Population within the South Cowichan area is projected to grow by more than 4,400 people over the next three decades[1]. This significant growth will be accompanied by an increased demand for water, placing even greater strain on this crucial resource. Consequently, CVRD has determined that a Water Management Plan should be developed to balance the needs of agriculture, a growing population, and the ecosystems that lend the South Cowichan area its valued place on Vancouver Island.

1.4 Report Structure

The report is organized as follows:

- Section 2 describes the biophysical setting of the Study Area including its physiography, climate and hydrology, and surface water and groundwater resources, based on available data collected by the study team;
- Section 3 describes the human setting (water use), including policies and plans that may affect water use;
- Section 4 analyzes current and future water use and demand;
- Section 5 puts these water use and demand estimates in the context of estimated surface water and groundwater balances (water supply); and
- Section 6 provides the Terms of Reference for the development of the Water Management Plan.

To assist non-technical readers in understanding some of the more obscure hydrogeological terminology used in this report, consultation of the following glossaries may be useful:

- Groundwater glossary: http://www.groundwater.org/gi/gwglossary.html
- Environment Canada freshwater (groundwater and surface water) glossary: http://www.ec.gc.ca/water/en/info/gloss/e_gloss.htm

[1] The projections in this study are based on Statistics Canada projections for regional populations and households, adjusted to account for development trends (as discussed with CVRD planners). Global and continental changes to climate, the economy, fossil fuel prices, and demography could affect population distribution in the South Cowichan area. The effects of these phenomena on population are uncertain, and were not assessed as part of this study.

- United States Environmental Protection Agency, safe water glossary: http://www.epa.gov/safewater/glossary.htm

Non-technical readers may also wish to refer to the following Streamline Watershed Management Bulletin article providing an overview of basic groundwater concepts:

- "Groundwater, more than water below the ground!" (Smerdon and Redding, 2007): http://www.forrex.org/publications/Streamline/ISS35/Streamline_Vol10_No2_art1.pdf

2. ENVIRONMENTAL SETTING

2.1 Climate

The climate of the South Cowichan area is described as "Transitional Cool Mediterranean", and is characterized by warm, humid summers and mild, wet winters (Tuller, 1979). The South Cowichan area is positioned within the rain shadow of the Vancouver Island Insular Ranges to the west, but is also influenced to a limited extent by the Olympic Mountains to the south. These mountains significantly modify easterly-moving, moisture-laden air masses, causing the area to be dominated by low-pressure systems in winter and high-pressure systems in summer.

The climatic uniqueness of this region enhances the importance of groundwater as a source of freshwater supply. Based on the Thornthwaite classification, there can be a moisture surplus of 40 - 160 cm in winter but a moisture deficit of 5 - 20 cm in summer. This lack of precipitation in the summer season may be a major factor for many water deficiency related problems encountered throughout the Nanaimo Lowland physiographic province.

2.1.1 Precipitation

The following six Environment Canada climate stations gather precipitation data within and around the South Cowichan area, as shown on Figure 1:

- Mill Bay 1 Southwest (ID No.1015136);
- Shawnigan Lake (ID No. 1017230);
- Sooke Lake North (ID No. 1017563);
- Duncan Glenora (ID No. 1022571);
- Duncan Kelvin Creek (ID No. 1012573); and Malahat (ID No. 1014820).

Table 1 below shows precipitation data from each of these stations for the years from 1997 to 2006 (2007 data had not been published at the time of writing of this report). The precipitation values include rain and snow water equivalent. This table also has the Canadian Climate Normals from 1971 – 2000 of the Shawnigan Lake and Sooke Lake North stations. As the Malahat station did not have a complete data set, it was excluded from the table.

Table 1 Total Precipitation (Rain and Snow Water Equivalent)

Year	Station Name				
	Shawnigan Lake (mm)	Sooke Lake North (mm)	Duncan Glenora (mm)	Duncan Kelvin Creek (mm)	Mill Bay (mm)
2006	1594.6	1904.5	1726.6	1821.7	Incomplete
2005	1089.6	1274.4	Incomplete	Incomplete	1226.5
2004	1104.2	1297.8	1285.1	1216.3	1037.1
2003	1382.0	1576.6	1579.7	Incomplete	1319.2
2002	1104.8	1333.0	1311.6	1236.2	965.8
2001	1115.2	1323.0	Incomplete	1164.0	1115.2
2000	943.8	1064.1	1106.4	959.8	812.3
1999	1710.2	2063.4	1975.6	1782.0	1528
1998	1487.8	1801.4	Incomplete	1533.8	1314.8
1997	1565.5	1984.0	1729.6	1695.0	1438.2
Average Precipitation	**1309.8**	**1562.2**	**1530.7**	**1426.1**	**1195.2**
Climate Normals 1971-2000	**1247.6**	**1492.4**			

Data presented in Table 1 above indicates that precipitation has increased in the last ten years (1997-2006) as compared to the 1971-2000 Climate Normals. Most significantly, the data shows that average yearly precipitation varies greatly between the stations, indicating that there are several microclimates within the Study Area. For example, based on the Canadian Climate Normals, Sooke Lake North receives approximately 20% more precipitation than Shawnigan Lake, although they are separated by only 9 km in distance and 93 m in elevation.

2.1.2 Temperature

The Shawnigan Lake climate station is the only station within the South Cowichan area that meets the World Meteorological Organization's (WMO) standards for temperature data. Figure 2 shows average monthly temperatures at Shawnigan Lake between 1971 through 2000 and 1997 through 2006. This data indicates that average daily temperatures over the last ten years have increased for all months by an average of 0.6ºC, as compared to the Canadian Climate Normals.

2.1.3 Evapotranspiration

Average monthly actual evapotranspiration data for the Study Area were taken from water balance tabulations for Victoria International Airport station calculated by Environment Canada, which was the closest climate station to the Study Area. Monthly average Potential Evapotranspiration (PE) data were calculated using the Thornthwaite and Mather Method (1955). In the Environment Canada water balance tabulations, when the total available free water equals or exceeds the PE for the period, actual

evapotranspiration (AE) is set equal to PE. When the total available free water is less than the PE for the period, water is drawn from soil storage to satisfy the evaporative demand. Monthly average calculated AE values for Victoria International Airport are presented in Table 2 below.

Table 2 Average Monthly Actual Evapotranspiration (Calculated) – 1951 to 1980

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Actual Evapotranspiration (mm)	12	18	28	46	72	62	27	28	39	40	22	15	409

2.1.4 Snowfall and Snowpack Accumulation

Although precipitation varies greatly within the South Cowichan area, snowfall does not vary as much. According to the 1971 – 2000 Canadian Climate Normals, the Shawnigan Lake station had a yearly average snowfall of 75.5 mm and Sooke Lake North station had a yearly average snowfall of 79.2 mm. This constitutes only a 5% difference as opposed to the 20% difference in total precipitation between the two stations.

Much of the snow that falls in higher elevations of the southwest portion of the Study Area (near Sooke Lake North) accumulates through the winter, melts in the spring and summer, and subsequently infiltrates into the ground and/or runs into surface water bodies. The snow that falls in the lower elevations does not accumulate throughout the winter, and instead melts and runs off shortly after falling onto the ground (typically in less than two weeks).

The Jump Creek station (ID No. 3B23P) shown on Figure 1, located approximately 1,160 m above sea level and 7.5 km north of Cowichan Lake, is the only BC Ministry of Environment (MOE) station that keeps track of snow in terms of snow water equivalent near the Study Area. Figure 3 shows snow pillow data in terms of snow water equivalent for this station.

It is difficult to quantify how much snow is locked up in the winter months for the entire Study Area. What can be inferred from the data is that a majority of the snow from higher elevations melts in the spring and summer and turns into runoff and groundwater infiltration.

2.2 Physiography

The South Cowichan region is positioned within the Nanaimo Lowland zone of the Insular Mountain Range physiographic province (Holland 1976).

The Nanaimo Lowland forms a strip of low lying country below 600 metres elevation that extends for 280 km along the east coast of Vancouver Island from Sayward on Johnstone Strait to Jordan River west of Victoria. Georgia Strait and the Gulf Islands archipelago flank the Lowland to the east, while rugged, mountainous country of the Vancouver Island Ranges forms its western border. The Nanaimo Lowland reaches a maximum width of 32 km between Galiano Island and Shawnigan Lake.

The major geomorphic features of the Nanaimo Lowland are the product of structural, erosional, and depositional processes. Folding and faulting of the bedrock, erosion and repeated glaciation, as well as isostatic and eustatic changes of sea level, have all contributed to the physiographic features of this region.

Differential erosion of bedrock throughout this physiographic zone has produced a distinctive pattern of cuesta-like landforms where areas underlain by competent sandstone, conglomerate, and volcanic or intrusive igneous rocks form ridges, and soft shale, mudstone, or areas with intense bedrock fracturing form bowls or valleys. In areas predominantly underlain by metamorphosed granitoid rocks such as to the east, west, and south of Shawnigan Lake, the terrain tends to be more rugged with the development of steep, conical hills and bedrock fracture-controlled valley lineaments. The bedrock surface between the north end of Shawnigan Lake and Cowichan Bay has been extensively modified by glaciation, which deposited a thick mantle of heterolithic debris over most of the area during the glaciers' advancing and retreating phases.

2.3 Bedrock Geology

Rocks from two discrete geological provinces, known as the Wrangellia and Overlap Terranes, underlie most of the South Cowichan area (BCGS, 2008). The boundary between the Wrangellia and Overlaps Terranes is represented by a northwest-trending erosional unconformity that runs south of the Cowichan Bay area and meets the marine shoreline at Cherry Point. Rocks from a third discrete geological province, known as the Crescent Terrane, underlie the southernmost tip of the Study Area at the Goldstream River estuary. This terrane is separated from the Wrangellia Terrane by the regional-scale Survey Mountain Fault.

The Overlap Terrane consists of sedimentary rocks of the Upper Cretaceous Nanaimo Group (see Figure 4). The Nanaimo Group in the South Cowichan area is represented by the Comox and Haslam Formations, a conformable sequence of marine and non-marine sedimentary rocks that grades upwards from carbonate-rich deltaic sandstone and conglomerate, through rhythmic marine beds of siltstone, sandstone, and coal-bearing shale, into pure shale and mudstone. Nanaimo Group rocks are only rarely exposed within the South Cowichan region due to their deep burial by glacial sediments, but are often encountered at depth by drilled wells throughout the Cowichan Bay and Cherry point areas.

The Wrangellia Terrane is represented by a range of igneous, volcanic, and sedimentary rocks of various ages within the Horne Lake – Cowichan uplift (see Figure 4), one of a number of northwest-trending geanticlines within the Wrangellia Terrane that make up the structural backbone of southern Vancouver Island. Stratigraphic components within this terrane are as follows:

- The central core of the Horne Lake – Cowichan uplift in the South Cowichan area is formed by Palaeozoic-aged, granitoid rocks of the Westcoast Crystalline Complex, and includes the Wark and Colquitz Gneiss Formations (see Figure 4). Westcoast Crystalline Complex rocks are commonly exposed as conical hills throughout the southern half of the South Cowichan area, and along the shoreline of Saanich Inlet from Bamberton to Goldstream;

- The northern flank of the Horne Lake – Cowichan uplift in the South Cowichan area adjacent to the Westcoast Crystalline Complex consists of a structurally complex assemblage of sedimentary and volcanic rocks of the Sicker, Buttle Lake, Vancouver, and Bonanza Groups:
  - Sicker Group rocks are represented by a large, northeast-trending block of basaltic volcanic rocks of the middle to upper Devonian-aged Duck Lake Formation. These rocks tend to be erosionally recessive and are locally exposed north of Cobble Hill near Hutchison and Cobble Hill Roads;
  - Buttle Lake Group rocks consist of several small, northeast-trending slivers of marble of the Mississippian to Lower Permian-aged Mount Mark Formation. Buttle Lake rocks were historically mined at the Cobble Hill quarry, are host to a number of small karst formations west of Cobble Hill village, and is erosionally recessive;
  - Vancouver Group rocks are represented by one small, northwest-trending sliver of marble of the Middle to Upper Triassic-aged Quatsino Formation. This isolated rock package outcrops on the east shore of Shawnigan Lake to the immediate south of Old Baldy Mountain, and is erosionally recessive; and
  - Bonanza Group rocks consist of a large, northwest-trending package of calc-alkaline basaltic rocks of Lower Jurassic age. These rocks form a series of conical hills around the north and east sides of Shawnigan Lake, and are exposed along the shoreline of Saanich Inlet from the Mill Bay ferry terminal to Bamberton;
- An ovoid area around Mill Bay village that fronts Saanich Inlet from Cherry Point to the Mill Bay ferry terminal consists of a complex of granodiorite stocks of early to middle Jurassic-aged Island Plutonic suite. These are coeval with the Bonanza Group volcanics and intrude older rocks of the Sicker Group to the north.

The structural geology of the South Cowichan area is complex. Rocks within the Wrangellia Terrane exhibit a coarse, northwest-trending fabric. Most regional-scale faults in this terrane assume north to northwest orientations with the exception of a single, east-northeast trending major structure that cuts across the north end of Shawnigan Lake and offsets the older northwest-trending faults. Rocks of the Wrangellia and Overlap Terranes also underwent extensive folding and faulting along a northwest axis during the Late Tertiary era when the Cascade and Olympic Mountains were being formed in Washington State. This late-stage deformation manifests as a series of low-angle thrust faults and fold axes that are locally offset by minor, northeast-trending normal faults.

With the exception of the highly regionally metamorphosed gneisses of the Wark and Colquitz Formation rocks south of Shawnigan Lake, metamorphic grade in the South Cowichan area is generally quite low but generally increases with the age of the rock packages. Bonanza Group rocks are heavily veined and show minor replacement by laumontite, stilbite, calcite and minor quartz, assemblages typical of the zeolite metamorphic facies. Carbonate rocks of the Vancouver and Buttle Lake Groups commonly consist of recrystallized marble. Basalts of the Sicker Group commonly show amygdule infillings and veins of chlorite, calcite, epidote and quartz, typical of lower greenschist facies metamorphism.

2.4 Surficial Geology

Four laterally extensive, mappable stratigraphic units are present within the South Cowichan area (Huntley, 2001). Dominant landforms and sediments in this region are late glacial in age and record the advance, maximum, and retreat phases of the late Pleistocene-aged Fraser Glaciation. Minor landforms and sediments are of post-glacial age and represent the fluvial and marine reworking of all earlier deposits. The thickness of the surficial cover within the South Cowichan region generally increases from southwest to northeast.

The stratigraphy of these units is described below and shown on Figure 5:

- Advance-phase glacial outwash materials, known as the "Quadra Sands", represent the oldest surficial deposits in the area. These include ice-distal sand and gravel-rich glaciofluvial sediments and glaciolacustrine deposits, ice-proximal gravel-rich outwash, and ice-contact debris-flow diamicton. Quadra Sand deposits do not outcrop within the South Cowichan, but have been recognized at depths of over 50 m below surface and up to elevations of 80 m above mean sea level beneath the Cowichan Bay / Cherry Point area, and likely occur in elongated lenses or beds with thicknesses in the range 15 – 20 m;
- Glacial maximum deposits, known as the "Vashon Drift", include massive lodgement till and glacigenic debris flows, with minor interbedded, subglacial and/or ice-contact glaciofluvial sand and gravel interbeds. These moraine deposits overlie the Quadra Sands materials described above, and can locally exceed 60 m in thickness. Deposition of the Vashon Drift was widespread throughout the South Cowichan Area, with deposition occurring at all elevations and in most areas. Glaciofluvial deposits of the Vashon Drift are known to underlie, onlap, and/or incise the morainal deposits, often vary widely in thickness, and can occur in usual topographic settings such as on hilltops or as hanging valley terraces;
- Retreat-phase glacial deposits, known as the "Capilano Sediments", include glaciomarine and minor glaciofluvial sediments. These deposits, which are the product of wasting tidewater glaciers and sediment deposition along retreating ice-margins, are present within the Koksilah and Cowichan valleys, Cowichan Bay and Satellite Channel areas, and within Saanich Inlet. Capilano Sediments overlie winnowed deposits of the Vashon Drift described above, and are present on hillsides up to elevations of roughly 80 m above mean sea level. Glaciomarine and glaciolacustrine deposits of the Capilano Sediments occur as draping veneers and blankets up to 15 m thick, while glaciofluvial deposits are confined to impersistent, linear deposits and kame deltas that occupy glacial melt water channels; and
- Post-glacial materials, known as the "Salish Sediments", represent the youngest surficial deposits in the area, and include fluvial, alluvial, deltaic, and marine deposits that represent recent reworking of all earlier deposits. Salish Sediments overlie all other deposits, and are present along most watercourses, in estuaries, and along shorelines throughout the South Cowichan area.

2.5 Groundwater

2.5.1 Data Collection / Analysis

Data collection and analysis for the groundwater component of this project was achieved using the following methods and sources:

- Collation and review of geology and groundwater data, including:
  - Maps of surficial geology (Guthrie and Penner,2005) and bedrock geology (Massey et al., 2003a,b; Guthrie, 2005);
  - MOE aquifer classification polygons (BC Water Resources Atlas[2]) and associated aquifer classification worksheets;
  - MOE groundwater observation well network data (Province of BC, 2007);
  - BCGS aquifer information (MOE Aquifer Classification Database, 2007); and
  - Water well information for the Mill Bay, Cobble Hill, and Cowichan areas as selected through the WELLS database. This includes well tag numbers, depth of well, yield, bedrock depth, and aquifer lithology;
- Search of digital libraries, including EcoCat and GSC/MOE archives, for pertinent reports, and review of these reports. Identified reports from Ecocat are listed in Table 3 below;
- Collection of information on major water users (e.g., improvement districts) within the Study Area;
- Liaison with MOE's regional hydrogeologist, Nanaimo region (Pat Lapcevic), and MOE's senior groundwater specialist in Victoria (Mike Wei), including:
  - Discussion of review of observation well data for the Cobble Hill aquifer for evidence of declining water levels;
  - Obtaining aquifer classification worksheets (see above); and
  - Obtaining information on geologic cross sections for the Study Area as produced by MOE; and
- Collation of other expertise on groundwater resources in the Study Area:
  - A one-day tour of the Study Area with Mr. David Slade (Drillwell Enterprises Ltd.); and
  - A telephone interview with Ms. Gypsy Fisher, graduate student working at SFU on hydrostratigraphic modeling and analysis of the Comox-Merville aquifer and underlying fractured sedimentary bedrock, Vancouver Island.

[2] http://www.env.gov.bc.ca/wsd/data_searches/wrbc/index.html

Based on the above information, the groundwater component of this study sought to synthesize current understandings of groundwater systems within the South Cowichan area. Specific objectives were to:

- Develop a conceptual understanding of aquifers in the Study Area based on existing information, including identification of aquifer boundaries and inter-connectedness, recharge mechanisms, groundwater flow directions and well yields; and
- Develop a preliminary general water budget for the Study Area.

A preliminary conceptual hydrogeological model is developed below, while water budget calculations are presented in Section 5.1.

Table 3 Reports from Ecocat Search

Author	Title	Year
H.W.Nasmith	Groundwater for Irrigation in the Cowichan Valley of Southern Vancouver Island	1953
H. Nasmith	Groundwater for Farm Use in Lower Cowichan Valley, Vancouver Island	1955
J.C.Foweraker	Notes on Groundwater Supplies in Cowichan Indian Reserve No.1, Duncan BC	1970
J.C.Foweraker	Groundwater Potential available to the Corporation of the District of North Cowichan at the South end of the District	1975
A.P. Kohut	Groundwater Potential, Chemanius Area, North Cowichan Municipality	1975
J.C.Foweraker	Groundwater Research project Cowichan River Aquifers near Duncun BC Final Report	1976
J.C.Foweraker	Cowichan River Aquifers near Duncan	1976
A.P. Kohut	Cowichan Estuary Task Force - Preliminary Groundwater Study	1978
M.Zubel	Somenos Road Area of the North Cowichan Groundwater Potential	1978
A.P. Kohut	CVRD - North Oyster Diamond Settlement Plan - Cassidy Aquifer	1979
G.Buble	Bootsman Well and Related Water Problems in Cobble Hill Area	1979
K.D. Ronneseth	Agricultural Capability Assessment A Groundwater potential Study: Cowichan Valley to Mill Bay	1981
A.P. Kohut	Salt Water Intrusion Problem Cowichan Bay	1981
MOE	Cobble Hill Waterworks	1983
M. Wei	Cowichan Bay Waterworks District Review of data from the new Well	1985
A.P. Kohut	Groundwater Quality Monitoring and Assessment program 1985/1986 Cowichan-Koksilah Estuary	1985
A.P. Kohut	Groundwater Quality Monitoring and Assessment program 1985/1986 Cowichan-Koksilah Estuary Fall Field Survey	1985
M.Zubel	Cowichan-Koksilah Water Management Plan - Groundwater Input	1985
R.P. Richards	Cowichan River Surface/Groundwater Study	1986
A.P. Kohut	Groundwater Quality Monitoring - Cowichan Bay Area – Duncan	1986
MOE	Ministry of Environment and Parks Cowichan-Koksilah Water Management Plan Executive Summary	1986
J. Kwong	Saltwater Intrusion Mill Bay Area, Shawnigan Lake District	1987
A.P. Kohut	Groundwater Quality Monitoring and Assessment Program Cowichan-Koksilah Estuary , Summary of Sampling	1989
A.P. Kohut	Water Chemistry differences of the upper and lower aquifers near the Cowichan-Koksilah Estuary	1989
W.S. Hodge	Well Information Telegraph Road Cowichan Bay	1989
B.I. Ingimundson	Groundwater Supply Mill Bay B.C. Thurber Engineering	1992
W.R.Turner	Community Water Supply Well Test Shawnigan Hills Production Well No. 9 (Turner Groundwater Consultants)	1994
M. Wei	Wheelbarrow Springs, Mill Bay Waterworks District, Mill Bay, BC	1996
F.Chwojka	Groundwater Quality Monitoring and Assessment Program Cowichan-Koksilah Estuary , concerns and problem areas	1997

2.5.2 Groundwater Occurrence / Distribution

The occurrence and distribution of groundwater resources within the South Cowichan area is typical of Vancouver Island's heavily glaciated coastal regions (MOE 1991). In these areas, low-porosity bedrock is often covered by a heterogeneous assemblage of unconsolidated glacial and post-glacial deposits, whose relative porosities may be spatially variable and related to their depositional origins.

Groundwater in bedrock will tend to collect mainly within open joint and fracture systems, along bedding plane partings, to a lesser extent within intergranular pore spaces of the rock itself. In the case of limestone, groundwater can also collect in channels and voids formed by the dissolution of the rock by water. Wells completed within massive rocks of the Sicker, Buttle Lake, Vancouver, Bonanza, and Nanaimo Groups, as well as within the intrusive rocks of the Westcoast Crystalline Complex and Island Plutonic Suite, that do not intersect fracture systems contain very little groundwater due to these rocks' low primary porosity. Bedrock fracture aquifers can be either confined or unconfined depending on their structural geometry and degree of fracture connectivity.

Wells completed in closely-spaced joint systems and/or intense zones of bedrock fracturing (i.e. where swarms of multiple, subparallel faults are present, or where fault zones with differing orientations intersect) can often initially produce high groundwater flow rates. However, the long-term flow rates and sustainability of these wells can often be highly variable and expensive to evaluate due to variations in bedrock fracture geometry and intensity. Specific fracture systems within major fault zones may also be more hydraulically significant than others due to differences in their bulk hydraulic conductivities, often related to the type of tectonic stress regime hosting the fracture systems, fracture connectivity, and/or blockage by impermeable materials.

Groundwater may be present within near-surface, unconsolidated sediments with high primary porosity as unconfined or semi-confined aquifers. In particular, laterally extensive glaciofluvial deposits of the Vashon Drift, Capilano Sediments, and Salish Sediments can be highly significant in terms of their groundwater potential. The amount of water that can be extracted by individual wells completed in these aquifers may be highly variable depending on the permeability of the aquifer materials, the thickness and extent of the aquifer, the rate of aquifer recharge, and on well construction. Recharge of these aquifers is likely to be primarily from the infiltration of precipitation or surface water sources. Unconfined aquifers of this type may be highly vulnerable to surface contamination.

At intermediate depths, groundwater may occur within thin, permeable interbeds within thick, loosely consolidated morainal (till) deposits of the Vashon Drift. In particular, deep subglacial and/or ice-contact glaciofluvial sand and gravel beds and lenses may be highly significant in terms of their groundwater potential. Wells completed in these materials often initially report high yields, but such aquifers may not be sustainable over the long term due to unpredictable facies variations, deposit extents, and recharge potentials. Semi-confined aquifers of this type may be moderately vulnerable to surface contamination depending on their stratigraphic setting. Many private properties and rural developments within the Mill Bay, Cobble Hill, Cowichan Station, Cowichan Bay, and Cherry Point areas are serviced by wells developed within these near-surface and intermediate depth unconsolidated sediments.

Groundwater may also be present in deep, confined aquifers within permeable, loosely consolidated sediments that are overlain by deposits of low permeability glaciomarine clay and till. In particular, glaciofluvial outwash deposits of Quadra Sands are highly significant in terms of their groundwater potential. The amount of water that has been historically extracted along the east side of Vancouver Island by wells completed in the Quadra Sands aquifers is considerable, and several municipalities maintain well fields that draw their water supply from these deposits. However, individual well yields may be locally variable depending on the permeability of the aquifer materials, the thickness and extent of the aquifer, and on well construction. The recharge of Quadra Sands aquifers is not clearly understood due to their characteristically deep stratigraphic position. Infiltration of water through overlying, low-permeability tills may contribute some recharge, as may underlying, water-bearing geological structures where the Quadra Sands deposits are in direct contact with bedrock. In some areas, wells developed within the Quadra Sands show declining water levels over time, which may suggest that extraction rates locally exceed recharge. Aquifers of this type are not as vulnerable to surface contamination as near-surface, unconfined aquifers. A small number of agricultural and private properties south of Cowichan Bay between Duncan and Cherry Point are developed within these deep unconsolidated materials.

Recent fluvial deposits of the Salish Sediments often host important aquifers (such as the Cowichan River's river gravels from which the City of Duncan draws its municipal water supply). However, extensive deposits of this type are not present within the Study Area's boundaries. Glaciolacustrine and glaciomarine deposits of the Capilano Sediment, as well as dense morainal diamicton deposits of the Vashon Drift, are not considered hydrogeologically significant due to their inherent low permeabilities.

Free-draining ice-contact deposits of the Capilano Sediments and recent colluvial debris flows, which are both common surficial deposit types within the Study Area, are not considered prospective to host groundwater since they are often positioned above the level of the local water table.

2.5.3 Groundwater Flow

To date, groundwater flow directions have mostly been inferred based on the presence of prospective discharge locations. Regional groundwater flow patterns in surficial aquifers largely mirror topography, with groundwater recharge taking place at higher elevations and discharge occurring at lower elevations. Groundwater discharge is usually detectable as base flow in creeks, as linear seepage zones or spring lines on hillsides, and as sag ponds or wetlands in low-lying surface depressions.

Groundwater divides in unconsolidated glacial and post-glacial deposits typically tend to be roughly coincident with surface catchment divides, although the total volume of water entering bedrock aquifers may originate from more than one surface water catchment (i.e. determined by whether the geological structure crosses surface watershed divides). Local flow regimes and hydraulic gradients within different bedrock fracture aquifers may be complex and distinct from regional patterns due to their unique geometric arrangements. While surface fracture mapping may provide an understanding of the fundamental structural characteristics of specific bedrock aquifers, this information does not always

directly equate to subsurface groundwater occurrence or flow patterns. For example, fractures observable at surface may not represent the system's most significant groundwater flow conduits or storage media.

Groundwater flow rates within bedrock fracture zones are expected to be rapid compared to flow within surficial deposits. The majority of groundwater flow in bedrock aquifers usually occurs within 100 m of surface. If large scale fault systems are present, significant groundwater flow may also occur at depths of hundreds of metres and across adjacent surface watersheds, with deep flow systems eventually discharging into major river systems, lakes, and/or the marine environment.

2.5.4 Groundwater Quality

Groundwater quality within the South Cowichan area's aquifers is linked to the parent chemistry of the aquifer media and the residency time of the aquifer's contained water resources. Groundwater in the Study Area's surficial and bedrock aquifers is generally of acceptable quality for most uses. Groundwater drawn from surficial aquifers tends to be of higher quality than that extracted from bedrock aquifers, with bedrock wells often producing comparatively harder and more mineralized groundwater with elevated pH levels. Groundwater drawn from bedrock formations with high concentrations of disseminated iron pyrite and/or hydrothermal mineralization systems may over the long-term produce water with elevated concentrations of iron, manganese, or other deleterious compounds, particularly if mineralized zones become dewatered and subsequently oxidized by sustained well pumping. Long-duration pump testing of any new wells developed within the Study Area is recommended to determine whether groundwater being extracted may be subject to seasonal and/or long-term water quality variations.

Wells developed adjacent to marine shorelines in either surficial or bedrock aquifers may be subject to varying degrees of contamination by seawater. The degree of saline intrusion is often unpredictable, and may be the product of a number of site-specific issues, including groundwater extraction rates, well construction, and the degree of hydraulic connectivity between the aquifer and the marine environment.

2.5.5 Groundwater Vulnerability

The relative sensitivities of groundwater aquifers to contamination, as well as the degree of influence on their contained groundwater by surface water bodies, is dictated largely by whether the aquifers are confined or unconfined (i.e. on the presence or absence of overlying aquitards or aquicludes), and on their geomorphic setting.

Areas where surficial aquifers are unconfined and permit relatively high groundwater recharge rates, or where bedrock aquifers outcrop at the land surface or are overlain only by a thin soil veneer, will be highly susceptible to surface contamination. Unconfined aquifer locations often coincide with large deposits of fluvial and glaciofluvial sediments and include the Mill Bay Aquifer #206. Examples of highly vulnerable bedrock groundwater systems include the Shawnigan Lake Aquifer #203 and the Malahat Aquifer #208.

Bedrock fracture aquifers are particularly vulnerable to surface contamination, since groundwater flow rates through open fracture systems and bedrock voids (such as karst systems) are typically rapid compared to movement through intergranular pore spaces of unconsolidated aquifers. Consequently,

management of bedrock groundwater resources should include the preservation of soil cover and vegetation, and the establishment of areally extensive wellhead and catchment protection areas.

At the initiation of this project, MOE's regional hydrogeologist, Pat Lapcevic, indicated that a collaborative vulnerability mapping project for the area was underway ("Vancouver Island Water Resources Vulnerability Mapping Project", based primarily from Vancouver Island University[3], which the CVRD is supporting). It was agreed upon with the regional hydrogeologist that this project would not undertake any vulnerability assessments for the Study Area so as not to duplicate this valuable work that will address threats to the aquifers in the Study Area. On 28 January 2009, MOE's regional hydrogeologist indicated that the vulnerability mapping was nearing completion and that results from this project would be released to the public in a few months time. The CVRD should have access to these results by February 2009 for comment and feedback. The results from the vulnerability project will consist of:

- Maps indicating areas of low, medium or high vulnerability. Alternatively, maps of low, low-medium, medium, medium-high and high vulnerability may be created. The level of detail of the vulnerability classification that is warranted (based on available data) is in the review stage.
- A report outlining the basis for the vulnerability maps (a DRASTIC modelling approach, Wei, 1998), and providing guidance regarding the interpretation of these maps.

The findings from this aquifer vulnerability mapping project should be included in developing the South Cowichan water plan. The recommended development of a groundwater model may be able to provide additional information on aquifer vulnerabilities, wellhead protection areas and sensitive recharge areas.

2.5.6 Groundwater Surface Water Interactions

Traditionally, management of water resources has focused on surface water or groundwater as if they were separate entities. As development of land and water resources increases, it is apparent that development of either of these resources affects the quantity and quality of the other.

Nearly all surface-water features (streams, lakes, reservoirs, wetlands, and estuaries) interact with groundwater. These interactions take many forms. In many situations, surface-water bodies gain water and solutes from groundwater systems (i.e. base flow) and in others the surface water body may be a source of groundwater recharge (i.e. a losing stream) and causes changes in groundwater quality. As a result, withdrawal of water from streams can deplete groundwater or conversely, utilization of groundwater can deplete water in streams, lakes, or wetlands. Pollution of surface water can cause degradation of groundwater quality and conversely pollution of groundwater can degrade surface water.

Consequently, effective land and water management requires a clear understanding of the linkages between groundwater and surface water as it applies to any given hydrologic setting.

[3] http://web.mala.bc.ca/groundwater/

2.5.7 Regional Groundwater Development

The BC provincial government has delineated 13 discrete aquifers within the Study Area based primarily on aquifer media similarities encountered in drilled, water-bearing wells throughout the region. Synoptic descriptions of these aquifers are presented in Table 4 below, with their locations shown on Figure 6. Detailed aquifer descriptions are provided in Appendix 1.

Table 4 Summary of mapped aquifers

Tag	Name	Descriptive Location	Type	Size (km^2)
197	Cherry Point	Cowichan Bay / Cobble Hill	Sand and Gravel	39
199		Cowichan Station	Sand and Gravel	3.5
201	Kingburne	Cobble Hill	Sand and Gravel	1.7
205	Carlton	Cobble Hill / Shawnigan Lake	Sand and Gravel	2.6
206	Mill Bay	Mill Bay	Sand and Gravel	2.7
196	South Cowichan	Deerholm / Duncan	Bedrock	45.8
198	Cowichan Station	Cowichan Station / Duncan	Bedrock	6.1
200	Kelvin Creek	Cobble Hill / Duncan	Bedrock	27.7
202	North Shawnigan	Shawnigan Lake / Cobble Hill	Bedrock	20
203	Shawnigan Lake	Shawnigan Lake / Cobble Hill	Bedrock	30.5
204	Cobble Hill	Cobble Hill / Mill Bay	Bedrock	21.4
207	Bamberton	Mill Bay / Shawnigan Lake	Bedrock	27
208	Malahat	Malahat	Bedrock	20.5

Note: Information derived from aquifer classification worksheets. No worksheet was received for aquifer 199; this aquifer is not described below

Eight bedrock aquifers have been delineated within the Study Area that collectively cover an area of almost 200 km^2. Most private properties and rural developments surrounding and south of Shawnigan Lake, as well as those located west of Saanich Inlet from Bamberton to Goldstream, are serviced by wells developed within bedrock aquifers. Although areally extensive bedrock aquifers have also been mapped beneath the Cobble Hill, Cowichan Station, Mill Bay, and Deerholm areas, only a small proportion of water users in these areas rely on wells developed within these aquifers as their primary water sources.

Five surficial aquifers have been delineated within the Study Area that collectively cover an area of about 50 km^2 and locally overlie the bedrock aquifers described above (see Figure 6). Many private properties and rural developments within the Mill Bay, Cobble Hill, Cowichan Station, Cowichan Bay, and Cherry Point areas are serviced by wells developed within near-surface and intermediate depth unconsolidated sediments of the Vashon Drift and Capilano Sediments.

The lack of mapped bedrock aquifers in the Cowichan Bay area (below the Cherry Point Aquifer 197) and southeast of Shawnigan Lake (between bedrock aquifers 203 and 208; Figure 6) is conspicuous and needs to be investigated. Bedrock groundwater systems likely exist in these areas but may not yet have been mapped by MOE.

Searches of publicly available information sources revealed that there is a general lack of lack of regional-scale geologic cross-sections for the Study Area that depict aquifer boundaries and their degree of inter-connection. Existing cross-sections are only local-scale and can be found in historical documents provided on EcoCat, including studies for the Cobble Hill waterworks (MOE, 1983), the Mill Bay waterworks district (Wei,1996), the Cowichan-Koksilah estuary (Wei, 1985), and a salt water intrusion study for Cowichan Bay (Kohut, 1981). The Cobble Hill waterworks cross-sections are reproduced as Figures 7A and 7B. These cross-sections identify the Cherry Point aquifer in the area of greatest groundwater use and reveal the following hydrostratigraphic sequence:

- A surficial till layer;
- A shallow water bearing zone (apparently present as discontinuous sand lenses);
- An intermediate till layer (local present between the shallow water bearing zone and the aquifer);
- A deeper water bearing zone (Cherry Point aquifer);
- A deeper till layer (locally present between the aquifer and bedrock); and
- Bedrock (stratification within bedrock is not distinguished).

This study attempted to develop a number of regional-scale geologic cross-sections for the area, but was hampered by the limited data search-and-retrieve capabilities of MOE's existing WELLS database. A clear understanding of the hydrostratigraphy of the South Cowichan area should be obtained prior to the development of a water management strategy for the region. Development of a conceptual hydrostratigraphic model would be the first step towards development of a numerical model for groundwater balance calculations.

2.5.8 Estimated Groundwater Recharge Rates

To date, limited information is available on groundwater recharge mechanisms and rates within the South Cowichan area (see Table 5 below). For the Mill Bay aquifer, Lowen (1994a) estimated the percentage to be approximately 45% of the annual rainfall, while Kreye et al. (1996) provided an estimate of 62%. These estimates likely apply to the unconfined southern portion of the Mill Bay aquifer, which is the local groundwater recharge area. Within the Study Area as a whole, areas where surficial aquifers are unconfined and may permit relatively high groundwater recharge rates appear to be relatively rare. Such locations are potentially indicated by fluvial and glaciofluvial sediment cover (Figure 5). It is expected that recharge to groundwater-bearing surficial zones and bedrock aquifers covered by moraine or glaciomarine / glaciolacustrine deposits (i.e. confined aquifers) is lower than the percentages indicated above. The groundwater model developed by EBA Engineering Consultants for the Cobble Hill Protection Plan (EBA, 2006) utilized a recharge rate of 295 mm/yr or about 23% of annual precipitation at the Shawnigan Lake station. This latter recharge rate may be applicable to the confined Cherry Point aquifer.

Based on analysis of well hydrograph data, the period of time to recharge is expected to the on the order of several years for the Cherry Point aquifer. Significantly longer time periods may be expected in areas where the regional water table is considerably below land surface. For example, if the water table is 10 m

below ground surface, it may take up to 34 years for infiltration to reach the groundwater system based on a rate of 295 mm/yr. As such, regional-scale groundwater systems may respond relatively slowly to climate change and other regional influences (e.g., water abstraction) and it may take years or decades for corresponding effects to fully establish.

Additional work is required to better estimate groundwater recharge rates on a regional basis (i.e. for the Study Area as a whole). This work could be based on a combination of approaches:

- Well hydrograph analyses (e.g., from MOE's observation well network) to assess aquifer hydraulic properties and aquifer responses to seasonal and inter-annual variations in recharge conditions. Well hydrograph analysis is complicated by the influence of both recharge conditions and water withdrawals on measured groundwater levels and as a stand-alone option is therefore not expected to yield reliable results regarding groundwater recharge rates;
- Hydrograph separation / base flow regression analyses to estimate groundwater discharge fluxes from seasonal low flows. Apart from the fact that limited gauging data exists for the Study Area, base flow regression analyses are complicated by the fact that streams are regulated and (or) influenced by water diversions. As such, this approach is not expected to yield reliable results; and
- Groundwater recharge calculations as the residual of precipitation, evaporation, surface runoff and soil water storage using either the HELP (Hydrologic Evaluation of Landfill Performance) model (Schroeder et al., 1994) or the MIKE-SHE model (Abbott et al., 1986; Refsgaard and Storm, 1995). Both models have been used for this purpose in a variety of settings in British Columbia (e.g., Scibec and Allen, 2006; Denny et al., 2007). This is considered the most promising approach.

Once estimates of recharge rates are obtained, this information would ideally be combined in a groundwater model for the Study Area that also incorporates information on well yields (aquifer transmissivity) and groundwater levels. These data would be used to calibrate the groundwater model to ensure that it accurately represents groundwater flow directions, rates and volumes. The purpose of the groundwater model would be to better evaluate groundwater budgets for aquifers within the Study Area and to assess groundwater availability within the context of climate change and water demand projections. The groundwater model could also be used to generate planning densities (i.e. by preferentially locating population in designated areas linked to high-yielding (portions of) aquifers), although planning at this level of detail would likely require much more comprehensive, quantitative, and site-specific hydrogeologic information than is presently available.

Development of maps of groundwater flow directions, while planned for this project, was hampered by limitations of the WELLS database. Once groundwater surface elevations have been determined from the WELLS database, this information could be used to map groundwater flow directions directly. However, the preferred option would be to use this information to calibrate a groundwater flow model, which could be used to quantitatively assess flow directions, velocities, and recharge/discharge relationships, including:

- Hydraulic connectivity of aquifers with surface waters and highland recharge areas; and
- Hydraulic connectivity between overburden and bedrock aquifers.

Table 5 Aquifer vulnerability, recharge and groundwater flow information

Tag	Aquifer Vulnerability	Confining Unit Thickness (m)	Depth to Water (mbgs)	Inferred Recharge Mechanisms	Groundwater Flow Direction
197	Low	20.0 (0 - 87.8)	27.4 (0 - 93.0)	Precipitation	North to Cowichan Bay
199	Low	No aquifer classification worksheet available			
201	Low	10.7 (0 - 48.2)	6.1 (2.4 - 25.9)	Precipitation, runoff	West to Koksilah River
205	Low	23.5 (0 - 65.5)	12.8 (0 - 37.8)	Precipitation (probably)	Not determined
206	High	7.5 (0 - ??)	6.7 (0 - 38.1)	Precipitation and/or upslope zones	North and northeast
196	Low	7.5 (0 - 69.5)	8.5 (1.2 - 89.6)	Precipitation, runoff surficial aquifers	To Cowichan River
198	Low	13.6 (0 - 41.1)	9.7 (0.5 - 49.7)	Precipitation, surficial aquifers	Not determined
200	Moderate	3.0 (0 - 28.7)	11.9 (0 - 44.2)	Not determined (precipitation)	Not determined
202	Moderate	2.1 (0 - 53.3)	8.4 (0 - 81.7)	Not determined (precipitation)	Not determined
203	High	0.3 (0 - 59.7)	5.9 (0 - 59.7)	Precipitation, runoff	To Shawnigan Lake
204	Moderate	3.0 (0 - 62.5)	5.2 (0 - 50.3)	Not determined (precipitation)	Toward Saanich Inlet
207	Moderate	4.6 (0 - 64.3)	7.6 (0 - 61.0)	Not determined (precipitation)	East and/or north
208	High	1.2 (0 - 16.2)	15.8 (1.5 - 76.2)	Precipitation, runoff	Toward Saanich Inlet

2.5.9 Aquifer Productivity / Well Yields

Surficial aquifers within the South Cowichan region are generally more productive than the bedrock aquifers, as indicated by the summary of well yields in Table 6 below. Reported bedrock aquifer productivity (MOE, 1994) generally increases eastward from low to moderate. However, these conclusions may be of limited relevance since estimates of aquifer productivity have been based primarily on airlifted well yields at the time of well development and not on aquifer yield and sustainability data from extended pump testing (not presently recorded by MOE). Long-duration pump testing of any new wells developed within the Study Area is prudent to determine whether local groundwater extraction rates are sustainable during dry summer conditions, and to confirm that such extraction does not result in deleterious effects on ambient environmental receptors or neighbouring human interests.

Given the comparatively large size and structural complexity of the region's bedrock aquifers, opportunities may exist for increasing bedrock groundwater use in the South Cowichan area. However, identifying productive bedrock groundwater zones may prove to be technically challenging and costly since the majority of bedrock groundwater is hosted by fracture systems of unknown morphologies and orientations. Comprehensive assessment of the area's fractured bedrock groundwater potential will require more site-specific hydrogeologic information than is presently available. Lithological and/or structural evaluations of the region's bedrock and surficial deposit groups could provide a more reliable depiction of their primary and secondary porosity potentials

Table 6 Productivity, well yield and water use information for mapped aquifers

Tag	Productivity	Demand	Type of Water Use	Reliance on Source	Well Yield (L/s)
197	Moderate	Moderate	Multiple	Conjunctive (surface water, bedrock)	0.63 (0.01 - 17.35)
199	Moderate	Moderate	Multiple	No aquifer classification worksheet available	
201	Moderate	Moderate	Domestic	Conjunctive (surface water)	0.76 (0.38 - 4.73)
205	Moderate	Moderate	Multiple	Conjunctive (surface water)	0.85 (0.19 - 3.16)
206	Moderate	Moderate	Multiple	Conjunctive (surface water, bedrock)	0.75 (0.09 - 22.1)
196	Low	Low	Domestic	Conjunctive (surface water)	0.13 (0.02 - 0.63)
198	Low	Low	Domestic	Conjunctive (surface water, surficial aquifer)	0.13 (0.06 - 1.26)
200	Low	Low	Domestic	Conjunctive (surface water)	0.19 (0.02 - 1.58)
202	Low	Moderate	Multiple	Conjunctive (surface water)	0.19 (0.02 - 5.68)
203	Low	Moderate	Multiple	Conjunctive (surface water)	0.19 (0.01 to 4.42)
204	Moderate	Moderate	Multiple	Conjunctive (surface water, surficial aquifer)	0.25 (0.03 – 8.52)
207	Moderate	Moderate	Multiple	Conjunctive (surface water, surficial aquifer)	0.25 (0.02 - 12.62)
208	Moderate	Low	Domestic	Conjunctive (surface water)	0.38 (0.03 to 3.79)

Notes

Aquifer tags and productivity/demand rankings from MOE (BC Water Resources Atlas; MOE, 1994). Type of water use, reliance on source and well yield estimates derived from aquifer classification worksheets. Well yields in brackets indicate ranges; values before brackets indicate median values

The relative proportion of current groundwater and surface water use is not currently known with precision, since groundwater usage within the South Cowichan area is not metered or regulated. More detailed information on well yields and aquifer transmissivity is being compiled in a joint venture between the Geological Survey of Canada (GSC) and the MOE, conducted at Simon Fraser University (SFU) under the lead of Dr. Dianna Allen. The purpose of this study is to provide quantitative estimates of aquifer hydrogeologic properties based on compilation of well installation and testing reports (Jessica Liggett, SFU, personal communication). The SFU project has been ongoing concurrently with this Phase 1 water study. As such, findings from the SFU project could not yet be incorporated in this report.

2.5.10 Observation Well Network

Table 7 below summarizes the five MOE observation wells within the Study Area, the locations of which are shown on Figure 6. Three active observation wells have been completed in the Cherry Point Aquifer (197): #233 (Cowichan Bay), #320 (Braithwaite Estates), and #345 (Arbutus Ridge). Two additional wells (#255 and #256) appear to have been completed in the Cobble Hill bedrock aquifer while the remaining well (#350) is located in a gravel pit in the Mill Bay Aquifer #206.

Observation well hydrographs for the Cherry Point observation wells are provided in Figure 8 together with precipitation data for the period of record.

Table 7 Observation Well Summary

Observation Well	Aquifer and Type	Well Depth (m)	Period of Record
Cowichan Bay (233)	Cherry Point 197 (surficial)	58	1978 - present
Braithwaite Estates (320)	Cherry Point 197 (surficial)	36	1992 - present
Arbutus Ridge (345)	Cherry Point 197 (surficial)	87	1999 - present
Cobble Hill (256)	Cobble Hill 204 (bedrock)	261	1980 - 2003
Mill Bay (350)	Mill Bay 206 (surficial)	39	2001 - 2006

2.5.11 Water Level Trends

Study team personnel met with Mr. David Slade from Drillwell Enterprises Ltd., who facilitated a tour of the South Cowichan area. Mr Slade is very knowledgeable on the geology and groundwater resources in the Study Area, and has been concerned with apparent declining groundwater levels and the need for deepening of domestic wells in the Hutchinson Road area. These concerns would appear to align with declining water levels noted for MOE observation well #320 in the same area. The area for which declining water levels and/or deepening of wells is tentatively indicated in Figure 6 ("Area of Concern"). A complete discourse of findings from the tour with Mr. Slade in provided in Appendix 2.

MOE has reviewed evidence for declining water levels based on data provided by Mr. Slade, and historical data from MOE observation wells in the area. This review was summarized in a January 23, 2007 letter from MOE's regional hydrogeologist to Gerry Giles of the CVRD. A copy of the analysis by MOE's regional hydrogeologist and accompanying letter is provided in Appendix 3.

The water level measurements for the three deepened domestic wells, the Cobble Hill Improvement District main well, and the monitoring well at the Cobble Hill Elementary School (data provided by Mr. Slade to MOE) suggest water level declines of between 0.07 to 0.17 m/yr are occurring, with total recorded water level changes of between 0.85 m (School well; 5 year period of record) and 3.96 m (domestic well #1; 24 year period of record). Between 2001 and 2006, the Braithwaite Estates observation well #320 showed a drop in peak water levels of 0.9 m, which was similar to that observed in the school well). The Arbutus Ridge observation well #345 showed a drop in peak annual water levels of 1.3 m over the last 4 years.

Based on this information, MOE concluded that "…while at first glance all of the data mentioned above suggests a drop in groundwater levels, it is important to note that Well #320 at Braithwaite Estates (the longest continuous record in the aquifer) also indicates a longer cycle likely related to precipitation where peak annual levels increased between 1995 and 2000, decreased between 2000 and 2003 and have been fairly steady since 2003. Clearly, this discrepancy should be analysed further to better understand the natural fluctuations in the aquifer. Our current observations are based on very limited data and levels in the two observation wells are impacted by pumping in neighbouring wells…"

This study's research team took an additional step and correlated measured water levels from the MOE observation wells against precipitation data for the Shawnigan Lake climate station (Figure 8). Striking

trends are apparent between the precipitation and water level data. Between 1985 and 1993, average annual precipitation was about 1100 mm/yr, while between 1994 and 1999 precipitation was considerably higher, averaging almost 1500 mm/yr. Between 2000 and 2005, annual precipitation declined again to an average of about 1100 mm/yr, while recent data for 2006 suggests a possible return to above-average precipitation. The trends noted in recorded water levels at the Braithwaite Estates observation well #320 would appear to reasonably match up with these temporal trends in precipitation, with a possible 1 to 3 year delay in the groundwater response. Such a delay would be expected based on the time it might take for infiltration from precipitation at land surface to reach the water table. Hence, it is not inconceivable that recent water level declines between 2000 and 2003 at the Braithwaite Estates observation well are at least in part due to natural fluctuations. Shallow wells in particular are expected to be very sensitive to either natural or anthropogenically-induced declines in water table elevation.

Groundwater levels recorded at the Arbutus Ridge observation well #345 in the Cherry Point aquifer also appear to be declining, but the record for this location is too short to comment on any correlation with precipitation or anthropogenic pressures (Figure 8). At the Cowichan Bay observation well #233, groundwater levels appear to be relatively stable or may have been increasing somewhat between 1994 and 2000. The trend in groundwater levels at observation well #233 is distinctly different from the other two stations in the Cherry Point aquifer, possibly reflecting the location of this well in a groundwater discharge zone (Cowichan Bay) and/or location away from groundwater extraction points.

While the above well hydrograph analysis has shed additional light on the possible cause(s) of declining water levels in the Cherry Point aquifer, it is recommended that a groundwater model analysis be conducted to more unambiguously distinguish between natural water level fluctuations and possible water level declines due to anthropogenic pressures in the Cherry Point aquifer.

2.5.12 Limitations and Future Work

At the outset of this project, the WELLS database was expected to provide information with sufficient spatial coverage to assess hydraulic gradients, groundwater flow directions, and aquifer inter-connectivity within the South Cowichan area, as well as provide data on well yields and for developing geologic cross-sections that would aid the development of a conceptual hydrogeological model for the area. However, the present configuration of this database renders screening and interpretation of the thousands of well records within the Study Area extremely time-consuming:

- Individual wells need to be selected using Internet-based forms, which makes information retrieval difficult and time-consuming.
- Information cannot easily be linked to a GIS system to display spatial information;
- The resolution of the BGCS coordinates provided (kilometre scale accuracy) is inadequate for the purposes of this study and does not fully make use of the actual location information for each well;
- Well records cannot be viewed and selected spatially; and
- Numerous inconsistencies and errors in the database are apparent.

As of mid-January 2009, the study team was granted access to an improved database created at SFU (Toews and Allen, 2007) that addresses the above concerns. The WELLS database has been corrected and standardized at SFU under contract of the MOE, and repackaged into a Microsoft Access database to provide rapid and convenient viewing of all the well records, as well as the ability to modify information (and track changes made such that the original information is not compromised) and view / select well records from a GIS (optional).

Several steps are still required to make the SFU database more useful for this project. The required processing steps are:

- Selecting the well records in the Study Area from the database using the GIS option. The total number of well records is expected to range in the thousands;
- Screening of the selected well records for completeness and quality of information, notably lithological records (for the purpose of the geologic cross-sections), static water levels (groundwater flow directions), and well yields (aquifer productivity). This quality assurance and control step is required because water well drillers do not always provide the necessary data (i.e. many records will be incomplete), and when provided the quality of the information is typically highly variable. Also, the bulk of the domestic wells contained in the database is expected to be relatively shallow (e.g., dug wells) and is therefore of limited use for this study. Emphasis should be put on relatively deep wells that maximize information on the regional hydrostratigraphy; and
- Using GIS to link the SFU database to digital topographic information to estimate the ground surface elevation for each well. This step is necessary to convert water table depths listed in the database to groundwater surface elevations for use in flow direction mapping.

Once the above steps have been completed, the resulting information can be analyzed and interpreted to further enhance the conceptual hydrogeologic model of the Study Area.

2.6 Surface Water

Three watersheds are present within the South Cowichan area, namely the Saanich Inlet, Shawnigan, and Cowichan Watersheds (see Figure 1).

The portion of the Saanich Inlet Watershed within the Study Area covers approximately 6,187 hectares, and is located in its rugged southeast portion. Water drains into many of the large creeks located in this watershed. This area is characterized by a parallel drainage pattern in which a majority of the waterways start off at high elevations in the western part of the watershed, and flow down eastwards into the Saanich Inlet parallel to one another.

The Shawnigan Watershed, which lies entirely within the rugged western portion of the Study Area, covers approximately 11,305 hectares. The majority of this area is characterized by a centripetal drainage pattern in which all waterways flow toward a central topographic that hosts Shawnigan Lake. The northeastern portion of this watershed has a more dendritic drainage pattern, with Shawnigan Creek being the main artery.

A small portion of the Cowichan Watershed lies within the north part of the Study Area adjacent to the south shore of Cowichan Bay, and covers approximately 3,361 hectares. Terrain within this portion of the watershed is relatively flat and highlighted by an unusual ravine system along Cowichan Bay and Saanich Inlet. Most of the water drains into many of the ravines and small creeks that empty into the Bay and Inlet. This area can be classified as a radial drainage pattern.

Each watershed has the following surface water bodies as identified on the BC Water Resources Atlas (see Table 8 below).

Table 8 Surface Water Bodies

Saanich Inlet Watershed	Shawnigan Watershed	Cowichan Watershed
Arbutus Creek	Shawnigan Creek	Garnett Creek
Handysen Creek	Van Horne Creek	Manley Creek
Malahat Creek	Hollings Creek	Hutchinson Lake
Johns Creek	Elkington Lake	
Bamberton Creek	Devereaux Lake	
Spectacle Creek	Stebbings Lake	
Colpman Creek	Shawnigan Lake	
Irving Creek		
Camsusa Creek		
Wrigglesworth Lake		
Oliphant Lake		
Spectacle Lake		

Figure 9 shows the relationship between mean monthly precipitation from the Shawnigan Lake climate station and mean monthly discharge from Shawnigan Creek near the Mill Bay hydrometric station from the years 1978 through 2006. This figure indicates that the best time to extract and store water from surface water bodies would be in the fall and winter between November and March. This would help ensure that the critical low flow season vital to aquatic habitat is not affected.

2.7 Ecological Features

2.7.1 Biogeoclimatic Zones

There are two biogeoclimatic zones in South Cowichan: the Coastal Douglas Fir zone (CDF) and the Coastal Western Hemlock zone (CWH).

The CDF zone is limited to small pockets of southeast Vancouver Island, several islands in the Gulf of Georgia, and a narrow strip of the Lower Mainland, on elevations mostly below 150 m. The CDF zone is characterized by warm, dry summers and mild, wet winters. Mean annual precipitation varies from 647 to 1263 mm, with very little falling as snow from November to April. Snow generally melts within a week of falling (D. Meidinger and J. Pojar, 1991).

Most forests found in the CDF zone today are second growth stands, regenerated after logging that occurred in the early 1900s. The coastal variety of Douglas-fir is the most common tree species in upland forests. Mature and old growth coniferous forests are important for birds that eat conifer seeds or wood boring and bark insects, including Pileated Woodpecker, Yellow-bellied Sapsucker, Steller's Jay, Raven, Chestnut-backed Chickadee, and others. Deciduous thickets and shrubs offer a variety of flying insects and seeds for breeding populations of House Wren, Hutton's Vireo, Black-headed Grosbeak, and White-crowned Sparrow (D. Meidinger and J. Pojar, 1991). Figure 10 shows the location of the CWH and CDF biogeoclimatic zones in relation to the South Cowichan area. Eastern parts of the Study Area occur in the dryer CDF zone, while higher elevations and more western parts of the Study Area that receive greater annual rainfall are in the CWH zone.

The CWH zone occurs at low to middle elevations west of the coastal mountains, along the entire British Columbia coast and into Alaska and Washington. The CWH zone covers much of Vancouver Island, occupying elevations from sea level to 900 m on windward slopes in the south and mid-coast, and up to 1050 m on leeward slopes (D. Meidinger and J. Pojar, 1991). The CWH zone is generally the rainiest biogeoclimatic zone in British Columbia and is characterized by cool summers and mild winters. Mean annual precipitation ranges from 1,000 to 4,400 mm. Less than 15 percent of total precipitation occurs as snowfall in the south (D. Meidinger and J. Pojar, 1991).

Tree, shrub, and herb species commonly found in CDF and CWH zones are listed in Table 9 below.

Table 9 Vegetation Characteristic of CDF and CWH Zones

Vegetation Layer	CDF Zone Species	CWH Zone Species
Tree	Douglas-fir, Bigleaf maple, Western redcedar, Grand fir, Western flowering dogwood, Shore/lodgepole pine	Douglas-fir, Western hemlock, Western redcedar, Shore/lodgepole pine, red alder, bigleaf maple
Shrub	Salal, Dull Oregon-grape, Labrador tea, Indian-plum, Salmonberry, Red elderberry	Salal, Dull Oregon-grape, Red huckleberry, Salmonberry, Devil's club, Labrador tea
Herb	Sword fern, Vanilla leaf, Three-leaved foamflower, Lady fern, Skunk cabbage, False lily-of-the-valley.	Vanilla-leaf, Sword fern, Wall-lettuce, Bracken, Sweet-scented bedstraw, Three-leafed foamflower, Deer fern, Lady fern, Oak fern, Skunk cabbage.

2.7.2 Riparian Areas

Riparian zones provide an important link between aquatic and terrestrial habitats in a landscape. Riparian areas allow wildlife to travel between habitat 'islands' and help to circulate nutrients among different ecosystems. Riparian vegetation connects the water's edge with dry land and plays an important role in maintaining aquatic system health in the following ways:

- Trees and shrubs that border and overhang waterbodies keep water cool through the process of evapotranspiration, which moderates the temperature of lake, river, and stream water, benefiting fish and aquatic invertebrates, and preventing excess algae growth;

- Plants growing along stream, lake, and estuary banks collect sediment, preventing banks and shorelines from eroding. This provides structure and strength through root growth;
- Leaf, twig, and needle drop provides nutrients to aquatic invertebrates, which in turn nourish fish; and
- Vegetation protects stream banks, and trees that fall into waterbodies create pools and hiding places for fish.

Riparian zones provide habitat for a large array of mammals, birds, fish, and invertebrates that depend on riparian vegetation for nourishment, travel, and protection (CRD website). Riparian areas are characterized by shallow water table conditions.

2.7.3 Invasive Vegetation Species

When invasive species alter an ecosystem, many of the benefits that people and animals derive from those areas are lost. Invasive species can significantly affect an ecosystem or landscape by altering the chemical composition and pH of soil, altering the structure of the foreshore, displacing species that rely on native plants or animals, altering fire regimes, and fragmenting the landscape where patches of invasive plants flourish (Capital Regional District website). There are a number of invasive plant species of concern on Southern Vancouver Island, including:

- European Beachgrass and Japanese Weed in marine shoreline areas
- Eurasian watermilfoil, Reed Canary Grass, and Purple Loosestrife in freshwater and wetland areas, and
- Scotch Broom, Himalayan Blackberry, Orchard Grass, Common Holly, English Ivy, Laurel-leafed Daphne, Gorse, Canada Thistle, Sweet Vernalgrass, and Hedgehod Dogtail in upland areas.

2.7.4 Fisheries

Maintaining fisheries requires intact and healthy fish habitat. Reliable water flows throughout the year are crucial, and are affected by weather conditions, reservoir storage and release practices, and relationships of groundwater and surface water. Base flows of many streams are maintained by inflows from groundwater. Hence, infiltration of rainfall into groundwater helps to protect stream flows, as does ensuring that groundwater removal via wells does not excessively lower water tables. During summer, groundwater temperatures are typically lower than those of surface water, so groundwater entering streams and lakes helps to protect fisheries against excessively warm water. Maintaining a healthy riparian area is important to moderating water temperature, protecting stream bank integrity, and providing food and organic matter inputs to streams.

The lakes, rivers, and streams in South Cowichan area support fish stocks of Coho, Kokanee, and Steelhead salmon, Rainbow, Eastern brook, and Cutthroat trout, Brown bullhead, Smallmouth bass, Yellow perch, and Pumpkinseed sunfish. Water-bodies providing important fish habitat include Shawnigan Lake, Shawnigan Creek, Spectacle Lake, Manley Creek, Camsusa Creek, and Garnett Creek

(Caskey, pers. comm., 2008). Riparian areas provide important habitat for fish while groundwater contributions to rivers and streams are vital for maintaining low-flows and regulating stream temperatures, issues that are essential for the survival and reproduction of aquatic life.

Shawnigan Creek has never supported Coho in its natural state due to the presence of impassable waterfalls at its outlet into Mill Bay. However, a run was established in the late 1970s by stocking the creek with Coho fry from Goldstream hatchery. Volunteers capture adult Coho each year when they return to the falls and truck them to release points upstream to spawn (Best, 2001).

Shawnigan Lake supports an isolated population of native Kokanee salmon. The salmon are landlocked descendants of sockeye that were stranded in the lake when ocean levels dropped after the most recent ice sheets melted. Following deglaciation, isostatic rebound caused Vancouver Island to rise, creating falls at the lower reaches of Shawnigan Creek (Best, 2001). Rainbow and Cutthroat trout, Smallmouth bass, Yellow perch, and Pumpkinseed sunfish are also found in Shawnigan Lake. Stocks of Rainbow trout are replenished in the lake on an ongoing basis, with almost 7,000 having been released into the Lake since March 2008 (Go Fish BC website).

Lower Shawnigan Creek flows from the northern end of Shawnigan Lake and winds approximately 11 km through suburban, forestry, and agricultural land to the falls at Mill Bay. In 1964, a weir was constructed approximately 450 metres downstream of the Lake on Lower Shawnigan Creek to store 1.2 million cubic meters (1,000 acre-feet) of spring runoff in the lake. The original 60 cm (two-foot) high weir consisted of a cement base poured directly onto the bedrock, with a 3m (9 foot) wide stoplog opening (Best, 2001). Two years ago, the CVRD replaced the original weir with a new, larger weir that better provides for fish passage between the lake and the creek (Law, pers. comm., 2008).

MOE oversaw operation of the original weir, but responsibility for operation of the new weir was transferred to the CVRD. MOE endorses maintaining a 20% Mean Annual Discharge (MAD) in waterways modified by flow control structures to protect a healthy fish habitat. In reality, agreements reached with waterworks authorities often provide for a much lower MAD. In Shawnigan Creek, the flow equates to 1% of MAD, or 0.014 m^3/s, at the outlet (March to October), resulting in insufficient flow to sustain the ecological function of the system (Law, pers. comm., 2008). Maintaining healthy fish habitat is challenged by domestic use, as water withdrawn in summer months to supply increasing numbers of homes around Shawnigan Lake, compromises critical summer flow volumes in the creek (Best, 2001).

Low flow issues are apparent in many other creeks and streams in South Cowichan, including Garnett Creek, Johns Creek, and Spectacle Creek (Law, pers. comm., 2008).

2.7.5 Wildlife

The South Cowichan region provides habitat for many bird and wildlife species. Species often found in riparian areas, wetlands, meadows, floodplains, lakes, and streams in the CDF and CWH zones are listed in Table 10 below.

Many of the wildlife species depend on surface water for food (prey), water and in some instances nesting (waterfowl, otters etc.) There are only indirect linkages with groundwater (e.g., base flow supporting fish

habitat with the fish acting as prey). Riparian habitats tend to have the greatest amount of biomass and are often identified as key habitats in the life history of much terrestrial and aquatic wildlife. Though species relying on surface water for part or all of their life history, such as amphibians, shrews, and water birds are closely linked to riparian habitats, many terrestrial wildlife species also use riparian habitats. Riparian forests are suitable for a diverse suite of breeding birds, including waterfowl, woodpeckers, owls, and passerines. Because of the rich biomass in riparian areas, many mammal species higher in the food chain use these corridors for movement and feeding. Riparian areas support a large number of rare and endangered wildlife species.

The South Cowichan region is situated on the Pacific Flyway, a major bird migration route used by more than 220 bird species, including Savannah sparrows, Urasian widgeon, and species of waterfowl listed in Table 10 below. Memory Island Provincial Park in the Shawnigan watershed provides sanctuary and habitat for a variety of small mammals, amphibians, and reptiles and because of its isolation from lakeshore development, protects nesting waterfowl during the spring (BC Parks website). Resident breeding birds in Memory Island Provincial Park include Common mergansers, Belted kingfishers, and Common snipe.

Table 10 Wildlife Species in CDF and CWH Zones

CDF Zone Wildlife Species	CWH Zone Wildlife Species
Black-tailed Deer, Black Bear, Grey Wolf, Raccoon, River Otter, Mink, Deer Mouse, Wandering and Vagrant Shrew	Black-tailed Deer, Black Bear, Grey Wolf, River Otter, Mink, Deer Mouse, Wandering Shrew, Roosevelt Elk, Pacific Jumping Mouse, Pacific Water Shrew
Osprey, Short-eared Owl, Blue and Ruffed Grouse, Trumpeter Swan, Canada Goose, Ring-necked Duck, Redhead, Harlequin Duck, Wood Duck, Red-throated Loon, Common Merganser, Wilson's Phalarope, Black Tern, Mew Gull, American Dipper, Bald Eagle, Great Blue Heron, Green-backed Heron, Yellow-headed Blackbird, Purple Martin	Osprey, Short-eared Owl, Snowy Owl, Ruffed Grouse, Trumpeter Swan, Sandhill Crane, Ring-necked Duck, Redhead, Harlequin Duck, Wood Duck, Red-throated Loon, Common Merganser, Wilson's Phalarope, Black Tern, Mew Gull, American Dipper, Bald Eagle, Great Blue Heron, Green-backed Heron, Yellow-headed Blackbird, Purple Martin
Western Garter Snake, Northwestern Garter Snake, Painted Turtle, Western Toad, Bullfrog, Red-legged Frog, Northwestern Salamander, Long-toed Salamander, Rough-skinned Newt, Sharp-tailed Snake.	Common Garter Snake, Western Garter Snake, Northwestern Garter Snake, Painted Turtle, Western Toad, Bullfrog, Red-legged Frog, Northwestern Salamander, Long-toed Salamander, Rough-skinned Newt, Tailed Frog, pacific Giant Salamander.

2.7.6 Conservation Initiatives

The forests, meadows, wetlands, lakes, rivers, and streams of the South Cowichan area provide habitat for a diverse range of flora and fauna. Growth and expansion of urban centres can place pressure on sensitive areas that support important wildlife habitats. Conservation initiatives undertaken in South Cowichan protect some of the important aquatic and terrestrial habitats in the area. Initiatives relating to water management are described below.

Sensitive Ecosystem Inventories Project

The Sensitive Ecosystem Inventories (SEI) Project is a joint federal and provincial initiative of Environment Canada (Canadian Wildlife Service), the BC Ministry of Environment, and the Habitat Conservation Trust Fund. The purpose of the SEI Project is to "identify remnants of rare and fragile terrestrial ecosystems [in British Columbia] and to encourage land use decisions that will ensure the continued integrity of these ecosystems" (MOE website). A Conservation Manual has been produced for the SEI for East Vancouver Island and Gulf Islands, providing guidance on the protection of sensitive ecosystems. The project identifies 166 ha of 'Older Second Growth Forest' (defined as a large stand of conifer dominated forest, between 60 and 100 years old) at McCurdy Point in the Saanich Inlet watershed, and 62 ha of 'Old Forest' (defined as a conifer dominated forest with an average tree age of 100 years or greater) near Oliphant Lake, also in the Saanich Inlet watershed, as rare and fragile ecosystems that require protection (MOE website).

Vancouver Island Wetlands Management Program

The Vancouver Island Wetlands Management Program (VIWMP) is a partnership between The Nature Trust, BC Ministry of Environment (MOE), Ducks Unlimited Canada, Habitat Conservation Trust Fund, and Canadian Wildlife Service. The program involves the management of more than 50 conservation areas, of which most are coastal wetlands and estuaries owned by The Nature Trust and managed by MOE. Projects are implemented by the program's Vancouver Island Conservation Land Manager through planning and funding support from program partners (The Nature Trust website).

Ducks Unlimited Canada (DUC)

DUC is working to protect more than 52,600 hectares of waterfowl habitat in the Georgia Basin, including the East Coast of Vancouver Island.

DUC is working with government to:

- Effect policy changes that protect priority areas;
- Purchase land;
- Eestablish conservation easements; and
- Undertake on-farm planning with landowners to protect diminishing areas (Ducks Unlimited Canada website).

South Cowichan Stewardship Project

The South Cowichan Stewardship Project was a two-year environmental program, operating throughout 2002-2004. The initiative was designed to conserve and protect ecologically sensitive areas along critical streams and rivers in the region, including Shawnigan Creek. Privately owned land bordering sensitive streams were the primary focus of the project.

The purpose of the project was to assist individual landowners in identifying critical habitat along streams and rivers on their properties and to build awareness of the need for management to protect the resources (South Cowichan Stewardship Project website).

3. HUMAN SETTING

3.1 Human Use

The South Cowichan region's temperate climate, high recreational and landscape value, and proximity to Victoria and Nanaimo make the area a highly desirable place for people to live, work, and enjoy recreational pursuits.

More than 17,000 people live in the rural communities of Cobble Hill, Mill Bay, Malahat, Shawnigan Lake Village, and Cowichan Bay. The three watersheds in the South Cowichan area each support a diverse range of land uses. Land use characteristics of each watershed are described in the following sections.

3.1.1 Shawnigan Watershed

Shawnigan watershed straddles Electoral Areas A and B and is dominated by Shawnigan Lake, located centrally in the watershed (Figure 11). The lake has a surface area of approximately 530 hectares, and the watershed covers approximately 10,000 hectares.

The watershed supports a population of 8,891 people (2006 Census). Pockets of residential land dot the perimeter of Shawnigan Lake. The greatest concentrations of development are in the villages of Shawnigan Lake and Cobble Hill. There are approximately 4,146 residential land parcels in the watershed, including vacant lots and seasonal dwellings. Approximately 600 residential lots have frontage on Shawnigan Lake.

Forestry is the dominant land use in the watershed, and has provided economic security to the region since the middle of the 19th Century (CVRD website). Land designated as 'forestry' by BC Assessment Authority (BCAA) covers an area of 5,909 hectares, or 57 percent, of the total watershed. Residential land use accounts for 3,391 hectares, or 33 percent, of the total land area in Shawnigan watershed, and agriculture accounts for 721 hectares, or 7 percent, of the total watershed area.

Residential growth continues to occur in and around the Village of Shawnigan Lake, at the northern end of Lake. There is also growing development pressure in the southern portion of the watershed, where residential development is proposed on large forestry parcels. Approval of the Elkington Estate development, currently under review by CVRD, would see the construction of approximately 85 dwellings on 1,000 acres of land surrounding Elkington Pond, Stebbings Lake, and Devereaux Lake. Development of various large Crown land parcels south of Shawnigan Lake has been slow until now due to First Nations Treaty talks, but development of these parcels in future is likely (Tippett, pers. comm., 2008).

3.1.2 Saanich Inlet Watershed

Saanich Inlet watershed is bound by Shawnigan watershed in the west, Saanich Inlet to the east, the Greater Victoria Water Supply Area in the south, and the Cowichan watershed in the north (Figure 12). The watershed straddles the boundary between Electoral Areas A and B, and is characterized by steep sloping terrain along the coast and short, high gradient watercourses that drain into the Saanich Inlet.

Forestry accounts for 72 percent of total land area in the Saanich Inlet watershed. Logging can alter the hydrology of an area in a variety of ways, including:

- Increased water yield year-round, resulting from a decline in the amount of evapotranspiration occurring in a watershed;
- Shortened interval between rainfall and peak runoff (shorter, steeper runoff peaks);
- Increased rates of erosion and sediment yield;
- Increased number of mass wasting (landslide) events;
- Reduced water-holding of surface soils in logged areas, resulting from decreased surface organic matter; and
- Altered patterns of runoff, as logging roads channel water in ways that differ from pre-construction configurations.

Understanding the natures and extent of changes to hydrology resulting from logging requires site-specific studies, monitoring, and expert assessment of affected sub-basins.

The Saanich Inlet watershed has a population of 2,219 people, residing mainly in the communities of Mill Bay, in and around the Malahat First Nation Reserve, and towards the southern extent of the watershed along the Trans-Canada Highway.

Saanich Inlet watershed, like Shawnigan watershed, is facing development pressure both in and around existing residential communities, and on land currently in forestry use. The Bamberton proposal, a 437-unit mixed-use development, was recently approved on vacant land south of Mill Bay. The Bamberton proposal would convert land that is currently zoned for forestry activity to approximately 3,200 new household units. The Bamberton development application, now being considered by CVRD, states that 1,046 housing units would be detached homes on urban lots, 1,072 would be attached units, and 1,109 units would be detached houses on the equivalent of suburban lots. The developer proposes taking water from Oliphant Lake to satisfy water supply needs for this project (CVRD website).

The Malahat First Nation Reserve is located on the shores of Saanich Inlet, between Mill Bay to the north and Bamberton to the south. The Reserve supports approximately 24 residential units, a community building, a Treaty Association office, and a water reservoir. The total number of units serviced by the reservoir is unknown (Daniels, pers. comm., 2008). The First Nation is in the early stages of developing a community plan to guide economic development on the Reserve over the next decade. Implementation of this plan may result in additional residential and commercial development. The Malahat First Nation is concerned about the health of streams flowing through the Reserve. First Nation members have noticed that summer flows now cease completely and that winter flows in streams on the Reserve are reduced (Daniels, pers. comm., 2008).

3.1.3 Cowichan Watershed

The Cowichan watershed is the most densely populated watershed in the Study Area, supporting a population of 6,400 people on an area of approximately 3,000 hectares. The Cowichan watershed may also be the most complex in terms of municipal planning regulations, because it straddles the boundaries of Electoral Areas A, C, D, and E (Figure 13).

The Agricultural Land Reserve (ALR) accounts for 66 percent of the total land area in the Cowichan watershed, and 41 percent of the ALR is presently cultivated for agricultural and horticultural use. The remaining 34 percent of the watershed is in residential or commercial use. Major communities are Cobble Hill, Arbutus Ridge, and Cowichan Bay. Cowichan Bay is the only community in the South Cowichan area with full sewer and water servicing, which makes it an attractive region for future residential development (Tippett, pers. comm., 2008).

The Cowichan watershed contains four Cowichan Tribes reserves that support approximately 45 residential units. The Tribes are considering developing a resort and day spa near Kiltahlis Beach during the next 15 years. Minimal development of other reserve land is presently proposed (Elliott, pers. comm., 2008). The Tribes are concerned with sewage disposal in Cowichan Bay and oppose plans to pump sewage into Satellite Channel.

Cowichan Bay currently relies on its 1986 Official Settlement Plan for controlling land use and development. Drafting of a new OCP for the Cowichan Bay area is scheduled to begin in late 2008 (Tippett, pers. comm., 2008).

3.2 Recreational Use

Easy access from Victoria and Nanaimo to the South Cowichan region's lakes and rivers, and its warm climate that earned Cowichan its nickname, "The Warm Land", make the area popular for many recreational enthusiasts.

Shawnigan Lake is a popular recreational spot for fishing, water skiing, canoeing, kayaking, and swimming. The Lake accommodates the Victoria Aqua Ski Club, which uses Shawnigan Lake for training and competitions (British Columbia Travel and Discovery website). Cross-country skiing, hiking, horseback riding, 4x4 adventures, and motorcycling are also popular activities around Shawnigan Lake.

Four provincial parks and one regional park are located in the Study Area, including:

- West Shawnigan Lake Provincial Park (Shawnigan watershed);
- Memory Island Provincial Park (Shawnigan watershed);
- Spectacle Lake Provincial Park (Saanich Inlet watershed);
- Bamberton Provincial Park (Saanich Inlet watershed); and
- Trans-Canada Trail Regional Park (Shawnigan watershed).

The parks offer a range of activities including camping, swimming, fishing, hiking and boating. The Trans-Canada Trail Regional Park follows the abandoned Canadian National Railway (CNR) right-of-way from Sooke Lake Road at the south end of Shawnigan Lake to Holt Creek trestle in the Glenora area (British Columbia Travel and Discovery website).

3.3 Plans and Policies Affecting Water

Federal, provincial, and municipal levels of government, as well as non-governmental organizations (NGOs), are responsible for the management of the province's water resources. Federal, provincial, and municipal legislation and policy governing water management in the South Cowichan area are described in the following section.

3.3.1 Local Government Official Community Plans

An Official Community Plan (OCP) is designed to present a long-term vision for a community, and to establish goals, priorities, and guidelines for land use and community development.

The *Local Government Act* sets out the mandate under which an OCP is prepared and revised, and requires an OCP to include designations of land use policies regarding the location, amount, type and density of development, the location and area of sand and gravel deposits that are suitable for future sand and gravel extraction, restrictions on land use that is subject to hazardous conditions or that is environmentally sensitive to development, and the location and phasing of utilities and public facilities, including schools, parks, waste management, and disposal sites. Each of these plan elements has the potential to affect surface and groundwater quantity and quality.

Shawnigan, Saanich Inlet, and Cowichan watersheds cover the southeast portion of the CVRD, encompassing all of Electoral Areas A (Mill Bay-Malahat) and C (Cobble Hill), and part of Electoral Areas B (Shawnigan Lake), D (Cowichan Bay), and E (Cowichan Station).

There are five OCPs in the Study Area. The Village of Cobble Hill also has a Neighbourhood Plan. Electoral Areas B and C are currently working with CVRD to prepare a joint South Cowichan OCP to replace the current OCPs for Shawnigan Lake and Cobble Hill. At the time of writing this report, the South Cowichan OCP was in draft form. Information pertaining to the draft OCP was taken from the South Cowichan OCP Background Study (December 2007).

Brief summaries of the goals, objectives, and policies in each of the five OCPs, the draft South Cowichan OCP, and the Neighbourhood Plan affecting the Study Area, as they relate to water supply, demand, and protection, are provided in the following sections.

Electoral Area A – Mill Bay and Malahat Official Community Plan

- Preserve agricultural lands, forest and mineral lands, and important fish habitat for future generations;

- Identify, protect, and enhance environmentally sensitive areas (including natural watercourses, the Saanich Inlet, streams, wetlands, lakes, and riparian leave strip areas), aquatic systems, and land areas for the long term benefit of natural ecosystems;
- Preserve and improve land, water, and air resources by upgrading liquid and solid waste disposal methods;
- Protect and where feasible restore the quality of aquatic and marine shoreline habitats and ecosystems in recognition of the sensitive marine waters of the Saanich Inlet; and
- Maintain cooperation with federal and provincial government agencies in protecting watercourses against activities that may reduce their fish bearing potential, or suitability as domestic water supplies.

Electoral Area B – Shawnigan Lake Official Community Plan

- Ensure that Shawnigan Lake is maintained as a dependable bulk source of potable water by strictly regulating all development in its watershed through regulatory bylaws;
- Favour Shawnigan Village and the existing higher density residential areas for improvement of community services (e.g. water, sewer);
- Ensure that the overriding consideration in any development is the preservation of the natural qualities and recreational amenities of land and water areas, especially Shawnigan Lake;
- Encourage farmers to provide off-stream water retention areas in order to store winter water runoff for summer irrigation purposes;
- Encourage careful logging practices that reduce the risk of local flooding, nutrient loading of the lake, and siltation of the lake;
- Discourage filling or depositing of soil, rock, or other materials in wetlands or marsh areas of lakes, rivers or other watercourses;
- Protect Shawnigan Creek and other local watercourses against activities that may reduce their fish bearing potential or suitability as domestic water supplies;
- Encourage the Ministry of Environment to upgrade the existing water level control structure on Shawnigan Creek outflow at the northern end of the lake for more efficient and safe control of water levels;
- Favour residential growth in the existing Village area north and north-east of Shawnigan Lake, and outside the Shawnigan Lake watershed; and
- In-fill existing residential areas only where development will not adversely affect water quality and the flow regime of Shawnigan Lake.

Electoral Area C – Cobble Hill Official Community Plan

- Protect reliable potable water supplies;
- Protect streams, lakes, and wetlands from undesirable forms of development, to maintain their environmental quality and aesthetic appeal;
- Protect freshwater and saltwater areas from contamination and degradation;
- Encourage clustering of residential development in settlement nodes to save or preserve undisturbed tracts of land for recreation and groundwater recharge;
- Ensure adequate water supplies are available for fire protection and domestic purposes during peak demand periods;
- Protect Garnett Creek and other watercourses against activities which may alter their fish bearing potential;
- Protect Dougan's Lake from use or activity that may jeopardize its water quality (gas powered boating is prohibited);
- Consider potential water supply and development of storage for the long term needs of agriculture during land use development stage; and
- Encourage farmers to provide off-stream water retention areas to store winter water runoff for summer irrigation purposes.

Electoral Area C – Cobble Hill Village Neighbourhood Plan

- Improve provision of community water and sewer services to the village; and
- Protect the aquifer that provides the source of water for the Cobble Hill Improvement District.

Electoral Areas B and C – Proposed South Cowichan Official Community Plan

The CVRD is currently in the process of preparing a joint OCP for Electoral Areas B and C. Objectives and policies have not yet been drafted. Policy recommendations included in the South Cowichan OCP Background Study (December 2007) relating to surface and groundwater quality and quantity are summarized in the following section.

- Recognize current and project future water use and guide development to provide or maintain adequate supplies of safe drinking water for residents, while protecting stream flows and lake and wetland levels required for wildlife and fish;
- Buffer riparian areas, including streams, lakes, and wetlands from development as per the Riparian Areas Regulation (RAR);
- Manage land use and development, and solid and liquid waste, to maintain or improve water quality;

- Ensure septic tanks are properly maintained;
- Encourage water users to work together to coordinate water management; and
- Develop Well Protection Plans for all areas.

Electoral Area D – Cowichan Bay Official Settlement Plan

- Protect sensitive areas from the impacts of development;
- Protect natural fresh water environments against activities that could adversely affect their fish bearing capability or suitability for use as domestic water supply;
- Evaluate all new residential development on the basis of its effect on existing water supplies;
- Protect groundwater sources and enhance water distribution and sewage collection systems;
- Encourage farmers to establish reservoirs to store winter rain water for summer irrigation purposes; and
- Discourage clear-cutting of forested areas around Cowichan Bay.

Electoral Area E and Part of F – Cowichan - Koksilah Official Community Plan

- Protect and enhance watercourses, wetlands, lakes, rivers, marshes, and other sensitive areas to maintain their natural habitat, environmental quality, aesthetic appeal and recreational value;
- Rehabilitate damaged natural aquatic spawning and rearing areas;
- Prevent development that would adversely affect the availability of water for present and future users;
- Ensure adequate water supply is available for fire fighting and domestic purposes during periods of peak demand; and
- Prohibit land uses requiring the disposal of waste materials, including stormwater, sewage, garbage, and industrial effluent, where they will adversely affect the quality and quantity of surface and groundwater resources.

3.3.2 Provincial Government

The Provincial Government regulates the management of water in British Columbia through Acts, Regulations, policies and codes. Legislation covers a range of topics including fish habitat protection, drinking water, dam safety, riparian areas, and flow management. Table 11 below summarises Provincial legislation relevant to water management in the South Cowichan area.

Table 11 Provincial Legislation Governing Water Management in British Columbia

Legislation	Summary
Water Act	The Act vests the right to the use and flow of all water in any stream in British Columbia in the Provincial Crown, except to the extent that private rights have been established under licences or approvals given under the Act. Water licences are issued to extract water from surface water sources. The Ministry of Environment is responsible for issuing water licences under the Act and regulates the amount of water that can be extracted, the time of year when extraction is allowed, and the location where water can be diverted for use. The right to water under these licences is based on a 'prior appropriation system' meaning that the right to take water is based on the date when the licence was issued (e.g. in times of low flow the older water licence holders have priority over newer licences). The Act's influence over groundwater use is limited to requiring well drilling to be performed by qualified professionals and to allowing for the recording of well data into the provincial well database.
Groundwater Protection Regulation	Establishes a registration system for qualified well drillers and standards for drilling, sealing, maintaining and closing wells. Wells must be flood proofed so runoff contamination cannot occur during flooding or heavy rains.
Water Protection Act	The purpose of the Act is to foster sustainable use of British Columbia's water resources. The Act re-confirms ownership of surface and groundwater in the Province, defines existing bulk water removal rights, prohibits bulk removal of British Columbia's water to locations outside the Province, and prohibits large-scale diversion between major watersheds of the Province.
Fish Protection Act	The purpose of the Act is to protect and restore fish habitat in waters under provincial jurisdiction. The Act authorizes a regional water manager to consider the impact on fish and fish habitat in or near streams when deciding whether to grant a licence or approval under the Water Act. The Act also allows for the designation of sensitive streams and imposes certain restrictions on granting water licences, which will impact those streams. There are no designated 'sensitive streams' in the Study Area.

Legislation	Summary
Drinking Water Protection Act	The Act provides a statutory framework for protecting drinking water systems in British Columbia. Its primary focus is protecting public health by ensuring comprehensive regulation of water supply systems, establishing mechanisms for source protection, and providing for greater public accountability of water suppliers. Key elements of the Act include; Establishment of water quality standards, including tap and source standards, Requirements for assessments and response plans in relation to threats to drinking water, Public accountability, and Development of community based Drinking Water Protection Plans. Water suppliers must provide potable water, obtain construction and operating permits, meet qualification standards for operators, have emergency contingency plans, follow monitoring requirements, and report threats to drinking water. Exemptions are made for 'small systems'. The Act sets out specific provisions for inspection, monitoring, and the appointment of drinking water officers with the authority to investigate complaints. A report to the local drinking water officer is required if a spill that is also reportable to the Provincial Emergency Program under the Environmental Management Act may result in a threat to drinking water.
Riparian Areas Regulation	The purpose of the regulation is to establish directives to protect riparian areas from development. The regulation establishes a system whereby site-specific assessment of a development's effects on fish habitat can be completed. The regulation allows for development to go ahead when there will be no impact on fish habitat or when it is demonstrated that impacts can be mitigated. Assessments must be carried out by a qualified environmental professional and circulated to three levels of government through an electronic database. Local government is required to consider conclusions made in the assessment in determining whether a development permit can be issued.
Dam Safety Regulations	The Dam Safety Regulations provide guidance on dam operation, maintenance, alteration, safety, reporting, and inspections.
Environmental Management Act	The Act addresses waste disposal, hazardous waste, municipal waste management, and contaminated site remediation. Regulations and regulatory amendments have been developed to support the Act, covering exemptions such as domestic sewage releases and disposal systems that are below specified thresholds.
Forest and Range Practices Act	The Act governs the activities of forest and range licensees in British Columbia to maintain a high level of protection for forest values including watersheds and wildlife. It sets the framework for achieving 'results-based' forestry on public land. The framework requires forest operators to set specific targets or strategies for environmental objectives established by the government for soils, timber, fish, biodiversity, cultural heritage, forage and plant communities, visual quality, water, wildlife, and resource and recreation features.
Land Act	The Act governs the disposition of provincial Crown land in British Columbia. Crown land includes land that is covered by water, such as the foreshore and the beds of lakes, rivers and streams.

3.3.3 Federal Government

Under the *Constitution Act* the protection of fresh water is primarily a provincial responsibility and British Columbia has passed acts related to the protection of water. The primary role for the federal government is working with the provinces to coordinate federal and provincial efforts to protect water resources, and to step in where there are issues of national concern (British Columbia Guide to Watershed Law and Planning website). Federal government also has an important role in promoting national standards and guidelines, providing infrastructure funding, and supporting research and data collection (Brandes, 2005).

Federal legislation relevant to water management in South Cowichan is described in Table 12 below.

Table 12 Federal Legislation Governing Water Management in Canada

Legislation	Summary
Fisheries Act	The primary purpose of the Act is to protect Canada's fisheries as a natural resource by safeguarding both fish and fish habitat. The Act regulates harvesting and provides protection for waters 'frequented by fish' or areas constituting fish habitat. The Department of Fisheries and Oceans (DFO) primarily administer the Act, but the environmental protection parts are administered by Environment Canada. On November 29, 2007 the federal government introduced Bill C-32, the *Fisheries Act 2007*. This Act, if passed, will completely replace the current Act. The new Act expands DFOs order powers and expands powers to implement regulations setting out the conditions under which a harmful alteration, disruption or destruction of fish habitat (HADD) may occur.
Canadian Environmental Protection Act	The Act is the principal federal environmental statute governing environmental activities in federal jurisdiction, such as the regulation of toxic substances, cross-border air and water pollution, and dumping into the oceans. It also contains specific provisions to regulate environmental activity on lands and operations under the jurisdiction of federal departments and entities. CEPA provides a system for evaluating and regulating toxic substances, imposes requirements for pollution prevention planning and emergency plans, and contains broad public participation provisions. CEPA is administered by Environment Canada.
Navigable Waters Protection Act	The Act prohibits the unauthorized construction or placement of a 'work' on, over, under, through, or across navigable water and is administered by Transport Canada. Where a project falls into the definition of a 'work', the federal government must approve it before it is undertaken, triggering the environmental assessment process provided for under CEAA.
Federal Water Policy	Administered by Environment Canada. The Policy is a statement of the federal government's philosophy and goals for Canada's freshwater resources and of the proposed ways of achieving them. The underlying philosophy is that Canadians must start viewing water as a key to environmental health and as a scarce commodity having real value that must be managed accordingly. The overall objective of the Federal Water Policy is to encourage the use of freshwater "in an efficient and equitable manner consistent with the social, economic and environmental needs of present and future generations".

4. WATER USE AND DEMAND

4.1 Estimates of Present Water Withdrawal

Water is withdrawn from surface water and groundwater sources in the South Cowichan area to support many uses, including conservation, industrial, residential, commercial, and institutional use, crop irrigation, land improvement, stock watering, and storage.

Information on the number and location of groundwater wells and licence holder information for surface water licences in the Study Area was obtained from drilling experts, waterworks authorities, and the MOE Water Stewardship Division's Water Licence Database. The data gathered provide an indication of how many groundwater wells there are in the Study Area and how much surface water is licensed for withdrawal each year. The data do not provide a clear picture of the total volume of water withdrawn because there is currently no regulation that requires monitoring of groundwater withdrawals. Although the surface water licence withdrawal data identify volumes that may be withdrawn under the licence agreement, actual withdrawal amounts were not available from the waterworks authorities surveyed. More detailed withdrawal data are necessary to allow a better understanding of potential demand versus supply issues.

Surface water withdrawal data was obtained from the MOE Water Stewardship Division's Water Licence Database (see Table 13 below). Surface water licences are assessed and categorised by MOE under the following status groups:

- Current;
- Awaiting sign; and
- Pending (i.e. Apportionment Pending, Cancellation Pending, Abandonment Pending, or Victoria Apportionment).

Points of diversion in the Study Area are identified in Figure 14.

Table 13 Surface Water Licensed Withdrawals – Current and Pending, 2008

Use	Total Volume of Surface Water Withdrawn (m^3/yr)		
	Current Licensed amount	Pending Licences	Total
Conservation	631,522	0	631,522
Industrial	2,714	1,844,537	1,847,250
Residential	3,641,661	858,230	4,499,892
Enterprise	46,977	1,382	48,359
Institutional	84,282	0	84,282
Irrigation	1,095,799	84,370	1,180,169
Land Improvement	2,445,438	0	2,445,438
Stockwatering	829	4,283	5,112
Storage	3,333,407	3,278,590	6,611,997
Total	**11,282,630**	**6,071,391**	**17,354,021**

Limited water withdrawal data was obtained from local water authorities in the Study Area, including CVRD, Mill Bay Waterworks District, and Lidstech Holdings Limited (see Table 14 below).

Table 14 Water utility groundwater extraction information

Utility Name	Area	Water Source	Extraction Data (Approximate)	Number of people/homes serviced
Canadian Retirement Corporation	Cobble Hill	Three wells (#5, #6, #7) in Cherry Point Aquifer 197	191,500 m^3/yr	
Douglas and Moth Waterwork Ltd	Duncan	Two wells	30gal/min (one well)	139 homes
Genoa Bay Properties Ltd	Duncan	2/3 of water supply from spring 1/3 from deep well	6,800m^3/yr	52 people
Keparo Water Society	Mill Bay	Well	11,700m^3/yr	28 homes
Vanland Road Water Society	Cobble Hill	Well	14.631m^3/day (Nov. '07)	23 homes

4.2 Population and Forecast Growth Estimates

Population and household distribution data for each watershed were required to determine current water use and to estimate future water demand in South Cowichan. The sources of population and household distribution information used for this study and the methodology applied to interpret data are described in Sections 4.2.1 and 4.2.2 below.

4.2.1 Current Population and Household Distribution in South Cowichan

Population data for the CVRD were gathered from the Statistics Canada figures on the 2006 Census. Dissemination Area data[4] were examined to determine the total population in each watershed. Table 15 below identifies the proportion of total Study Area population in each Electoral Area and watershed.

Table 15 Population Distribution in South Cowichan, by Jurisdiction and Watershed - 2006

Jurisdiction and Watershed	Total Population In Study Area	% of Total Study Area Population
Study Area Total Population	**17,485**	**100**
Area A, Mill Bay - Malahat	**4,075**	**23.3**
Shawnigan watershed	1,310	7.5
Saanich watershed	2,115	12.1
Cowichan watershed	650	3.7
Area B, Shawnigan Lake	**6,485**	**37.1**
Shawnigan watershed	6,471	37.0
Saanich watershed	14	0.1
Area C, Cobble Hill	**4,145**	**23.7**
Shawnigan watershed	1,110	6.3
Cowichan watershed	3,035	17.4
Area D, Cowichan Bay	**2,155**	**12.3**
Cowichan watershed	2,155	12.3
Area E, Cowichan Station	**490**	**2.8**
Cowichan watershed	490	2.8
First Nations Reserves	**135**	**0.8**

The total population of the CVRD is 80,731 people (Census 2006). Twenty-two percent (17,485 people) of the Regional District's population reside in the Study Area. There are 8,891 people living in the Shawnigan watershed, 2,219 people living in the Saanich Inlet watershed, and 6,375 people living in the Cowichan watershed.

The BC Assessment Authority (BCAA) collects and reviews land use data across British Columbia on an annual basis. BCAA Actual Land Use data for 2007-2008 were used to determine the distribution of household units in the Study Area (Table 16). Fifty-three percent of all household units in the Study Area are in the Shawnigan watershed, 36 percent are in the Cowichan watershed, and 11 percent are in the Saanich Inlet watershed.

[4] Each Electoral Area in Canada is split into small geographic blocks with a population of 400 to 700 people; these blocks are called "dissemination areas".

Table 16 Number of Residential Units in South Cowichan by Watershed and Residential Unit Type – 2008

Unit Type	Total Number of Residential Units by Watershed			Total
	Shawnigan	Saanich Inlet	Cowichan	
Urban	2,263	571	1,720	4,554
Suburban	1,163	120	634	1,917
Rural	170	54	144	368
Attached	396	60	182	638
Total	3,992	805	2,680	7,477

4.2.2 Forecast Growth Estimates

Population and household growth estimates were determined using BC STATS P.E.O.P.L.E 32 (Population Extrapolation for Organization Planning with Less Error, run cycle 32) population and household projections and estimates data (1986-2036), BCAA Actual Land Use data (2008), information obtained through discussion with CVRD Planning staff, and by reviewing OCP and development application documents.

BC STATS update provincial and sub-provincial population and household projections annually and estimates are date-referenced to July 1 of each year. The most recent sub-provincial projection was produced in August 2007 and was used as a basis for forecasting population and household growth in Shawnigan, Saanich Inlet, and Cowichan watersheds for the period 2008 to 2036.

Figure 15 illustrates BC STATS P.E.O.P.L.E 32 population and household projection estimates data for the CVRD (2006 – 2036). The Regional District's population is forecast to grow from 80,731 people (2006 Census), to 101,268 people in 2036, representing 25 percent growth in regional population over 30 years.

Based on BC STATS population projections, 22,000 people will live in South Cowichan by year 2036. If residential developments being planned for South Cowichan proceed, then the population could be much higher than the BC STATS projections. As discussed in detail in Section 4.3.1 of this report, the 2036 population of South Cowichan could reach 32,000.

4.2.3 Estimates of Present Water Use Based on Land Use Analysis

Estimates of present water use in South Cowichan were developed through analysis of BCAA Actual Land Use data (2008), zoning bylaws, major water utility withdrawal rates, average household and other sector water use consumption rates, and current housing and population data. The methods applied and the assumptions made in determining present water use for the Study Area are presented in Sections 4.3.1 to 4.3.4 below.

4.2.4 Land Use Analysis and Water Consumption Rates

One of the first steps in determining water use in South Cowichan was to identify how people use the land. Land use for individual parcels in the Study Area was mapped using BCAA Actual Land Use data for 2007-2008. The data were compared to CVRD zoning bylaws to correct anomalies or gaps in BCAA individual parcel information. No field checking was conducted as part of this mapping exercise.

BCAA groups land use types in the province into more than 150 categories. Approximately 120 categories are represented in the Study Area (e.g. grain and forage, dairy, small fruits, campgrounds, duplex, hotels, sawmills, railway etc.). It was necessary to further aggregate BCAA categories to support the needs of this water study. The eleven land use types represented in the Study Area and the terms used in this study to describe each group include:

- Urban residential;
- Suburban residential;
- Rural residential;
- Attached housing;
- Commercial;
- Industrial;
- Institutional;
- Playing fields (including golf courses);
- Agriculture – livestock and poultry;
- Agriculture – forage and grains; and
- Horticulture – berries, fruits, and vegetables.

Residential Land Use

'Other' Land Use

'Urban' Water Uses

Agricultural Land Use

Water consumption rates, per household unit and per hectare of land for other land use types, were determined by reviewing historical withdrawal data for water utilities in the Study Area, consumption rates by land use type used to estimate water use in the Cowichan Basin, and research from other parts of Canada. The annual water consumption rates used to estimate commercial, industrial, institutional, playing fields, agricultural, and horticultural water use in South Cowichan, are the same as those used to estimate water consumption in the Cowichan Basin as part of the Cowichan Basin Water Management Plan preparation in 2005.

Water consumption rates by land use type are described in Table 17 below. The water consumption rates should be considered as broad estimates. Actual levels of use are affected by a number of factors, including climate and weather, types of plumbing fixtures, conservation measures, density of development, and water pricing mechanisms.

A review of Shawnigan Lake community water supply annual consumption rates for residential use (December 2002) indicates that consumption rates range from 370 m^3 to 900 m^3 per household per year (Bryden et. al, 2002). The potential for large variations in water consumption between households should be taken into consideration when reviewing overall water use estimates.

Table 17 Water Consumption Rates, by Land Use Type

Land Use Type	Consumption (m^3/year)		Comment
	Per hectare	Per unit	
Detached housing	6,000		On average, detached housing consumes 6,000 m^3 of water per hectare, per year (Bryden *et al*, 2002). Zoning density provisions for all EAs in the Study Area were reviewed and averages were applied to this figure to determine 'per unit' consumption as follows; Urban lots = 10 units/ha, suburban lots = 5 unit/ha, and rural lots = 1 unit/ha. Attached housing permits an average of 30 units/ha = 180 m^3/unit/year.
Urban Lots		600	
Suburban Lots		1,200	
Rural Lots		6,000	
Attached Housing	5,000	180	
Commercial	7,000		Includes retail, offices, restaurants etc.
Industrial	4,800		Includes all industrial land uses.
Institutional	6,000		Includes schools, nursing homes, civic and cultural buildings etc.
Playing Fields	6,400		Includes golf courses and irrigated play fields
Agriculture	7,700		Average agricultural use for livestock, poultry, forage, and grains
Horticulture	5,600		Horticultural use for berries, nurseries, grapes, and tree fruits

The following assumptions were made in estimating current urban water use:

- Vacant residential lots have no associated water use;
- Seasonal urban and suburban unit water use is the same as full-time occupied urban and suburban dwellings. This assumption was made due to the lack of information on the annual duration of occupation for each seasonal dwelling, and some structures originally built as seasonal dwellings become occupied year-round; and
- Manufactured home parks use the same amount of water, per hectare, as Attached Housing. Individual manufactured homes were manually counted using Google Earth and orthophotography of the Study Area.

BCAA Actual land use data did not include the six First Nation Reserves in the Study Area. Residential unit totals and identification of other land use practices on the reserves were determined using Google Earth and orthophoto coverage of the Study Area and through personal communication with Tribe leaders.

4.2.5 Present Residential Water Consumption Estimates

Present water consumption, by various forms of residential land use, was estimated by multiplying the total number of household units in each watershed by the corresponding water consumption rate for each unit type. Table 18 below presents current residential land use water consumption estimates based on the methodology described in Section 4.3.1 below.

Table 18 Water Consumption Estimates, by Residential Unit Type and Watershed - 2008

Unit Type	Water Use per Unit (m^3/yr)[5]	Water Consumption by Watershed (m^3/yr)			Total (m^3/yr)
		Shawnigan	Saanich Inlet	Cowichan	
Urban	600	1,358,000	343,000	1,032,000	2,732,000
Suburban	1,200	1,396,000	144,000	761,000	2,300,000
Rural	6,000	1,020,000	324,000	864,000	2,208,000
Attached	180	71,000	11,000	33,000	115,000
Total		**3,845,000**	**821,000**	**2,690,000**	**7,355,000**

4.2.6 'Other' Land Use Type Water Consumption Estimates

BCAA Actual Land Use data (2008) were used to identify the total area of land in the Study Area used for commercial, industrial, playing field, and institutional use. Present water consumption estimates for 'other' land use types were determined by multiplying the total land area associated with each land use type by the corresponding water consumption per hectare rates presented in Table 19 below. This table also presents current water consumption estimates for 'other' land use types, by watershed for 2008.

Table 19 Water Consumption Estimates, by 'Other' Land Use Type and Watershed – 2008

Other' Land Use Type	Water Use (m^3/ha/yr)[6]	Total Water Consumption, by Watershed (m^3/yr)			Total (m^3/yr)
		Shawnigan	Saanich Inlet	Cowichan	
Commercial	7,000	127,000	78,000	80,000	285,000
Industrial	4,800	224,000	148,000	399,000	771,000
Playing Fields	6,400	259,000	39,000	678,000	977,000
Institutional	6,000	1,028,000	186,000	122,000	1,336,000
Total		**1,638,000**	**451,000**	**1,279,000**	**3,369,000**

The water consumption estimate for institutional land use in the Shawnigan watershed is substantially higher than estimates for this use in the other two watersheds. This disparity is due to the large land area associated with Shawnigan Lake School (a residential school north of Shawnigan Lake).

4.2.7 Present Agricultural Water Consumption Estimates

Substantial areas of land are cultivated for agriculture in Shawnigan and Cowichan watersheds, but relatively little in Saanich Inlet. There are 3,200 ha of land in Agricultural Land Reserve (ALR) in the Study

[5] Brayden, G., Eng. P., Barr, L. (2002).

[6] "Cowichan Basin Water Management Plan – Water Issues", October 2005. Westland Resource Group Inc.

Area, of which 2,200 ha are currently cultivated for agricultural or horticultural purposes in two of the three watersheds (there is no ALR in the Saanich Inlet watershed). Agricultural and horticultural land use in the Study Area represents 11 percent of the total land area.

BCAA Actual Land Use data provided the basis for mapping agricultural and horticultural land in the Study Area. The ALR boundaries, CVRD Zoning Bylaws, and Google Earth were used to verify parcel classification.

BCAA data identified parcels of land used for grain and forage, vegetables, tree fruits, small fruits, beef, diary, poultry, and 'other' types of agriculture and horticulture. These land use types were aggregated into the following three groups reflecting like water consumption rates:

- *Agricultural – livestock and poultry***,** including beef, dairy, and poultry agricultural uses;
- *Agricultural – forage and grains*, including forage, grain, and 'other' agricultural uses; and
- *Horticulture – berries, fruits, vegetables,* including vegetables, tree fruits, small fruits, grapes, and berries.

Tables 20 and 21 below identify the total area and distribution of agricultural and horticultural land in South Cowichan.

Table 20 Total Area of Agricultural and Horticultural Land, by Use and Watershed – 2008

Use Type	Total Area by Watershed (ha)			Total (ha)
	Shawnigan	Saanich Inlet	Cowichan	
Agriculture - Livestock and poultry	567	4	685	1,257
Agriculture - Forage and grains	137	2	558	697
Horticulture - Berries, fruits, vegetables	18	0	55	72
Total	**722**	**6**	**1,298**	**2,026**

Table 21 Distribution of Agricultural and Horticultural Land, by Use and Watershed - 2008

Use Type	Distribution of Use, by Type in Each Watershed (%)		
	Shawnigan	Saanich Inlet	Cowichan
Agriculture - Livestock and poultry	79	67	53
Agriculture - Forage and grains	19	33	43
Horticulture - Berries, fruits, vegetables	2	0	4
Total (%)	**100**	**100**	**100**

Water consumption rates for agriculture and horticulture were based on cubic metres per hectare per year requirements for irrigation, stock watering, and other farm use, and were determined using the findings of an agricultural survey and research undertaken during development of the Cowichan Basin Water Management Plan in 2005 (see Table 22 below).

Table 22 Water Consumption Rates for Agricultural and Horticultural Land Use

Use Type	Water Use by Type (m^3/ha/yr)
Agriculture - Livestock-poultry	7,700
Agriculture - Forage and grains	7,700
Horticulture - Berries, fruits, vegetables	5,600

The total volume of water used for agriculture and horticulture was estimated by multiplying the total area of each land use type by its corresponding annual water consumption rate. Table 23 below presents current annual water consumption estimates by agricultural and horticultural land use type and watershed.

Table 23 Water Consumption Estimates, by Land Use Type and Watershed - 2008

Use Type	Water Consumption by Watershed (m^3/yr)			Total (m^3/yr)
	Shawnigan	Saanich Inlet	Cowichan	
Agriculture - Livestock-poultry	4,369,000	32,000	5,275,000	9,675,000
Agriculture - Forage and grains	1,055,000	15,000	4,297,000	5,368,000
Horticulture - Berries, fruits, vegetables	98,000	0	306,000	404,000
Total (m^3/yr)	**5,522,000**	**47,000**	**9,878,000**	**15,447,000**

Table 24 below provides a summary of overall water consumption in each watershed based on the calculations in Tables 20 to 23.

Table 24 Present Water Consumption for all Land Use Types, by Watershed – 2008

Land Use Type	Water Use by Watershed (m^3/yr)			Total (m^3/yr)
	Shawnigan	Saanich Inlet	Cowichan	
Residential	3,845,000	821,000	2,690,000	7,356,000
Other urban land use types	1,639,000	451,000	1,279,000	3,369,000
Agriculture and horticulture	5,522,000	47,000	9,878,000	15,447,000
Total	**11,006,000**	**1,319,000**	**13,847,000**	**26,172,000**

4.3 Future Water Demand Forecasts

Forecasting regional population growth, and the resulting water demand, was undertaken to help identify likely spatial changes in water use. An understanding of the possible changes to development and density patterns and the way that people will use water in future is necessary to forecasting water use and helping to sustainably manage the South Cowichan area's water supply.

4.3.1 Residential Water Demand Forecasts

The first step in forecasting residential water demand in South Cowichan was to estimate the degree of change in population and the number of additional household units that may be established in the Study Area over the next 30 years. Section 4.2.2 outlines how population growth and household unit projections were determined.

BC STATS P.E.O.P.L.E 32 model projects a 28 percent growth in the total number of household units in CVRD from 7,500 in 2008 to 9,500 units in 2036. The P.E.O.P.L.E. model does not account for some of the major development projects presently being planned for the South Cowichan area. CVRD Planning staff identified key areas where growth will be directed in future (Proposed South Cowichan OCP and Zoning Bylaws) and provided details of proposed developments, such as Bamberton, that seek to accommodate a large proportion of the area's growing population on land that is not currently in residential use. The proposed Bamberton development would construct approximately 3,200 new household units in the Saanich Inlet watershed, much of which is currently zoned for forestry. Assuming that Bamberton and other major developments proceed during the next 30 years, the number of housing units in South Cowichan would grow from 7,477 today to 13,742 in 2036, an increase of 84%. The greatest proportional change would occur in the Saanich Inlet watershed, with an increase from 805 units to 4,864, a six-fold increase. In Shawnigan and Cowichan watersheds, the growth in units is 33%.

These disparities between housing forecasts based on P.E.O.P.L.E. model projections versus the planned development in South Cowichan could affect estimated population of the area, too. The P.E.O.P.L.E. model yields a projected 2036 population of 22,000. Using housing unit forecasts based on planned development potential, the 2036 population of the South Cowichan area could reach 32,000.

The types of housing built in South Cowichan in the future are unlikely to be the same today. Planners expect to see a shift to smaller units, and more attached housing types (townhouses and apartments). For example, the Bamberton development application states that approximately 1,046 housing units will be detached houses on urban lots, 1,072 will be attached, and 1,109 units will be detached houses on the equivalent of suburban lots.The distribution of housing type in each watershed in 2008 was adjusted to reflect potential changes in housing type (Table 25).

Table 25 presents household unit distribution estimates for 2036, assuming that the Bamberton development will be approved and completed as proposed by 2036, that current nodes in Shawnigan Lake Village, Mill Bay, and Cowichan Bay will see increased density, and that the relative proportion of housing built on rural residential lots will decrease and smaller suburban and urban lots will increase.

Table 25 Household Unit Distribution Estimates (Targeted Densification), by watershed – 2036

Watershed and Jurisdiction	Total Household Units 2036	Household Units by Type and Distribution - 2036 Targeted Densification							
		Attached	% of total	Urban	% of total	Suburban	% of total	Rural	% of total
Shawnigan	5,300	1,060	20	3,021	57	1,113	21	106	2
Saanich Inlet	4,864	1,796	37	1,545	32	1,449	30	74	2
Cowichan	3,578	465	13	2,612	73	286	8	215	6
Total in Study Area	**13,742**	**3,321**	**24**	**7,178**	**52**	**2,849**	**21**	**395**	**3**
Total in CVRD	**48,024**								

The Province's 'Living Water Smart' Water Plan sets a goal of achieving 33 percent more efficiency in water use by 2020. Assuming that the province is successful in achieving this reduction in the South Cowichan area, a 33 percent saving in water use by 2036 was used to form the basis of a second scenario for estimating residential water demand. Scenario Two includes the assumptions applied to Scenario One (Targeted Densification), and adds the 33 percent reduction in water use. Hence, Scenario Two is called "Targeted Densification and Water Efficiency."

Tables 26 and 27 below identify residential water demand estimates, by watershed and unit type, for the Targeted Densification and Water Efficiency scenarios. These estimates are based on the household unit counts shown in Table 25.

Table 26 Scenario One - Residential Water Demand Estimates, by Watershed and Unit Type – 2036 Targeted Densification

Watershed	Residential water use, 2036 Targeted Densification (m^3/yr)				Total (m^3/yr)
	Urban	Suburban	Rural	Attached	
Shawnigan	1,813,000	1,336,000	636,000	191,000	3,975,000
Saanich Inlet	927,000	1,739,000	447,000	323,000	3,437,000
Cowichan	1,567,000	344,000	1,288,000	84,000	3,283,000
Total in Study Area	**4,307,000**	**3,419,000**	**2,371,000**	**598,000**	**10,695,000**

Table 27 Scenario Two - Residential Water Demand Estimates, by Watershed and Unit Type – 2036 Targeted Densification and 33% Water Efficiency

Watershed	Residential water use, 2036 Water Efficiency (m^3/yr)				Total (m^3/yr)
	Urban	Suburban	Rural	Attached	
Shawnigan	1,209,000	891,000	424,000	127,000	2,651,000
Saanich Inlet	618,000	1,160,000	298,000	216,000	2,292,000
Cowichan	1,045,000	229,000	859,000	56,000	2,190,000
Total in Study Area	**2,872,000**	**2,280,000**	**1,581,000**	**399,000**	**7,133,000**

4.3.2 'Other' Urban Land Use Water Demand Forecasts

Other' land use includes commercial, playing fields, industrial, and institutional uses.

Water demand estimates for 'other' urban land use types were determined by increasing 2008 water use estimates by 25 percent inline with regional population growth projected by the P.E.O.P.L.E 32 model. This forecast assumes that growth will be uniform across all watersheds and that there will be no significant change in annual water consumption rates per hectare of land use type. Table 28 below displays year 2036 water demand estimates, by watershed and land use type.

Table 28 Water Demand Estimates, by Watershed and 'Other' Urban Land Use Type – 2036

Land Use Type	2036 Water Demand Estimates: Water Consumption Estimate by Watershed (m^3/yr)			Total (m^3/yr)
	Shawnigan	Saanich Inlet	Cowichan	
Commercial	160,000	98,000	100,000	358,000
Industrial	281,000	185,000	513,000	979,000
Institutional	1,289,000	233,000	153,000	1,675,000
Playing Fields	325,000	49,000	851,000	1,225,000
'Other' Land Use Total	**2,056,000**	**566,000**	**1,617,000**	**4,236,000**

Water demand forecasts for 2036 for 'other' urban land use types were also modelled on the assumption that the province will achieve the 33% water conservation goal set out in the 'Living Water Smart' Water Plan by 2036. Table 29 below presents water demand forecasts for commercial, industrial, institutional, and playing field land use in South Cowichan in 2036, assuming 33 percent water efficiency is achieved.

Table 29 Water Demand Forecast, by Watershed and 'Other' Land Use Type, with 33 Percent Water Efficiency Saving - 2036

Land Use Type	2036 Water Demand Estimates (33 % efficiency), by Watershed (m^3/yr)			Total (m^3/yr)
	Shawnigan	Saanich Inlet	Cowichan	
Commercial	107,000	65,000	67,000	239,000
Industrial	188,000	124,000	342,000	654,000
Institutional	860,000	156,000	102,000	1,118,000
Playing Fields	217,000	33,000	567,000	817,000
'Other' Land Use Total	**1,372,000**	**378,000**	**1,078,000**	**2,828,000**

4.3.3 Agricultural Land Use Water Demand Forecasts

Water demand forecasts were generated for three scenarios of agricultural and horticultural land use distribution and intensity in the Study Area.

The 25 percent population growth projected by the P.E.O.P.L.E 32 model for South Cowichan over the next three decades will likely place pressure on some areas of agricultural land, particularly that on the urban fringes, to convert to urban or suburban land use. It will also support the farming sector in terms of consuming more local produce, particularly if fuel prices continue to increase.

Scenario One assumes that the agriculture and horticulture sector will expand to accommodate demand for fruit, vegetables, diary products, and meat by a growing regional population. Water demand is forecast

for the proportional increase in irrigation, production, and stock drinking water requirements. It is assumed that expansion of the agricultural and horticultural sector will reflect the forecast regional population growth of 25 percent above 2008 values. Table 30 below displays water demand forecasts for Scenario One.

Table 30: Scenario One: Water Demand Forecast – 25% Growth with 'Status Quo' Distribution, by Watershed - 2036

Land Use Type	Total Area (ha) and Water Demand Forecast (m^3/ha/yr)						Total Water Demand (m^3/ha/yr)
	Shawnigan		Saanich Inlet		Cowichan		
	Total (ha)	(m^3/ha/yr)	Total (ha)	(m^3/ha/yr)	Total (ha)	(m^3/ha/yr)	
Agriculture - Livestock and Poultry	711	5,480,000	5	40,000	859	6,616,000	12,136,000
Agriculture - Forage and Grains	172	1,323,000	3	19,000	700	5,391,000	6,733,000
Horticulture - Berries, Fruit, Vegetables	23	123,000	0	0	69	384,000	507,000
Total	**906**	**6,926,000**	**8**	**59,000**	**1,628**	**12,391,000**	**19,376,000**

The Study Area encompasses approximately 18,200 ha of land, of which 18 percent (3,200 ha) is classified as Agricultural Land Reserve (ALR). BCAA 2008 Actual Land Use data show that 11 percent of the Study Area (2,200 ha) is currently cultivated for agricultural and horticultural use. Scenario Two forecasts water demand for agricultural and horticultural land use in 2036, assuming that by year 2036 all ALR will be under cultivation. This assumption represents the addition of 1,000 ha of cultivated land to the existing 2,200 ha currently under cultivation.

Scenario Two also attempts to adjust the distribution of agricultural and horticultural land use to better reflect current trends in the sector, particularly the trend towards conversion of dairy farms to other agricultural use, such as cropland. This change often results in greater annual hay production, rather than combined hay and silage production, and reduces year round livestock water requirements, reducing total water use (Haddow, pers. comm., 2008). Other trends include water conservation initiatives, and more efficient production technology. Climate change (in particular, the likelihood of an increased incidence and intensity of droughts), rising fuel prices, and other economic factors could see the cost of farming and demand for local produce both increase.

Scenario Two assumes that the trend towards converting dairy farms to other forms of agricultural use will continue and estimates water demand based on a 50 percent reduction in livestock farming, from 2008 levels. It is assumed that the area of land in forage, grain, and horticulture will continue to grow as regional growth and demand for local produce increases. Other assumptions made in calculating water demand forecasts for Scenario Two include:

- Future water consumption rates for specified agricultural activities (cubic meters per hectare per year) will remain the same as 2008 values;
- The ratio of agricultural forage and grain cropland to horticultural land remains the same as current levels; and

- There is no growth of agricultural and horticultural land use in the Saanich Inlet watershed, where there is currently no ALR land.

Table 31 below displays water demand forecasts for the agricultural sector in terms of the assumptions made in Scenario Two.

Table 31: Scenario Two: Water Demand Forecast – 25% Growth in Horticulture and Forage and Grain Cultivation and 50% reduction in Cultivation for Livestock, by Watershed - 2036

Land Use Type	Total Area (ha) and Water Demand Forecast (m^3/ha/yr)						Total Water Demand (m^3/ha/yr)
	Shawnigan		Saanich Inlet		Cowichan		
	Total (ha)	(m^3/ha/yr)	Total (ha)	(m^3/ha/yr)	Total (ha)	(m^3/ha/yr)	
Agricultural - Livestock and Poultry	284	2,185,000	2	16,000	343	2,637,000	4,838,000
Agricultural - Forage and Grains	689	5,309,000	4	31,000	1,686	12,983,000	18,323,000
Horticultural - Berries, Fruit, Vegetables	73	406,000	0	0	157	879,000	1,285,000
Total	**1,046**	**7,900,000**	**6**	**47,000**	**2,186**	**16,499,000**	**24,446,000**

Scenario Three assumes the same parameters as Scenario Two, except that a 33 percent water efficiency factor is applied (as per British Columbia's 'Living Water Smart' Water Plan target efficiency by 2020). Scenario Three assumes that the efficiency target is achieved by 2036 and applies a blanket 33 percent saving across each of the three agricultural and horticultural land use types (see Table 32 below).

Table 32: Scenario Three: Water Demand Forecast – 33% Water Efficiency, by Watershed - 2036

Land Use Type	Total Area (ha) and Water Consumption Forecast (m^3/ha/yr)						Total Water Demand (m^3/ha/yr)
	Shawnigan		Saanich Inlet		Cowichan		
	Total (ha)	(m^3/ha/yr)	Total (ha)	(m^3/ha/yr)	Total (ha)	(m^3/ha/yr)	
Agricultural - Livestock and Poultry	284	1,456,000	2	11,000	343	1,758,000	3,225,000
Agricultural - Forage and Grains	689	3,539,000	4	21,000	1,686	8,656,000	12,216,000
Horticultural - Berries, Fruit, Vegetables	73	271,000	0	0	157	586,000	857,000
Total	**1,046**	**5,266,000**	**6**	**32,000**	**2,186**	**11,000,000**	**16,298,000**

Sections 4.4.1 – 4.4.3 present the methodology applied in forecasting water demand in 2036 in Shawnigan, Saanich Inlet, and Cowichan watersheds, and present water demand estimates for each land use type. Table 33 below provides a summary of total water demand estimates for all land use types in each watershed, based on the scenario results in Tables 27 to 34.

Table 33: South Cowichan Water Demand Estimates, by Land Use and Watershed – 2008 and 2036

Land Use Type and Watershed	Water Consumption Estimates (m^3/yr)		
	2008 Estimate	**2036 Densification**	**2036 Densification and conservation**
Residential Use			
Shawnigan	3,845,000	3,975,000	2,651,000
Saanich Inlet	821,000	3,436,000	2,292,000
Cowichan	2,690,000	3,283,000	2,190,000
Residential Use Total	7,356,000	10,694,000	7,133,000
Other Land Use			
Shawnigan	1,639,000	2,055,000	1,370,000
Saanich Inlet	451,000	565,000	377,000
Cowichan	1,279,000	1,616,000	1,078,000
Other Land Use Total	3,369,000	4,236,000	2,825,000
Agriculture - horticulture			
Shawnigan	5,522,000	6,927,000	5,266,000
Saanich Inlet	47,000	59,000	31,000
Cowichan	9,878,000	12,390,000	11,000,000
Agriculture - horticulture Total	15,447,000	19,376,000	16,297,000
Total	**26,172,000**	**34,306,000**	**26,255,000**

4.4 Ecological Protection

Maintaining ecological health in South Cowichan requires balancing the water quantity and quality needs of humans, wildlife, vegetation, and fisheries. With a finite water supply, a growing population, and changing climate, achieving sustainable management will be a complex task. Water management issues related to maintaining ecological health are described below.

- Lower Shawnigan Creek provides habitat for Coho salmon and Cutthroat trout. Fish need constant, clean, low temperature flows in rivers and creeks to support a healthy spawning and rearing habitat. Annual summer low flow in Lower Shawnigan Creek often results in increased water temperatures and exposed gravel beds, which adversely affects fish habitat and health;
- Summer low flows in Lower Shawnigan Creek are due in part to having insufficient lake storage to support both domestic use and downstream needs in summer. Care is required to ensure that a balance between accumulating sufficient storage for domestic use while maintaining sufficient flow for aquatic system health is achieved;
- Shawnigan Lake supports populations of native Kokanee salmon, Rainbow and Cutthroat trout, and Smallmouth bass. Fish stocks in the lake may be adversely affected if water quantity or quality in the lake declines;

- Riparian vegetation along lake margins and river and stream corridors is important in maintaining water quality and providing shade to cool water and protect fish habitat. As the population of South Cowichan grows, urban development will place more pressure on riparian vegetation and the habitats it supports;
- Harmful fecal coliform bacteria are present in surface runoff from Mill Bay Village to Saanich Inlet in high concentrations during and after rainfall events, and have prompted the closure of 12 of the 15 shellfish beaches in the Inlet;
- Metals and polycyclic aromatic hydrocarbons (PAHs) have been detected in Lower Shawnigan Creek. These, and other chemical contaminants, are detrimental to aquatic system health;
- Increased motorboat use on Shawnigan Lake has the potential to adversely affect lake water quality by introducing higher levels of hydrocarbons and other chemicals into the water. Adverse effects to water quality by recreational users could have a negative impact on aquatic system health and fish stocks; and
- Wastewater services in South Cowichan are limited, which means that most lakeshore residents rely on septic tanks to dispose of effluent. A study of water quality in Shawnigan Lake in 2004 found that coliform concentrations in the lake are considerably higher than inflow concentrations, suggesting that bacterial contamination is reaching the lake through other pathways, such as infiltrating water exposed to septic systems and tile fields (MOE website). Poor lake water quality has the potential to adversely affect aquatic habitats and will have a direct impact on domestic water supply.

4.5 Water Metering and Pricing

Water pricing in South Cowichan varies among service areas. In some cases a flat rate is charged for annual water use regardless of consumption rates. In other cases a 'sliding scale' is applied to water use. The latter often sets a base fee for consumption up to a certain level, with additional use charged at a higher rate. Billing rates for service areas administered by the CVRD are described in Table 34 below.

Table 34: CVRD Water Pricing in South Cowichan

Service Area	Rate System	Pricing Method
Shawnigan (Shawnigan watershed)	Flat	Traditionally $72 every six months. In July 2008 (including billing period July-December 2008) prices increased to $99 semi-annually (every six months).
Kerry Village Water (Saanich Inlet watershed)	Flat	$170 semi-annually
Satellite Park Water (Cowichan watershed)	Metered on sliding scale	$120 semi-annually
Fern Ridge Water (Saanich Inlet watershed)	Sliding scale	$157.50 semi-annually for up to 250m^3 consumption, thereafter sliding scale is applied
Lambourn Water	Flat	$157.50 semi-annually

5. WATER SUPPLY AND MANAGEMENT

5.1 Groundwater Budget

A groundwater budget is required to assess current and future water consumption against groundwater availability. A first-cut groundwater budget for the entire Study Area is developed. This budget is based on estimated groundwater recharge rates and the areal extent of mapped aquifers.

5.1.1 Recharge Rates

The groundwater budget calculations require information on groundwater recharge rates. The paragraphs below describe the sources of information used.

For the surficial aquifers, the best estimate recharge rate of 300 mm/yr was based on the EBA (1996) study, while the upper limit rate was based on Lowen (1994a), which is perceived to be representative of unconfined aquifer conditions (Section 2.4.3). The lower limit rate was based on professional judgement and may be reflective of areas where thicker confining units exist than at the Cherry Point aquifer (location of the EBA study).

Recharge to bedrock aquifers was estimated at 102 to 533 mm/yr for the nearby Gulf Islands (Denny et al., 2007) and these ranges have been used in the groundwater balance calculation. Generally, groundwater infiltration to bedrock aquifers is expected to be lower than to surficial aquifers due to the lower permeability of the rock matrix. An exception may be areas where bedrock fractures or faults are exposed at or near surface. Such areas could act as preferential recharge zones.

5.1.2 Water Balance Calculations

The groundwater budget should ideally seek to quantify the following components on an aquifer-by-aquifer basis:

- Recharge: natural (from precipitation) and artificial (irrigation; disposal systems);
- Groundwater utilization (water extraction);
- Seepage from or groundwater discharge (base flow) to streams, lakes and wetlands;
- Groundwater discharge to the marine environment (bedrock aquifers);
- Recharge from or discharge to adjacent or overlying or underlying aquifer (aquifer interconnectedness); and
- Changes in groundwater storage.

A numerical groundwater model is required to calculate all of these components on an aquifer by aquifer basis. However, this is outside the current scope of work. At present, the groundwater budget calculations are limited to an evaluation of annual groundwater inflows for the Study Area as a whole, based on total

surface area of the aquifers and estimated groundwater recharge rates. These calculations are presented in Table 35 and a narrative description of the groundwater balance components is provided below.

Recharge from Natural and Artificial Sources

The water budget calculations (Table 35 below) indicate that total annual groundwater inflows from natural recharge may range between about 25 million m^3 (lower limit estimate) and 110 million m^3 (upper limit), with a best estimate of about 45 million m^3. Considerable uncertainty therefore exists in natural recharge rates and the volume of the groundwater resource. It is expected that some of this uncertainty can be removed through the proposed groundwater model development.

Artificial recharge may include return flows from irrigation and domestic water use. Agricultural water use in the South Cowichan is substantial but a portion of this water use (less soil evaporation and plant uptake) will end up as groundwater recharge. Most sewage treatment in the region consists of ground disposal fields. A large portion of this consumed water will also eventually end up a groundwater recharge, particularly in the case of the Mill Bay area, where wastewater management systems are making increasingly greater use of rapid infiltration basins.

Table 35 Estimated annual inflows from natural recharge to surficial and bedrock aquifers

Aquifer		**Surficial**	**Bedrock**	
Surface Area (km^2)		50	150	
	Best Estimate	300	200	
	Lower Limit	195	102	
Recharge Rate (mm/yr)	Upper Limit	585	533	**Total**
	Best Estimate	15,000,000	30,000,000	45,000,000
	Lower Limit	9,750,000	15,300,000	25,050,000
Annual Inflow to Aquifers (m^3)	Upper Limit	29,250,000	79,950,000	109,200,000

Notes
Surface areas based on Table 5. Bedrock aquifer surface area excludes area where surficial aquifers are present
Recharge rates are based on annual precipitation of 1300 mm for Shawnigan Lake station (Table 1)

Groundwater Utilization

Estimates of total current water consumption within the Study Area are about 10.7 million m^3 for residential and other urban consumption, and about 15.4 million m^3 for agricultural uses for a total of about 26 million m^3. While precise data are lacking, it is estimated from the information review that about half (50 %) of this total water usage originates from a groundwater source. Based on the best estimate value for total natural groundwater inflows (45 million m^3), this would suggest that for the Study Area as a whole about 30% of annual groundwater inflows may be allocated for water consumption, with the remainder being available for other uses (e.g., ecological receptors). Taking uncertainty in natural groundwater inflows into account, this allocation level could be substantially higher or lower. As indicated in the above, a portion of irrigation and domestic water use is expected to end up as groundwater return flow (artificial recharge). This is likely not the case for urban water and sewage treatment systems.

Streams, Lakes and the Marine Environment

Based on the estimated level of groundwater utilization about 70% of natural groundwater inflows (i.e., approximately 32 Mm^3 per year) may presently be available for discharge to streams, lakes, wetlands and the marine environment. Taking uncertainty in natural groundwater inflows into account (Table 35), this volume could be substantially higher or lower. Furthermore, the relative allocation of discharge volumes to each of these receptors is presently unclear. This uncertainty can to a large extent be removed through the proposed groundwater model development. Qualitatively, it is expected that bedrock aquifers 204 (Cobble Hill), 207 (Bamberton) and 208 (Malahat) predominantly interact with the marine environment while the remaining aquifers predominantly interact with freshwater environments.

Aquifer Interconnectedness

Aquifer interconnectedness does not lead to a net increase or decrease in the overall groundwater supply but may affect water supply volumes in individual aquifers. For example, the bedrock aquifers that are overlain by substantial Vashon Drift deposits (Figure 5) depend on groundwater inflows from surficial aquifers as a source of recharge. Quantification of aquifer interconnectedness is premature given that the conceptual hydrostratigraphic model development is in the early stages and information on groundwater flow directions and rates is lacking due to limitations of the WELLS database. A groundwater model is needed to quantify aquifer interconnectedness.

Aquifer interconnectedness is described qualitatively in Table 36 below and is illustrated graphically in Figure 6. The table reveals the complex relationship between individual aquifers in the Study Area with only the Malahat bedrock aquifer (208) not in connection with any other mapped groundwater system.

Table 36 Summary of aquifer interconnectedness

Tag	Name	197	199	201	205	206	196	198	200	202	203	204	207	208
197	Cherry Point		X				X	X		X		X		
199		X					X	X		X				
201	Kingburne									X				
205	Carlton											X	X	
206	Mill Bay											X	X	
196	South Cowichan	X	X					X	X					
198	Cowichan Station	X	X				X							
200	Kelvin Creek						X			X				
202	North Shawnigan	X	X	X					X		X	X	X	
203	Shawnigan Lake									X			X	
204	Cobble Hill	X			X	X				X			X	
207	Bamberton				X	X				X	X	X		
208	Malahat													

Note: “x” indicates aquifer connection

Changes in Groundwater Storage

In the above assessments, it has been assumed that for the Study Area, as a whole, changes in groundwater storage are presently small compared to inflows from groundwater recharge. It is possible that in some portions of the South Cowichan groundwater extraction exceeds groundwater inflows, which could result in declining water levels (groundwater being removed from aquifer storage), as for example observed in the Cherry Point aquifer. Groundwater levels could also fluctuate in response to inter-annual variations in recharge (precipitation). Clearly, the groundwater budget needs to be analysed further to better understand the level of allocation of individual aquifers and to identify target areas were groundwater utilization could possibly be increased to meet anticipated increases in water demand. More detailed withdrawal data are also necessary to allow a better understanding of potential demand versus supply issues.

Climate Change

The potential effects of climate change on groundwater recharge have not yet been incorporated in this evaluation. Natural groundwater recharge from precipitation is expected to predominantly occur during the months that there is a surface water surplus (December through March). Under climate change, this surface water surplus is projected to increase. Hence, groundwater recharge will likely also increase,

leading to a possible positive impact on water supplies. However, the degree to which this will occur is dependent on geologic constraints (e.g., low permeability tills or massive bedrock might locally limit groundwater infiltration). Such interactions can be assessed by including climate change scenarios in the groundwater recharge modelling. The overburden groundwater systems in the Study Area are clearly sensitive to climate variability as evidenced by the well hydrographs for the Cherry Point aquifer (Figure 8), with relatively wet years leading to increased recharge and higher water levels and vice versa. Climate change may negatively affect groundwater resources through increased evaporation in areas where shallow water table conditions exist.

5.1.3 Recommendations for Groundwater Resource Evaluation

Considerable emphasis was put on the groundwater resource evaluation in this study. Nonetheless, this study revealed the complexity of the regional groundwater aquifers (a function of the complex geology of the Study Area), the lack of quantitative information regarding these aquifers, as well as sparseness of this data. As such, despite the effort put towards compiling data on aquifer systems in the Study Area, understanding of the groundwater resource remains conceptual and largely qualitative in nature. These findings reveals the need for a stand-alone groundwater study, culminating in the development of a model, which would consolidate available geologic and groundwater data for the Study Area and address current knowledge gaps.

The preferred numerical modelling code would be either MODFLOW (McDonald and Harbaugh 1988), MODFLOW-SURFACT or FEFLOW (Diersch, 2005). The United States Geological Survey (USGS) 3-dimensional groundwater flow code MODFLOW is widely accepted in the professional community and by regulators, and is well documented. The FEFLOW® (Finite Element subsurface FLOW) code is accepted in the professional community as a model of choice to solve complex hydrogeologic problems that cannot be handled by MODFLOW (such as fracture flow or variably saturated flow, i.e. groundwater flow above the water table). MODFLOW-SURFACT is a proprietary code adapted from the USGS MODFLOW model that can also handle fracture flow and variably saturated flow.

The steps for groundwater model development are outlined below:

a) Development of regional geologic cross-sections. Interpretation of these cross-sections should lead to a conceptual hydrostratigraphic model of the Study Area;

b) Compilation of information on well yields, aquifer transmissivity and hydraulic conductivity from the WELLS database (or the SFU version of this database) and the joint venture between the Geological Survey of Canada (GSC) and the MOE, conducted at SFU under the leadership of Dr. Dianna Allen;

c) Querying of the WELLS database (or the SFU version of this database) for static water levels. Where possible these static water levels should be supplemented with data from recent groundwater development projects in the area (i.e., improvement districts etc);

d) Development of a three-dimensional (3D) groundwater model encompassing the mapped aquifers in the Study Area and any upgradient recharge areas. The vertical layers in the 3D model should

be consistent with the geologic stratification identified under item A. Model parameterization (hydraulic conductivity distribution) should take into account the surficial and bedrock geology of the Study Area, mapped aquifers, and the conceptual hydrostratigraphic model (item A). Initial hydraulic conductivity values should be based on the compilation of information conducted under item B. Depending on budget constraints, appropriate recharge values for representative land classes could be based on stand-alone modelling) or through model calibration. The latter approach should take into account values quoted in Section 5.1.1 and any other pertinent studies in the area. Streams and lakes should be represented in the model as boundary conditions to assess groundwater-surface water interactions. T he model should also represent groundwater diversion from major water users (improvement districts etc.); and

e) Model calibration to static water levels from item C by adjusting select hydraulic conductivity and recharge values. The model calibration should be supported by sensitivity analyses, and presentation of final calibration results should include detailed statistics (tabular format), graphic representation of observed versus simulated groundwater levels and maps of calibration residuals (spatial analysis). Model calibration could also include pumping test data from recent groundwater development projects in the area, should such data be available.

Once developed the groundwater model could be used for determining groundwater budgets on an aquifer-by-aquifer basis, to assess natural versus anthropogenic pressures on groundwater flows, for aquifer and well vulnerability studies, and for long-term water supply planning. Groundwater budgets could possibly also be used to generate planning densities (i.e. by preferentially locating population in designated areas linked to high-yielding portions of aquifers), although planning at this level of detail would likely require much more comprehensive, quantitative and site-specific hydrogeologic information than is presently available.

For long-term water management planning purposes, future work might include integrated modelling of groundwater and surface water systems using, for example, MIKE-BASIN or MIKE-SHE (Abbott et al., 1986, Refsgaard and Storm, 1995), or by coupling FEFLOW to the MIKE model. An advantage of integrated hydrologic modelling is a rigorous treatment of groundwater-surface water interactions including anthropogenic pressures (groundwater and surface water use, irrigation) and natural pressures (climate variability and change) by simulating the entire land based component of the hydrologic cycle in a single model. However, integrated modelling of groundwater and surface water systems is a complex undertaking and not recommended at this time.

5.2 Surface Water Budgets

5.2.1 Methodology

To estimate current and future volumes of surface water in the South Cowichan Valley, a monthly water balance model was developed. This model was based on precipitation, an estimate of unit area runoff, lake evaporation, surface water abstractions and climate change scenarios.

Precipitation

Precipitation data from Environment Canada's Shawnigan Lake climate station was used for the model since this is the only station in the Study Area that meets the World Meteorological Organization's standards for precipitation.

Unit Area Runoff

Unit area runoff (L/s/km^2) was calculated based on monthly mean discharge data obtained from the Water Survey of Canada for Shawnigan Lake (see Table 37 below). This monthly average unit area runoff was then applied to each watershed in order to determine the average monthly inflow / runoff in each watershed. The runoff values account for groundwater recharge and evapotranspiration losses.

Table 37 - Current Monthly Average Unit Area Runoff Rates

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Monthly Average Unit area runoff (L/s/km^2)	46.1	47.7	47.4	26.2	10.4	6.7	4.3	3.2	2.0	1.7	22.4	57.0

Lake Evaporation

Monthly lake evaporation data was obtained from Environment Canada's Saanichton CDA climate station and multiplied by the total surface area of lakes within each watershed in order to determine the volume of lake evaporation loss within each watershed.

Surface Water Use Licences

Surface water use licences were obtained from the MOE. Water consumption patterns were adjusted temporally in order to account for an increased residential and agricultural usage between June 1 to October 1. Over this time period, water consumption increases because residents water their lawns, farmers irrigate their crops, and tourists arrive into the area. To calculate the water balance, it was estimated that residential consumption increased by 30% between June 1 to October 1 and that water supplied to for crop irrigation only occurs during this time period. All other types of water usage were distributed evenly over the year. Surface water licensed withdrawal for regional growth estimates were based on assuming all of the pending licenses with the Ministry of Environment would be approved. Beyond using the pending license estimate, it is difficult to forecast growth in regional surface water licences.

Climate Change

The British Columbia Ministry of Environment's climate models (MOE, 2008) predict the following important changes to climate to occur by the year 2050:

- Average temperature will have increased 2.0 – 3.0°C.
- Increasing frequency of 24-hr precipitation events greater than 80mm.
- 20% increase in precipitation.
- Summers will be hotter and drier and the winters will be wetter.

Table 38 below presents the assumed impacts of climate change on precipitation and evapotranspiration in the South Cowichan Valley.

Table 38 - Forecasted Climate Change for Precipitation and Evapotranspiration Values (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Current Precipitation (mm)	198.3	155.3	120.2	65.2	48.7	40.2	24.7	29.3	37.6	104.8	214.6	208.7	1248
% Change	135	135	130	120	110	75	70	60	60	75	135	135	
Predicted Precipitation (mm)	267.7	209.7	156.3	78.2	53.6	30.2	17.3	17.6	22.6	78.6	289.7	281.7	1503.1
Current Evapotranspiration (mm)	12.0	18.0	28.0	46.0	72.0	62.0	27.0	28.0	39.0	40.0	22.0	15.0	409
% Change (1)	120	120	120	120	120	120	120	120	120	120	120	120	
Predicted Evapotranspiration (mm)	14.4	21.6	33.6	55.2	86.4	74.4	32.4	33.6	46.8	48.0	26.4	18.0	490.8

Notes:

(1) - Based on predicted increases in temperature, evapotranspiration values were increased by 20%.

Future unit area runoff values were recalculated[7] using the predicted climate change impact on precipitation and evapotranspiration (see Table 39 below) and based on the assumption that runoff coefficients would not be significantly different from present day values. Table 39 below presents the revised values used in the water balance models future scenarios.

[7] Note that the method used to estimate future unit area runoff values differs slightly from the method presented in earlier drafts of this study. The predicted effects of changes in evapotranspiration were not included in the unit area runoff, rather the predicted change in evapotranspiration was included in the future water balance scenarios as a line item. Also the method presented in the draft report limited the maximum evapotranspiration to 115% of the monthly rainfall. This method erroneously added water back into the balance during some summer months. The revised method of estimating future unit area runoff limited the monthly evapotranspiration to the volume of available water during that month. During summer/early fall months were predicted evapotranspiration exceeded the available water the unit area runoff was zero.

Table 39 - Predicted Future Monthly Average Unit Area Runoff Rates

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Monthly Average Unit area runoff ($L/s/km^2$)	62.9	65.5	62.6	31.5	8.8	0.0	0.0	0.0	0.0	0.0	31.5	77.8

5.2.2 Water Balances

Table 40 below shows the current monthly and yearly water balance for each of the watersheds in the South Cowichan. Table 41 below shows the monthly and yearly water balance in 2036 based on regional growth and climate change. Table 42 below shows the monthly and yearly water balance in 2036 based on regional growth, climate change, and 33% water efficiency goals set by British Columbia's 'Living Water Smart' water plan. Figure 16 presents the monthly surface water balances for all three scenarios.

Table 40 - Current Water Balance

Component	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
A. Shawnigan Watershed (1000 m^3)													
Surface Water Supply													
Runoff / Inflow	14,000	13,000	14,300	7,690	3,160	1,960	1,300	968	597	501	6,560	17,300	81,300
Lake Evaporation	0	0	0	329	476	542	629	544	345	187	132	0	3,180
Surface Water Supply Balance	14,000	13,000	14,300	7,360	2,680	1,420	666	425	252	314	6,430	17,300	78,100
Surface Water Licenses													
Crop Irrigation	0	0	0	0	0	77	77	77	77	0	0	0	309
All Other Usage	562	562	562	562	562	730	730	730	730	562	562	562	7,410
Surface Water Demand Balance	562	562	562	562	562	807	807	807	807	562	562	562	7,720
Monthly Net Balance	**13,400**	**12,500**	**13,800**	**6,800**	**2,120**	**610**	**-140**	**-380**	**-560**	**-250**	**5,870**	**16,700**	**70,400**
B. Saanich Inlet Watershed (1000 m^3)													
Surface Water Supply													
Runoff / Inflow	7,640	7,140	7,850	4,210	1,730	1,070	709	530	327	274	3,590	9,440	44,500
Lake Evaporation	0	0	0	17	24	28	32	28	18	10	7	0	163
Surface Water Supply Balance	7,640	7,140	7,850	4,190	1,700	1,050	677	502	309	264	3,580	9,440	44,300
Surface Water Licenses													
Crop Irrigation	0	0	0	0	0	19	19	19	19	0	0	0	75
Other Land Usage	190	190	190	190	190	247	247	247	247	190	190	190	2,510
Surface Water Demand Balance	190	190	190	190	190	266	266	266	266	190	190	190	2,590
Monthly Net Balance	**7,440**	**6,950**	**7,660**	**4,000**	**1,510**	**779**	**410**	**236**	**43**	**74**	**3,390**	**9,250**	**41,800**

Component	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
C. Cowichan Watershed (1000 m^3)													
Surface Water Supply													
Runoff / Inflow	4,150	3,880	4,270	2,280	936	581	383	286	176	148	1,950	5,130	24,200
Lake Evaporation	0	0	0	0	0	0	0	0	0	0	0	0	0
Surface Water Supply Balance	4,150	3,880	4,270	2,280	936	581	383	286	176	148	1,950	5,130	24,163
Surface Water Licenses													
Crop Irrigation	0	0	0	0	0	178	178	178	178	0	0	0	710
All Other Usage	20	20	20	20	20	26	26	26	26	20	20	20	264
Surface Water Demand Balance	20	20	20	20	20	204	204	204	204	20	20	20	974
Monthly Net Balance	**4,130**	**3,860**	**4,250**	**2,260**	**916**	**377**	**179**	**82**	**-27**	**128**	**1,930**	**5,110**	**23,200**
South Cowichan Valley Monthly Net Balance	**25,000**	**23,300**	**25,700**	**13,100**	**4,550**	**1,770**	**449**	**-64**	**-540**	**-45**	**11,200**	**31,100**	**135,000**

Table 41 - Climate Change Water Balance with Regional Growth (2036)

Component	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
A. Shawnigan Watershed (1000 m^3)													
Surface Water Supply													
Runoff / Inflow	19,000	17,900	19,000	9,230	2,660	0	0	0	0	0	9,230	23,500	101,000
Lake Evaporation	0	0	0	395	571	651	754	652	414	224	158	0	3,820
Surface Water Supply Balance	19,000	16,200	19,000	8,530	2,270	-650	-750	-650	-410	-220	9,050	23,500	94,900
Surface Water Licenses													
Crop Irrigation	0	0	0	0	0	97	97	97	97	0	0	0	388
All Other Usage	656	656	656	656	656	853	853	853	853	656	656	656	8,660
Surface Water Demand Balance	656	656	656	656	656	950	950	950	950	656	656	656	9,040
Monthly Net Balance	**18,400**	**17,300**	**18,300**	**8,170**	**1,430**	**-1,600**	**-1,700**	**-1,600**	**-1,400**	**-880**	**8,410**	**22,900**	**87,700**
B. Saanich Inlet Watershed (1000 m^3)													
Surface Water Supply													
Runoff / Inflow	10,400	9,800	10,400	5,050	1,450	0	0	0	0	0	5,050	12,900	55,000
Lake Evaporation	0	0	0	20	29	33	39	33	21	12	8	0	195
Surface Water Supply Balance	10,400	8,850	10,400	4,870	1,520	-33	-39	-33	-21	-11	5,030	12,900	53,800
Surface Water Licenses													
Crop Irrigation	0	0	0	0	0	24	24	24	24	0	0	0	95
All Other Usage	590	590	590	590	590	767	767	767	767	590	590	590	7,790
Surface Water Demand Balance	590	590	590	590	590	790	790	790	790	590	590	590	7,880
Monthly Net Balance	**9,830**	**9,210**	**9,790**	**4,440**	**835**	**-820**	**-830**	**-820**	**-810**	**-600**	**4,450**	**12,300**	**47,000**

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Component	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
C. Cowichan Watershed (1000 m^3)													
Surface Water Supply													
Runoff / Inflow	5,660	5,320	5,640	2,740	790	0	0	0	0	0	2,740	7,000	29,900
Lake Evaporation	0	0	0	1	2	2	3	2	2	1	1	0	14
Surface Water Supply Balance	5,660	4,810	5,640	2,650	842	-2	-3	-2	-2	-1	2,740	7,000	29,300
Surface Water Licenses													
Crop Irrigation	0	0	0	0	0	223	223	223	223	0	0	0	892
All Other Usage	25	25	25	25	25	32	32	32	32	25	25	25	329
Surface Water Demand Balance	25	25	25	25	25	255	255	255	255	25	25	25	1,220
Monthly Net Balance	**5,640**	**5,300**	**5,610**	**2,720**	**763**	**-260**	**-260**	**-260**	**-260**	**-26**	**2,720**	**6,980**	**28,700**
South Cowichan Valley Monthly Net Balance	**33,800**	**31,800**	**33,700**	**15,300**	**3,030**	**-2,700**	**-2,800**	**-2,700**	**-2,400**	**-1,500**	**15,600**	**42,200**	**163,000**

Table 42 - Climate Change Water Balance with Regional Growth & Water Efficiency (2036)

Component	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
A. Shawnigan Watershed (1000 m^3)													
Surface Water Supply													
Runoff / Inflow	19,000	17,900	19,000	9,230	2,660	0	0	0	0	0	9,230	23,500	101,000
Lake Evaporation	0	0	0	395	571	651	754	652	414	224	158	0	3,820
Surface Water Supply Balance	19,000	16,200	19,000	8,530	2,270	-650	-750	-650	-410	-220	9,050	23,500	94,900
Surface Water Licenses													
Crop Irrigation	0	0	0	0	0	65	65	65	65	0	0	0	259
All Other Usage	437	437	437	437	437	568	568	568	568	437	437	437	5,770
Surface Water Demand Balance	437	437	437	437	437	633	633	633	633	437	437	437	6,030
Monthly Net Balance	**18,600**	**17,500**	**18,500**	**8,390**	**1,650**	**-1,300**	**-1,400**	**-1,300**	**-1,000**	**-660**	**8,630**	**23,100**	**90,700**
B. Saanich Inlet Watershed (1000 m^3)													
Surface Water Supply													
Runoff / Inflow	10,400	9,800	10,400	5,050	1,450	0	0	0	0	0	5,050	12,900	55,000
Lake Evaporation	0	0	0	20	29	33	39	33	21	12	8	0	195
Surface Water Supply Balance	10,400	8,850	10,400	4,870	1,520	-33	-39	-33	-21	-11	5,030	12,900	53,800
Surface Water Licenses													
Crop Irrigation	0	0	0	0	0	16	16	16	16	0	0	0	63
All Other Usage	393	393	393	393	393	511	511	511	511	393	393	393	5,190
Surface Water Demand Balance	393	393	393	393	393	527	527	527	527	393	393	393	5,250
Monthly Net Balance	**10,000**	**9,410**	**9,990**	**4,640**	**1,030**	**-560**	**-570**	**-560**	**-550**	**-400**	**4,650**	**12,500**	**49,600**

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Component	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
C. Cowichan Watershed (1000 m^3)													
Surface Water Supply													
Runoff / Inflow	5,660	5,320	5,640	2,740	790	0	0	0	0	0	2,740	7,000	29,900
Lake Evaporation	0	0	0	1	2	2	3	2	2	1	1	0	14
Surface Water Supply Balance	5,660	4,810	5,640	2,650	842	-2	-3	-2	-2	-1	2,740	7,000	29,300
Surface Water Licenses													
Crop Irrigation	0	0	0	0	0	149	149	149	149	0	0	0	594
All Other Usage	17	17	17	17	17	22	22	22	22	17	17	17	219
Surface Water Demand Balance	17	17	17	17	17	170	170	170	170	17	17	17	814
Monthly Net Balance	**5,640**	**5,310**	**5,620**	**2,720**	**771**	**-170**	**-170**	**-170**	**-170**	**-17**	**2,730**	**6,980**	**29,100**
South Cowichan Valley Monthly Net Balance	**34,300**	**32,200**	**34,100**	**15,800**	**3,450**	**-2,000**	**-2,100**	**-2,000**	**-1,800**	**-1,100**	**16,000**	**42,600**	**169,000**

The results of the water balance modelling for all three scenarios shows a significant excess of surface water during the winter months (December through March) and an overall net surplus of surface water for the year. However, for all scenarios the monthly net surface water balances decreases to a slight deficit during the late summer months and early fall. This does not necessarily indicate that creeks and rivers are dry during the summer months, rather that dry weather flows are maintained by release of water stored in lakes and groundwater base flows.

The present day water balance shows an annual net surplus of approximately 135 Mm^3, and between August and October there is a slight surface water budget deficit. The 2036 water balance shows that despite the predicted overall increase in annual precipitation and increase in annual net surplus of approximately 163 Mm^3, the duration of the net surface water deficit during the summer/fall increases to five months (June through October) starting a couple of months early in the year than the present day scenario. This is the result of the predicted reduced precipitation during the summer and the increase in temperature that produces higher lake evaporation and evapotranspiration, and the increase in water demand. When the 33% water efficiency goals are included the 2036 annual net surplus increases to 169 Mm^3, a 4% increase, but there is only a slight increase in the monthly water balance during the summer months and is in deficit June through October. If water supply requirements are to be satisfied throughout the year then additional measures beyond the 33% water efficiency goals will be required.

One option to maintaining surface water supplies during the summer months would be to store excess water during the winter months, either through artificially increasing recharge or utilizing surface storage, and using this water during the summer months. An assessment of the impact of water withdrawals on downstream aquatic and riparian habitat should be completed prior to determining additional storage requirements.

It is important to note that a year with average monthly rainfall, temperature and water use was modelled for the water balance calculations and that for drier years the duration and magnitude of the net surface water deficit would increase; conversely for wetter years these would likely decrease.

5.2.3 Recommendations for Surface Water Resource Evaluation

The surface water balance model results presented above are based on limited available data for the Study Area. Detailed, spatially explicit hydrological modelling that accounts for areas of lower or higher water use and demand within each watershed, and that accounts for watershed processes such as evapotranspiration in a more physically-based manner, was not undertaken due to the limited scope of this project, and no optimization of the use of surface water was conducted for this study. A detailed surface water resource evaluation would provide a basin wide representation of water availability, water demands, multi-use lake requirements, and environmental constraints including low flow requirements and water quality. It is recommended that such a study be undertaken as part of developing a long-term water management strategy for the South Cowichan.

Prior to development of a surface water model, additional data sets are required including local climate (precipitation, evaporation, and temperature), stream flow, lake water level, and water quality. It is recommended that a monitoring plan be developed to collect long-term records of these data.

Several commercial water resource allocation computer models are available. However, the preferred models would be either MIKE BASIN or MIKE-SHE as they incorporate rainfall-runoff, water use and allocation algorithms and a water quality module. MIKE BASIN and MIKE-SHE are GIS-based water resource and environmental modelling packages that provide a framework for managers and stakeholders to address multi-sectoral allocation and discharge issues in a river basin.

During periods of water shortage, disagreement over how to distribute the available water to users can occur. Rather than modelling water allocation according to a given set of rules, water allocation models can also be used to define new rules intended to maximize overall benefits while also taking into consideration environmental constraints (commonly termed Integrated Water Resources Management).

Once developed the water allocation model could be used as a tool to maximize benefits from water allocation, determine minimum storage requirements to maintain summer base flows, adapt to climate change, and improve surface water quality. Based on GIS the model would also be a useful tool for communicating with non-technical audiences.

In the short-term, it is recommended that existing groundwater knowledge gaps (as outlined below) should be addressed first.

5.3 Integrated Water Management

Opportunities for water conservation might exist through integrated resource management. This could include greening of existing and future housing developments (e.g., reuse of “grey” water for some domestic purposes, infiltration of rooftop runoff), or the reuse of stormwater-wastewater discharges for low-flow surface water augmentation and (or) groundwater recharge, which would positively impact the future supply-demand balance. A general rule of thumb when considering both community water supply and fisheries needs during periods of prolonged dry weather is that minimum base flows should equal 10% of the Mean Annual Discharge (defined as the average flow over the year). Integrated water management could be utilized to achieve this target minimum base flow. With the high levels of sewage & stormwater treatment now being required by the area's various local liquid waste management plans, it is likely to become the norm for new developments and existing infrastructure retrofits. Both the surface water resources model and groundwater model described about could be used to develop a comprehensive integrated water resource management plan for the region.

6. TERMS OF REFERENCE FOR WATER MANAGEMENT PLAN

6.1 Overview and Objectives

A preliminary water plan study of the South Cowichan region was jointly completed for the CVRD by WorleyParsons and Westland Resource Group. This study has provided information to support the development of a Water Management Plan for the area, and identifies issues that need to be addressed to ensure that water supply in South Cowichan meets future demand sustainability.

A phased approach is recommended towards development of the Water Management Plan, with major existing knowledge gaps being addressed as stand alone studies prior to development of the Plan. Recommended studies to be conducted prior to development of the Water Management Plan include:

- The acquisition of more detailed current surface water and groundwater withdrawal data is necessary to allow a better understanding of potential demand versus supply issues. This will require co-operation from major water users (improvement districts, etc.) and involvement from CVRD;
- A comprehensive, area-specific groundwater resource evaluation should be completed, which will culminate in the development of a numerical model that will establish detailed water budgets on an aquifer-by-aquifer basis. The groundwater resource evaluation and model development should take into account findings from MOE's aquifer vulnerability mapping project currently being completed, and use the model to refine understanding of local aquifer vulnerabilities;
- A comprehensive, baseline surface water quality monitoring program should be undertaken. This program should include, at a minimum, the collection of surface water samples on a quarterly basis from the area's key streams, lakes and reservoirs over a 1 to 2 year period. Prospective sampling locations should be identified through consultation with regional directors to identify potential areas of concern. Those locations for which the baseline program indicates possible water quality concerns could be incorporated in a longer-term monitoring program; and
- The potential effects of regional, national, and global pressures on population trend projections for the CVRD should be considered. Climate change could alter migration of people from areas experiencing water supply shortages or sea level increases. Economic upheavals and demographic shifts in Canadian society might also change housing choice and settlement patterns. The effects of such phenomena are difficult to anticipate and may increase the uncertainty in population trend projections for the CVRD.

Once these supplemental investigations and monitoring programs have been undertaken, a comprehensive Water Management Plan for the South Cowichan area should be developed to address issues raised by this preliminary study.

Completion of this Water Management Plan should result in the following tangible benefits:

- Enhanced understanding of local water issues;

- A workable management structure for each of Study Area's three watersheds over a 30-year planning horizon that represents the interests of all stakeholders; and
- A sense of balance between the future water needs of agriculture, a growing population, and the ecosystems of the South Cowichan area.

The scope of the Water Management Plan does not extend to regional water quality issues, except if they relate directly to water supply.

6.2 Spatial and Temporal Scope

The South Cowichan Water Management Plan will provide water management guidance across three watersheds in the Study Area during a thirty-year planning horizon.

It s recommended that the Water Management Plan should encompass a total area of 20,583 hectares, and will CVRD's Electoral Areas A and C in their entirety, and those parts of Electoral Areas B, D, and E that lie within the Shawnigan, Cowichan and Saanich Inlet watersheds (i.e. this project's Study Area). Even though some electoral area boundaries straddle watershed boundaries, the limited areal scope of this water plan will address most of the population's water supply demands and needs.

6.3 Issues Requiring Study and Stakeholder Consultation

This project examined current surface and groundwater supply and withdrawal rates with respect to land use practices, ecological requirements, and biophysical processes, and forecasts of future water demand based on estimates of future conditions. Issues were identified through discussions with key organizations and representatives. Perceptions of current water issues held by the wider community could not be fully explored with the resources available for this study. CVRD will need to address these gaps in information as they work to prepare the Water Management Plan for the South Cowichan area. These issues are described in the following sections.

6.3.1 Water Supply and Demand

Summer low flows in Lower Shawnigan Creek are currently detrimental to aquatic system health, and are due in part to having insufficient lake storage to support both domestic use and downstream needs in summer. Care is required to ensure that a balance between accumulating sufficient storage for domestic use while maintaining sufficient flow for aquatic system health is achieved.

Suggestions to increase summer storage in Shawnigan Lake by restricting flow past the dam in Lower Shawnigan Creek are controversial, since increased lake levels could affect lakeshore properties.

Agriculture would benefit from an increased availability of water for irrigation, particularly during dry summer months. Increased storage is encouraged where a water source, capable of providing sufficient, sustainable supply is available.

Climate change is likely to increase the incidence of summer droughts within the South Cowichan region. A warmer, drier climate will increase demand for water for domestic and agricultural use, as well as the

amount of water used to maintain ecosystem health. Care will be required to manage water supply to meet both human and ecosystem needs in a changing climate.

6.3.2 Regulatory Issues

Water management is a provincial responsibility. The Province's 'Living Water Smart' (LWS) Water Plan commits to achieving a 33 percent water efficiency target across British Columbia by 2020. LWS also commits the province to other actions to manage water more sustainably.

CVRD authority in water management is unclear, because local governments' ability to implement and enforce water use policies is limited by the present water governance structure in British Columbia.

Coordinating the efforts of the many agencies involved in water management in the South Cowichan region, including the CVRD, MOE, Fisheries and Oceans Canada, non-governmental organisations, and Cowichan and Malahat First Nations, will be important when developing the Water Management Plan.

Official Community Plan policies support sustainable use of water, but these policies may not be supported by resource legislation and regulations.

6.3.3 Wastewater

Approximately 600 residential lots adjoin Shawnigan Lake. Municipal wastewater services in the South Cowichan region are limited, which means that most lakeshore residents rely on on-site sewerage systems to treat and disperse their domestic sewage. A study of water quality in Shawnigan Lake, undertaken in 2004 by MOE, identified water quality issues with respect to high fecal coliform levels. Coliform concentrations in the lake were found to be considerably higher than inflow concentrations, suggesting that bacterial contamination is reaching the lake through other pathways, such as infiltrating water exposed to malfunctioning on-site sewerage systems. Most Shawnigan Lake residents rely on lake water for daily domestic use. Poor lake water quality has a direct impact on domestic water supply.

Twelve of fifteen shellfish beaches in the Saanich Inlet are closed due to fecal contamination. Fecal coliform bacteria are present in surface runoff to Saanich Inlet in high concentrations during and after rainfall events. The only point-source discharge of sewage in the Inlet is located in Mill Bay.

Chemical contaminants, including metals and polycyclic aromatic hydrocarbons (PAH), occur in low concentrations in Lower Shawnigan Creek, where they are detrimental to aquatic system health.

6.3.4 Recreation

Recreational users disagree about optimum levels of Shawnigan Lake in the summer. For instance, water skiers prefer higher water levels to protect them from exposed gravel beds, whereas some residents prefer lower lake levels for their own recreational activities.

Recreational use of Shawnigan Lake has the potential to affect, and to be affected by, lake water quality. For instance, water quality, and hence water supply for domestic use, may be adversely affected by increased levels of hydrocarbons and other chemicals in the water column and surface microlayer

associated with an increased use of motorboats on the lake. Swimming, skiing, fishing, or kayaking in water of poor quality has the potential to adversely affect human health.

6.4 Ecological Issues - Research Needs

Many streams in the South Cowichan region support fish stocks, including Coho salmon, Steelhead salmon, and Rainbow and Cutthroat trout. Water management needs to maintain or enhance fish habitat and fish populations.

Shawnigan Lake supports an isolated population of native Kokanee salmon, Rainbow and Cutthroat trout, and Smallmouth bass that may be adversely affected if water quantity or quality in the Lake declines.

Riparian vegetation along lake margins and river and stream corridors plays an important role in maintaining water quality and providing shade to cool water and protect fish habitat and wildlife corridors. As the human population of South Cowichan grows, urban development will place pressure on riparian vegetation and the habitats it supports.

Ecological requirements (i.e. minimum flows) to maintain these habitats are poorly understood. CVRD will need to address this gap in information as they work to prepare the Water Management Plan.

6.5 Available Information

The following documents should be reviewed prior to preparing the final South Cowichan Water Management Plan:

- The South Cowichan Water Plan Study (this report);
- Findings from various supplemental environmental / hydrogeological assessments and stakeholder consultation exercises recommended by this report;
- Findings from MOE's groundwater vulnerability mapping project;
- The Cowichan Basin Water Management Plan;
- Official Community Plans for Electoral Areas in the Cowichan Valley Regional District; and
- 'Living Water Smart', British Columbia's Water Plan.

6.6 Deliverables

The South Cowichan Water Management Plan will provide water management guidance for components of the three watersheds that span five CVRD Electoral Areas. Although some issues are watershed-specific, many of the challenges to better managing the South Cowichan region's water resources are shared by all three watersheds, some of which straddle jurisdictional boundaries. It is considered appropriate one management plan will be created that includes all three watersheds in South Cowichan. It is anticipated that each watershed will have its own discrete section in the final plan, which will set out issues, goals, objectives, and actions, and an implementation strategy relevant to each watershed. Sections addressing the context, planning process, public input, regional issues, and water management

guidance common to all three watersheds may be contained in a single section. CVRD will need to determine the best way to present the water management plan to clearly display the process, issues, goals, actions, and implementation strategies relevant to each watershed in the South Cowichan region.

CVRD recognizes the need to develop a plan for the sustainable management of water in the three South Cowichan watersheds. Part 4 of the Water Act, which enables the Minister to order or designate an area for the purpose of preparing a management plan and sets out the provisions for preparing and implementing the plan, does not apply to South Cowichan.

The process proposed to develop the Water Management Plan should include the following broad components:

- Review and analysis of existing background material;
- Identification of representatives to be part of a forum of key stakeholders that will be engaged throughout the plan development process to identify issues, objectives, and actions, and to review the draft plan;
- Development of a public engagement strategy to identify the ways to engage the community throughout the plan preparation phase;
- Public consultation, in particular the creation and engagement of a key stakeholder forum and involvement of the wider community to gain an understanding of water related issues in the Study Area and build support for the plan;
- Preparation of presentation materials for public meetings, reports, and workshops;
- Maintenance of close working relationships with CVRD staff, and regular reporting to the CVRD Board or committees;
- In conjunction with the key stakeholder forum, development of a vision and goals for effectively managing water in each South Cowichan watershed. Public input on the vision and goals developed through the forum should be gathered;
- Drafting of the Water Management Plan, including technical studies as required, including identification of demand and supply options, development and comparisons of supply management alternatives to determine a preferred option, and development of objectives, actions, and an implementation strategy;
- Liaison with CVRD staff, the key stakeholder forum, the CVRD Board, committees, and the public to gain feedback on the draft plan;
- Revision of the draft Water Management Plan based on comments received, and preparation of final documents; and
- Presentation of the final Water Management Plan to the CVRD, key stakeholders forum, and general public.

The team responsible for preparing the Water Management Plan should be required to present the following information to CVRD upon completion of the project:

- One electronic copy of all background reports and technical studies;
- Copies of public involvement materials;
- Five hard copies and one electronic copy of the draft plan; and
- One print-ready copy, one electronic copy, and five hard copies of the final plan, including illustrations and maps.

Map files should be provided in digital format and be compatible with the Cowichan Valley Regional District Geographical Information System.

6.7 Proposed Timeline

The following timeline outlined in Table 43 below is proposed to develop of the Water Management Plan. This phased approach takes into account that the proposed Water Management Plan has a budget of approximately $100,000 per year.

Table 43 Proposed Timeline for Development of the Water Management Plan and Subsequent Work

Component	Who	Timeline
Groundwater Resource Evaluation and Model	Consultant	2009
Surface Water Quality Study	Consultant	2009-2010
Estimating Current Water Use	CVRD and Consultant	2010
Issues Requiring Study and Stakeholder Consultation	CVRD and Consultant	2010-2011
Draft Water Management Plan	Consultant	2011
Stakeholder Consultation and Finalization of Water Management Plan	CVRD and Consultant	2012
Groundwater and Surface Water Management Model	Consultant	2012
Long-term monitoring plan (surface water)	Consultant	2012-

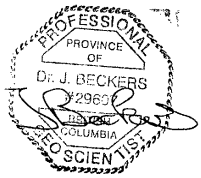
7. CLOSURE

We trust that this report satisfies your current requirements and provides suitable documentation of the tasks undertaken by this project. The study team of WorleyParsons and Westland Resource Group greatly appreciates having been given the opportunity to participate on this critical initiative.

If you have any questions or require further details, please contact the undersigned at any time.

Respectfully submitted:

WorleyParsons



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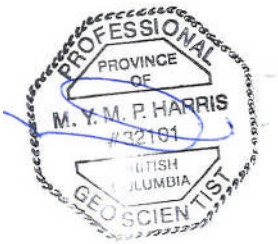

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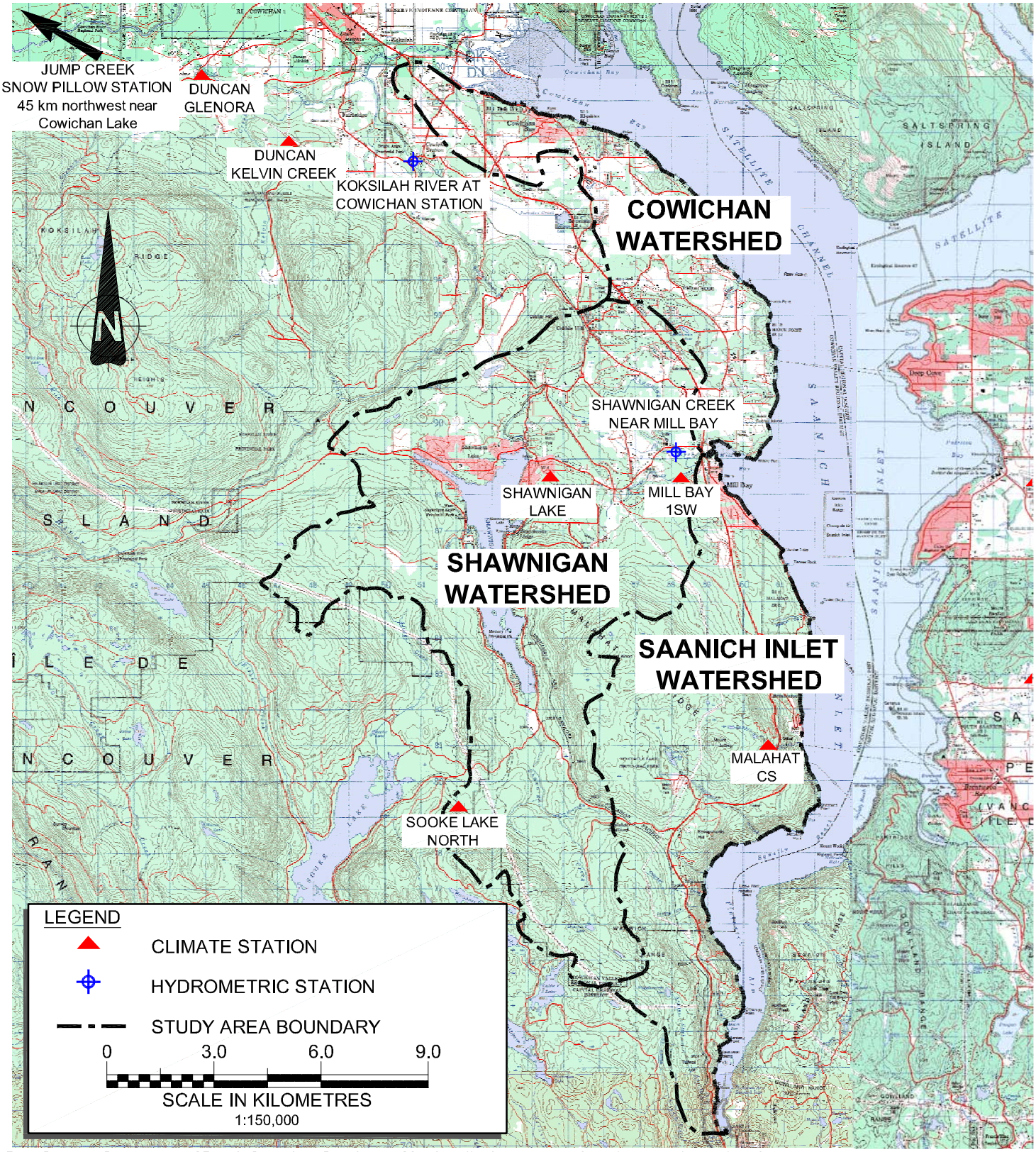

Data Source: Government of British Columbia Geophysics Map http://webmap.em.gov.bc.ca/mapplace/minpot/geophysics.asp
Basemap Source: National Topographic Servic Map Sheets: 92-b-13, 92-b-5, 92-b-14, 92-b-11, 92-b-6 & 92-b-12

Infrastructure & Environment

COWICHAN VALLEY REGIONAL DISTRICT
SOUTH COWICHAN WATER STUDY PLAN

STUDY AREA &
ENVIRONMENT CANADA CLIMATE STATIONS

WorleyParsons
resources & energy

2009-02-11	date	edited by	KM	drawn by	MH	app by

PROJECT NUMBER: V19830100

FIGURE: 1

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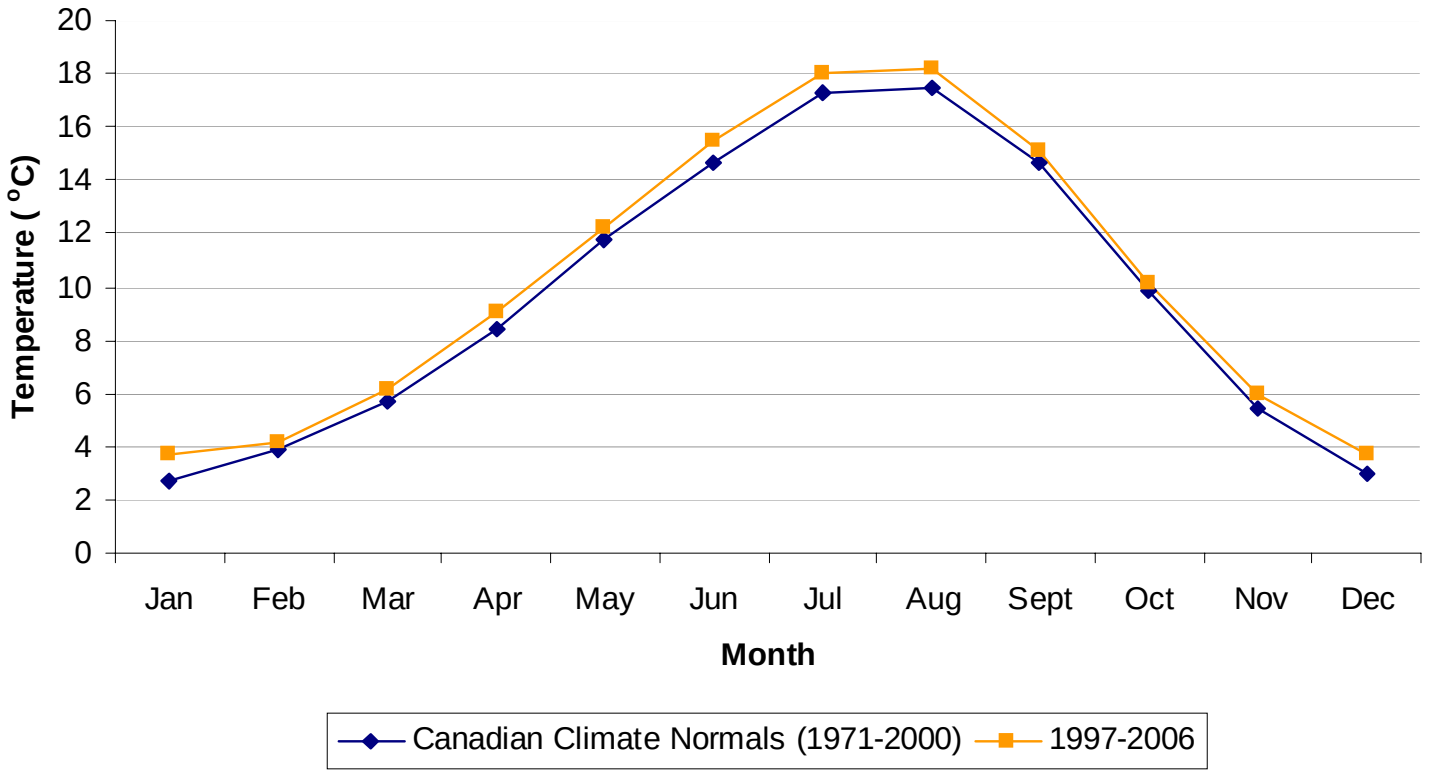

Data Source: Environment Canada - Meteorological Service of Canada

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COWICHAN VALLEY REGIONAL DISTRICT
SOUTH COWICHAN WATER STUDY PLAN

AVERAGE MONTHLY TEMPERATURE

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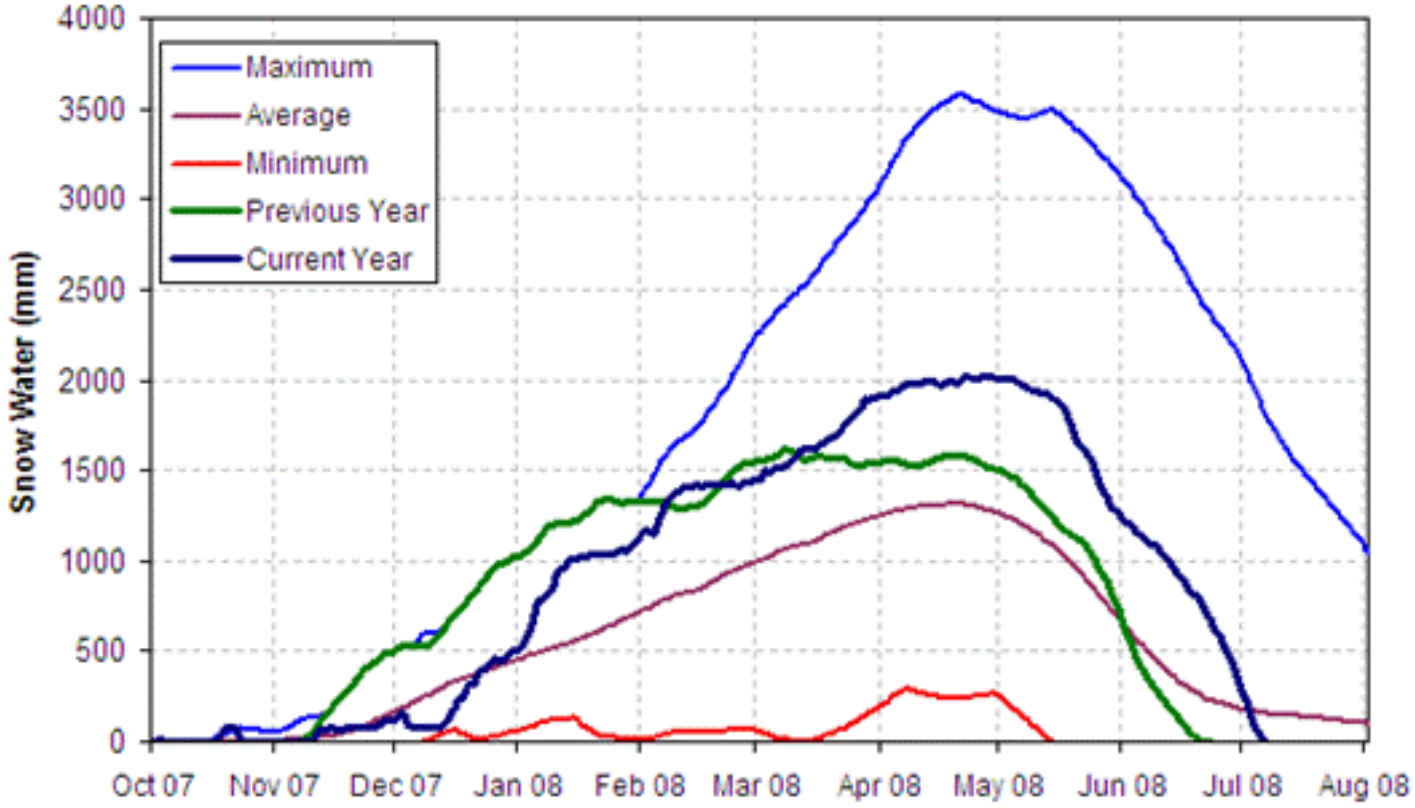

Data Source: Ministry of Environment Water Stewardship Division

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COWICHAN VALLEY REGIONAL DISTRICT
SOUTH COWICHAN WATER STUDY PLAN

JUMP CREEK SNOW PILLOW DATA

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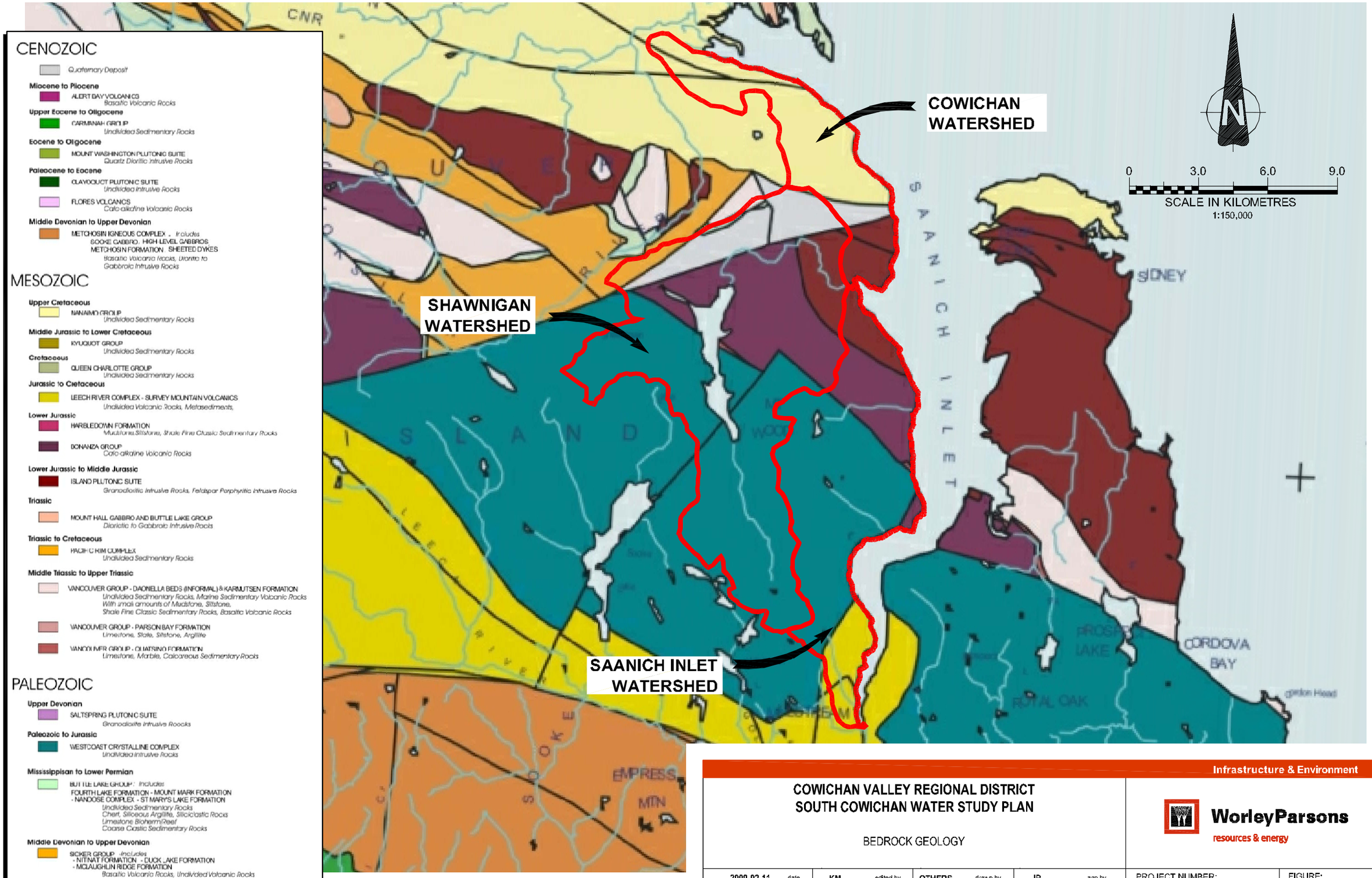

Source: British Columbia Ministry of Environment
Surficial Geology of Vancouver Island Map

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COWICHAN VALLEY REGIONAL DISTRICT
SOUTH COWICHAN WATER STUDY PLAN

BEDROCK GEOLOGY

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2009-02-11	date	KM	edited by	OTHERS	drawn by	JB	app by	PROJECT NUMBER: V19830100	FIGURE: 4

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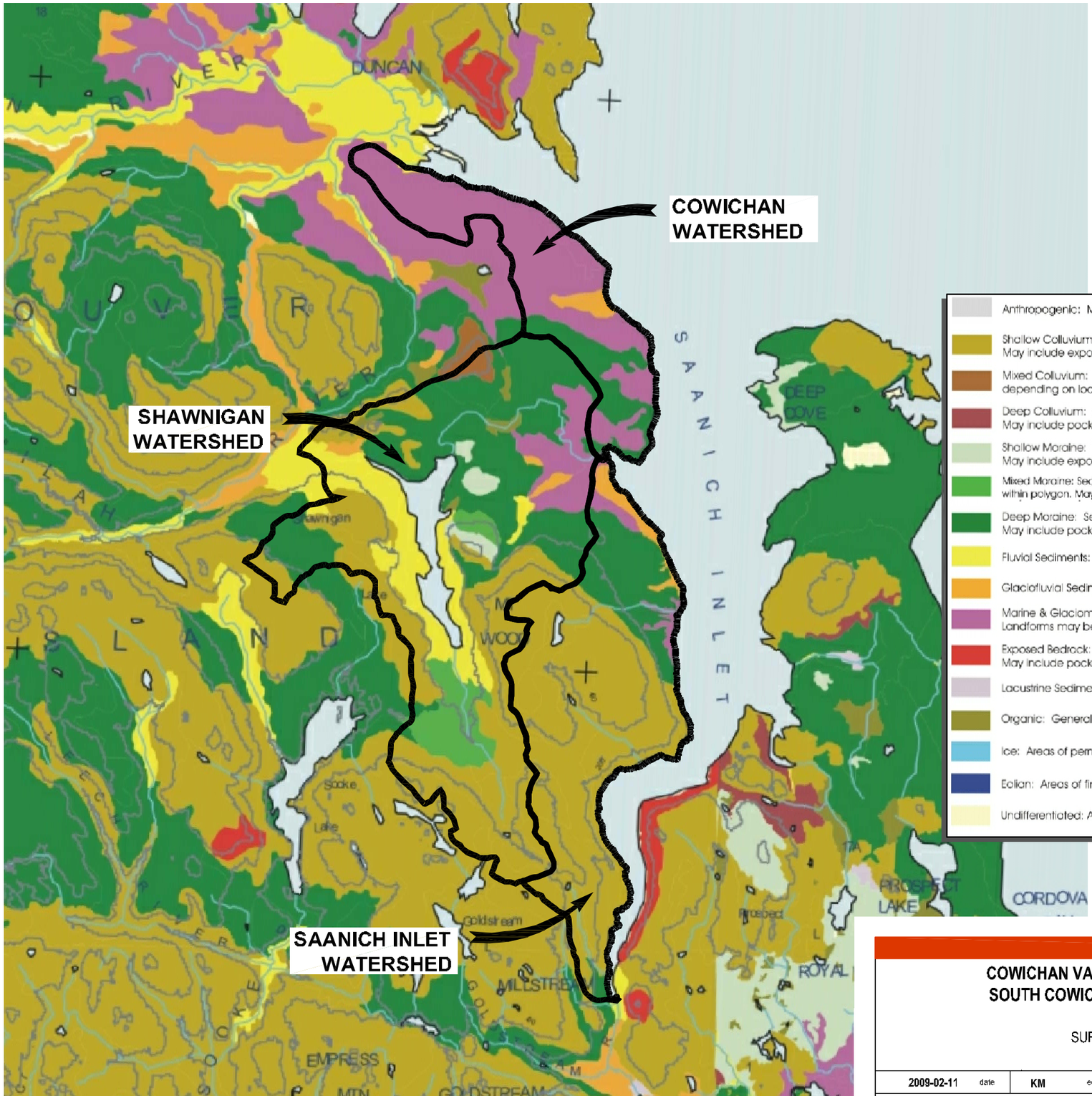

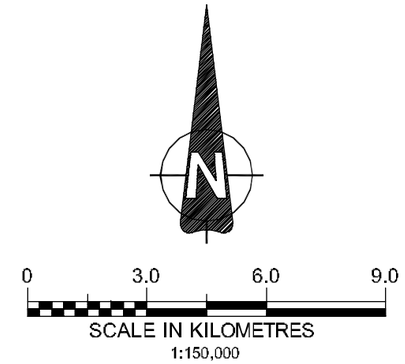

- Anthropogenic: Man-made deposit such as mine tailing
- Shallow Colluvium: Sediments are Generally less than 1m thick overlaying bedrock. May include exposed rock, deeper colluvium or pockets of till.
- Mixed Colluvium: Sediments estimated to be less than or more than 1m thick over bedrock depending on location within polygon. May include pockets of till or perched glaciofluvial deposits
- Deep Colluvium: Sediments are generally thicker than 1m overlying bedrock. May include pockets of till or perched glaciofluvial sediments.
- Shallow Moraine: Tills generally less than 1m thick overlying bedrock. May include exposed bedrock, deeper till pockets of colluvium.
- Mixed Moraine: Sediments estimated to be less then or more than 1m thick over Bedrock depending on location within polygon. May include pockets of Colluvium or Perched Glaciofluvial deposits
- Deep Moraine: Sediments are generally thicker than 1m overlying bedrock. May include pockets of colluvium or perched glaciofluvial sediments
- Fluvial Sediments: Typically formed of sand and gravel worked by the river over the last few melania
- Glaciofluvial Sediments: Sand and gravel deposits related to outwash from previous glaciations
- Marine & Glaciomarine: Marine sediments including clayey silt deposits and intertidal (Littoral) deposits of sand and gravel. Landforms may be raised relative to current shoreline.
- Exposed Bedrock: Bedrock outcrops with little or not (<10 cm) sediment covering them. May include pockets of shallow colluvium or till.
- Lacustrine Sediments: Generally silt and fine sand, stratified deposits from old lakes, or on exposed floors of seasonal lakes.
- Organic: Generally refers to sediments resulting from thick accumulations of vegetation in wetlands such as peat bogs, fens & swamps.
- Ice: Areas of permanent snow & ice
- Eolian: Areas of fine sand transported by wind.
- Undifferentiated: A layered sequence of surficial sediments not possible to map separately

Source: British Columbia Ministry of Environment Surficial Geology of Vancouver Island Map

Infrastructure & Environment

COWICHAN VALLEY REGIONAL DISTRICT
SOUTH COWICHAN WATER STUDY PLAN

SURFICIAL GEOLOGY

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2009-02-11	date	KM	edited by	OTHERS	drawn by	JB	app by	PROJECT NUMBER: V19830100	FIGURE: 5

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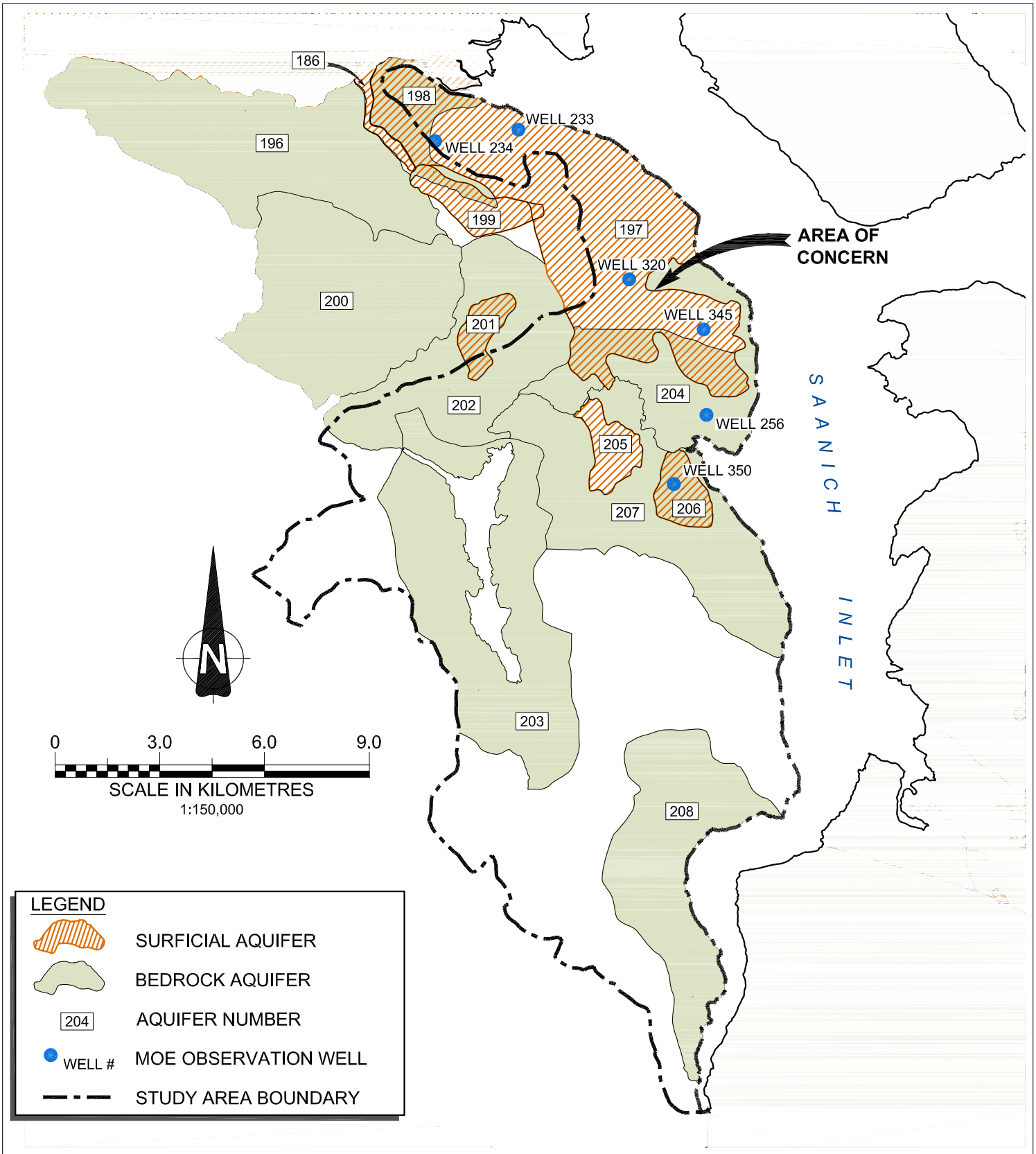

Source: British Columbia GeoBC Science & Information Branch (MOE)

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COWICHAN VALLEY REGIONAL DISTRICT
SOUTH COWICHAN WATER STUDY PLAN

MAPPED AQUIFERS AND OBSERVATION WELLS

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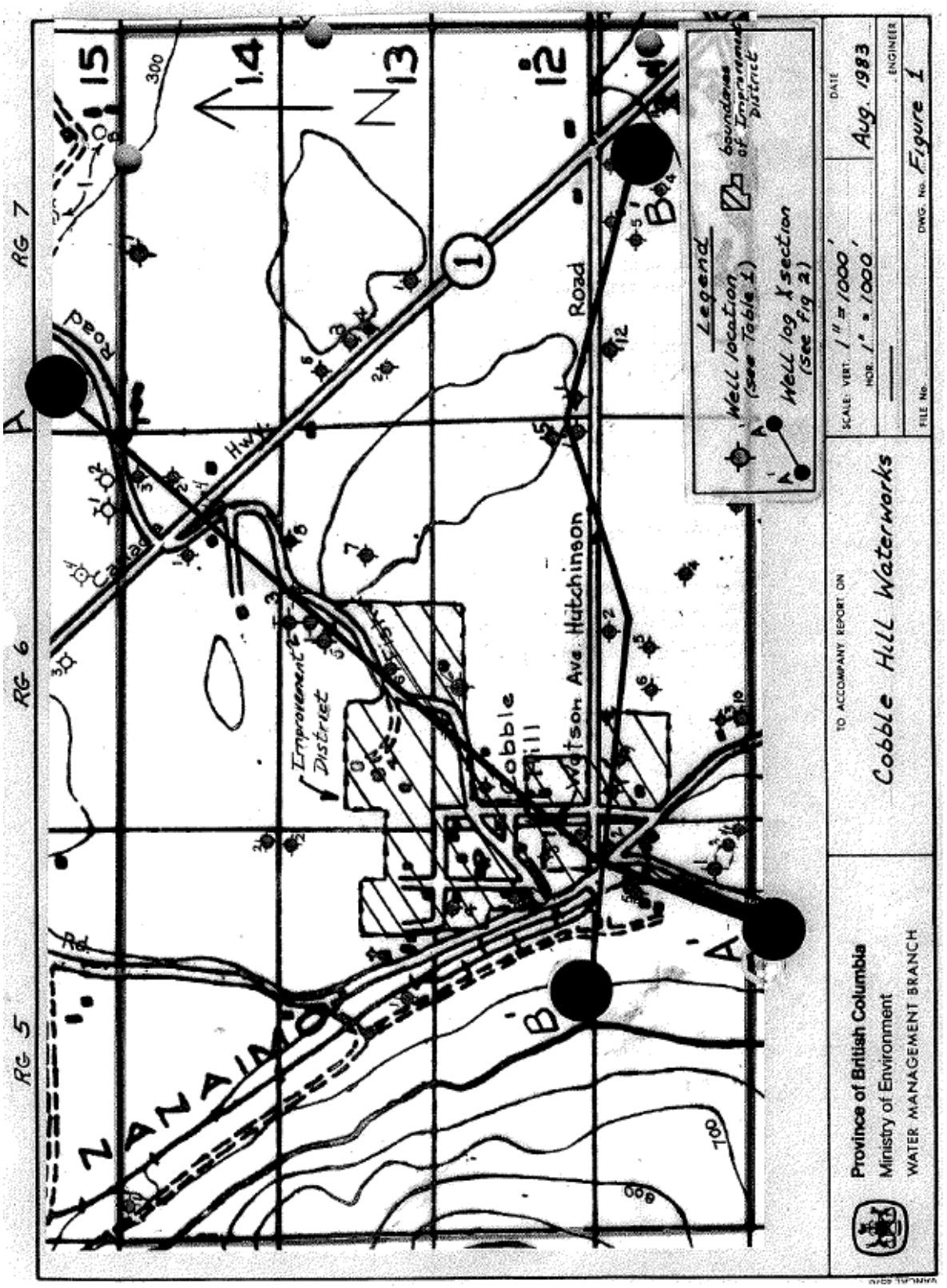
FILE: J:\1976-1995\V19830100_Cowichan District - Water Plan Study\DRAWINGS\FIGURES\FIGURE 6.dwg Issued By: Victoria CAD



Data Source: MOE Water Management Branch

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COWICHAN VALLEY REGIONAL DISTRICT
SOUTH COWICHAN WATER STUDY PLAN

COBBLE HILL WATER WORKS
MOE CROSS-SECTION LOCATIONS

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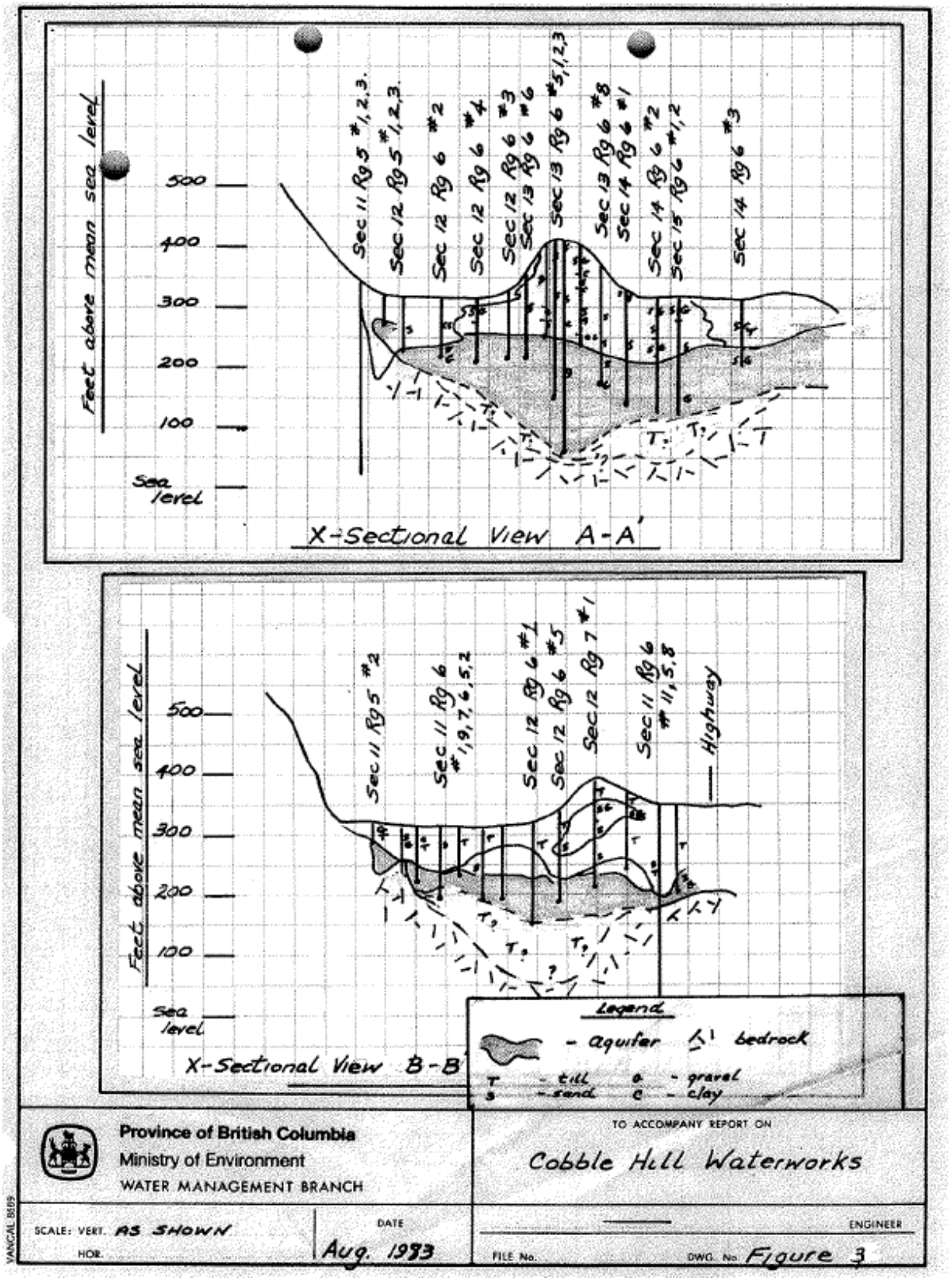
PROJECT NUMBER: V19830100

FIGURE: 7A

FILE: J:\1976-1995\V19830100_Cowichan District - Water Plan Study\DRAWINGS\FIGURES\FIGURE 7A.dwg Issued By: Victoria CAD



Data Source: MOE Water Management Branch

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SOUTH COWICHAN WATER STUDY PLAN

COBBLE HILL WATER WORKS
MOE CROSS-SECTIONS

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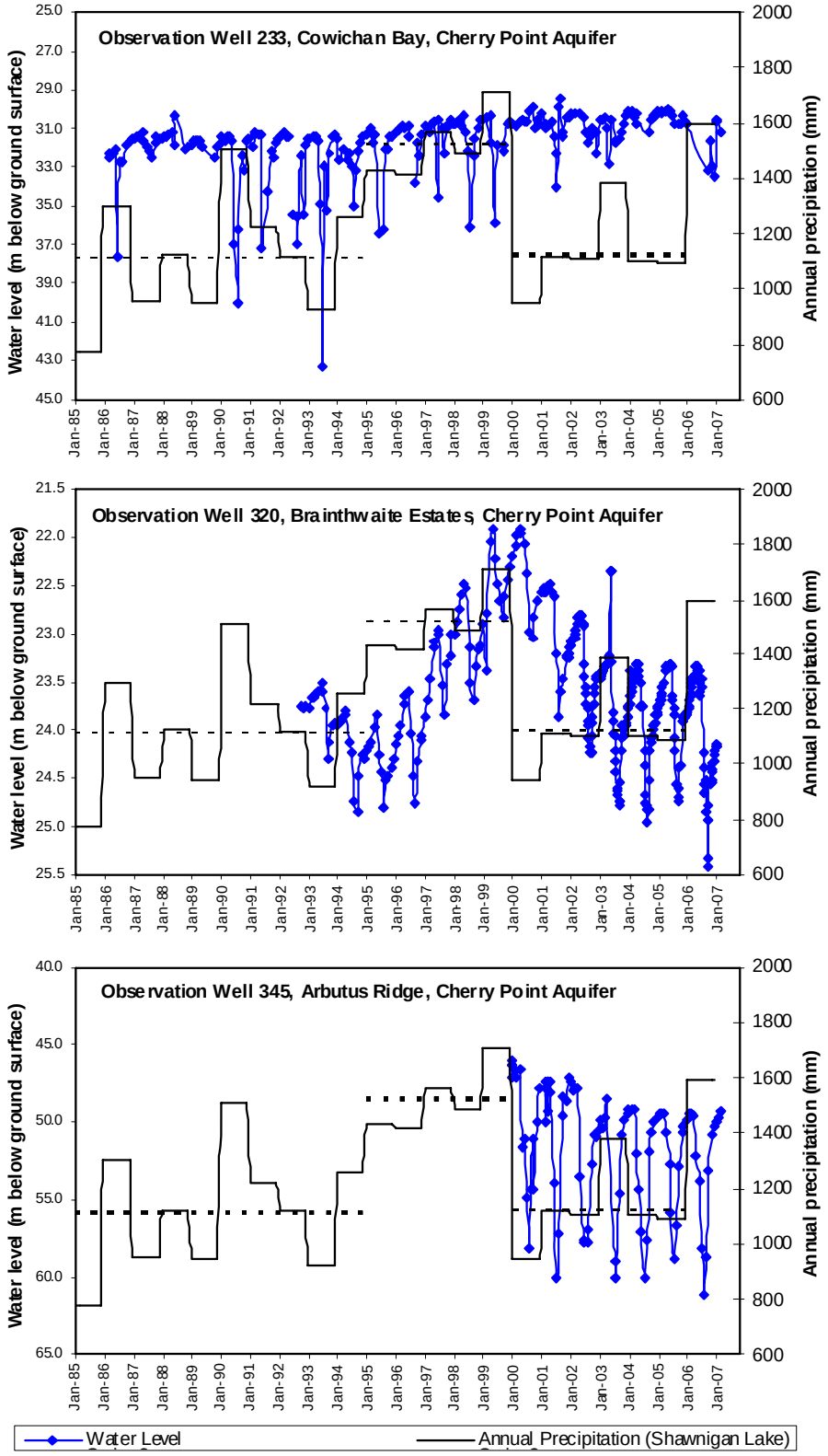
							V19830100	7B

FILE: J:\1976-1995\V19830100_Cowichan District - Water Plan Study\DRAWINGS\FIGURES\FIGURE 7B.dwg Issued By: Victoria CAD



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SOUTH COWICHAN WATER STUDY PLAN

OBSERVATION WELL HYDROGRAPHS
FOR THE CHERRY POINT AQUIFER

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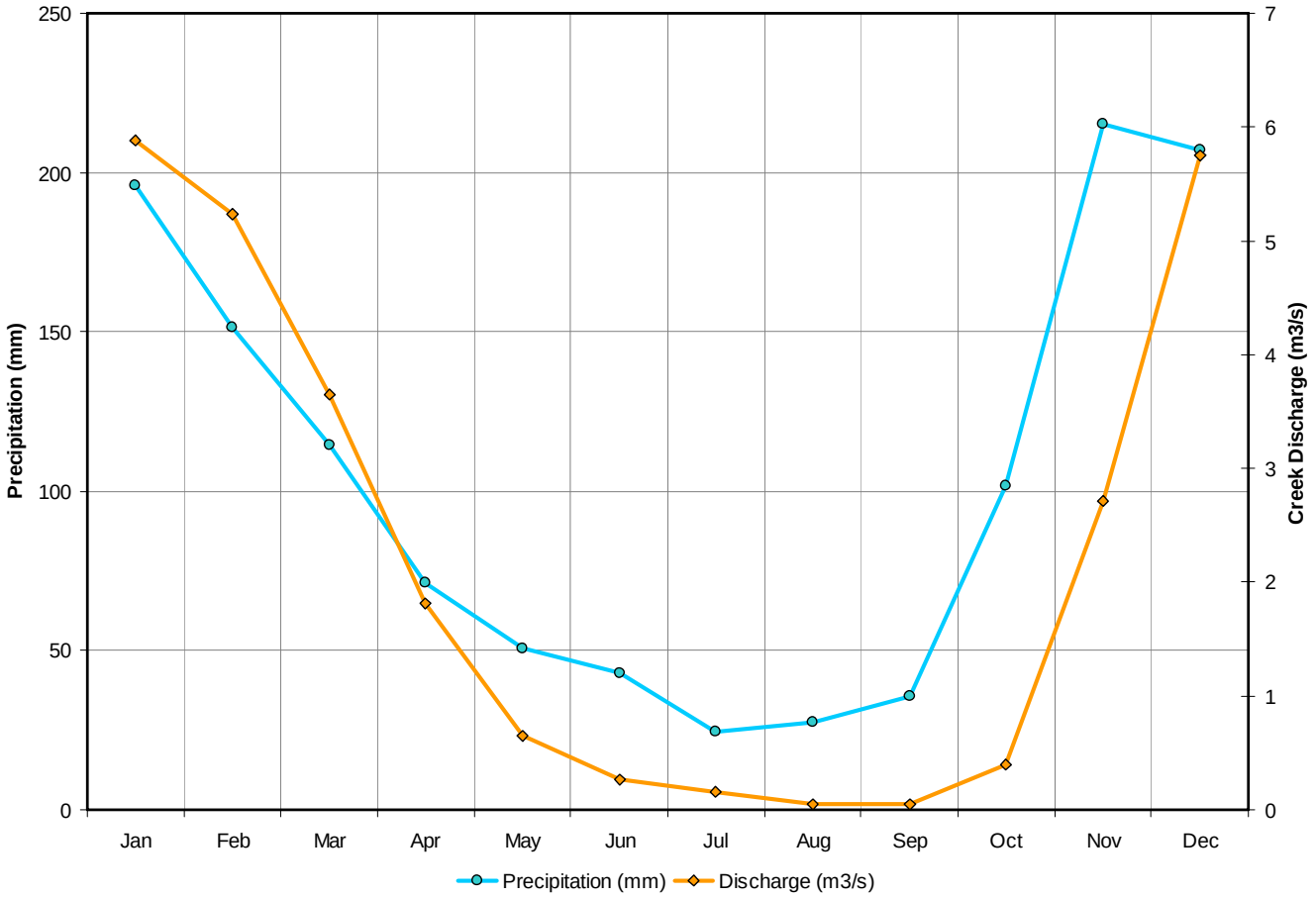
2009-02-11	date	edited by	OTHERS	drawn by	JB	app by	PROJECT NUMBER:	FIGURE:
							V19830100	8



Data Source: Environment Canada - Water Survey of Canada
Environment Canada - Meteorological Service of Canada

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SOUTH COWICHAN WATER STUDY PLAN

MEAN MONTHLY PRECIPITATION AND DISCHARGE
SHAWNIGAN CREEK NEAR MILL BAY

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2009-02-11 date	edited by	KM	drawn by	MH	app by	PROJECT NUMBER:	FIGURE:
						V19830100	9

Figure10 Biogeoclimatic Zones

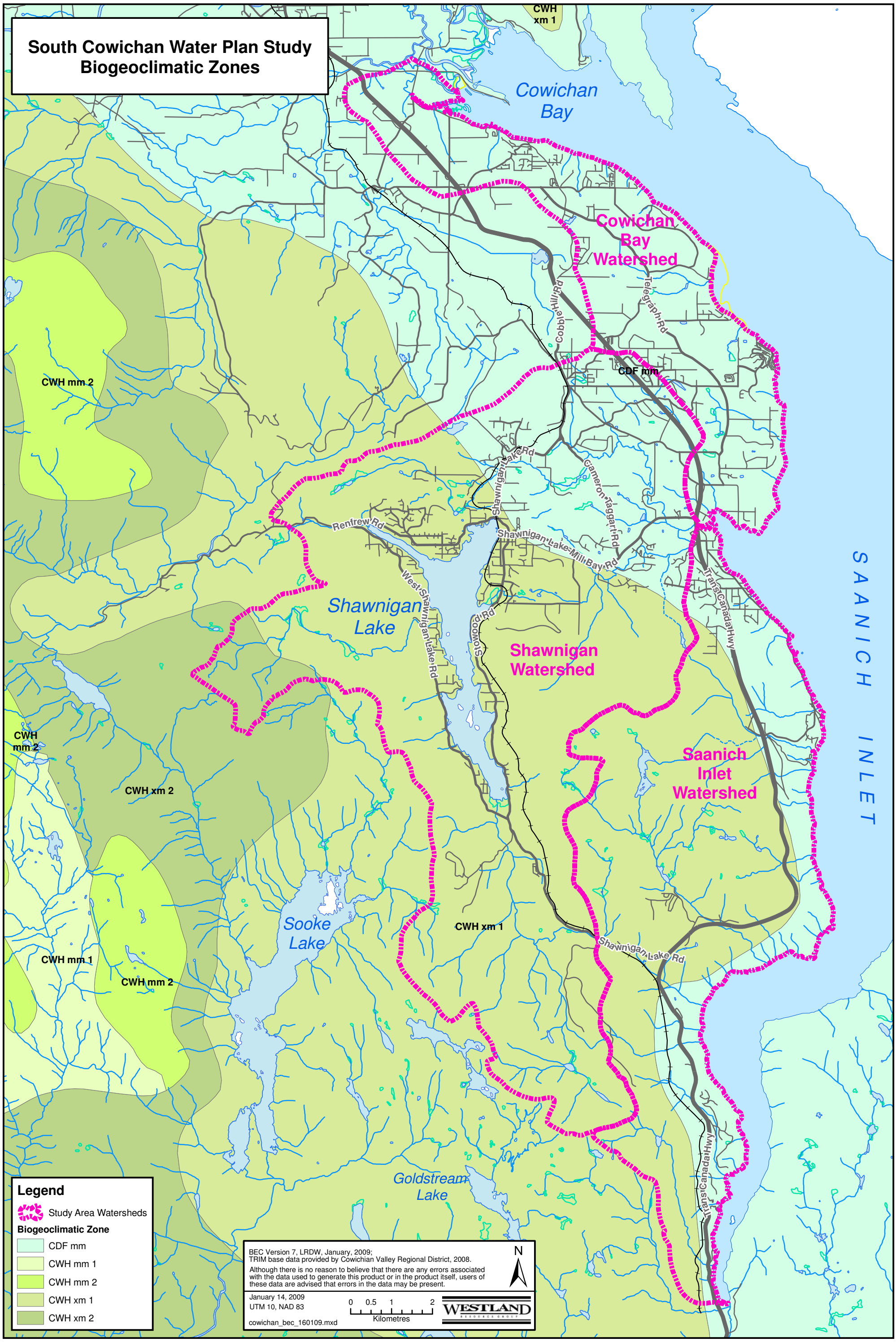


Figure11 Shawnigan Watershed

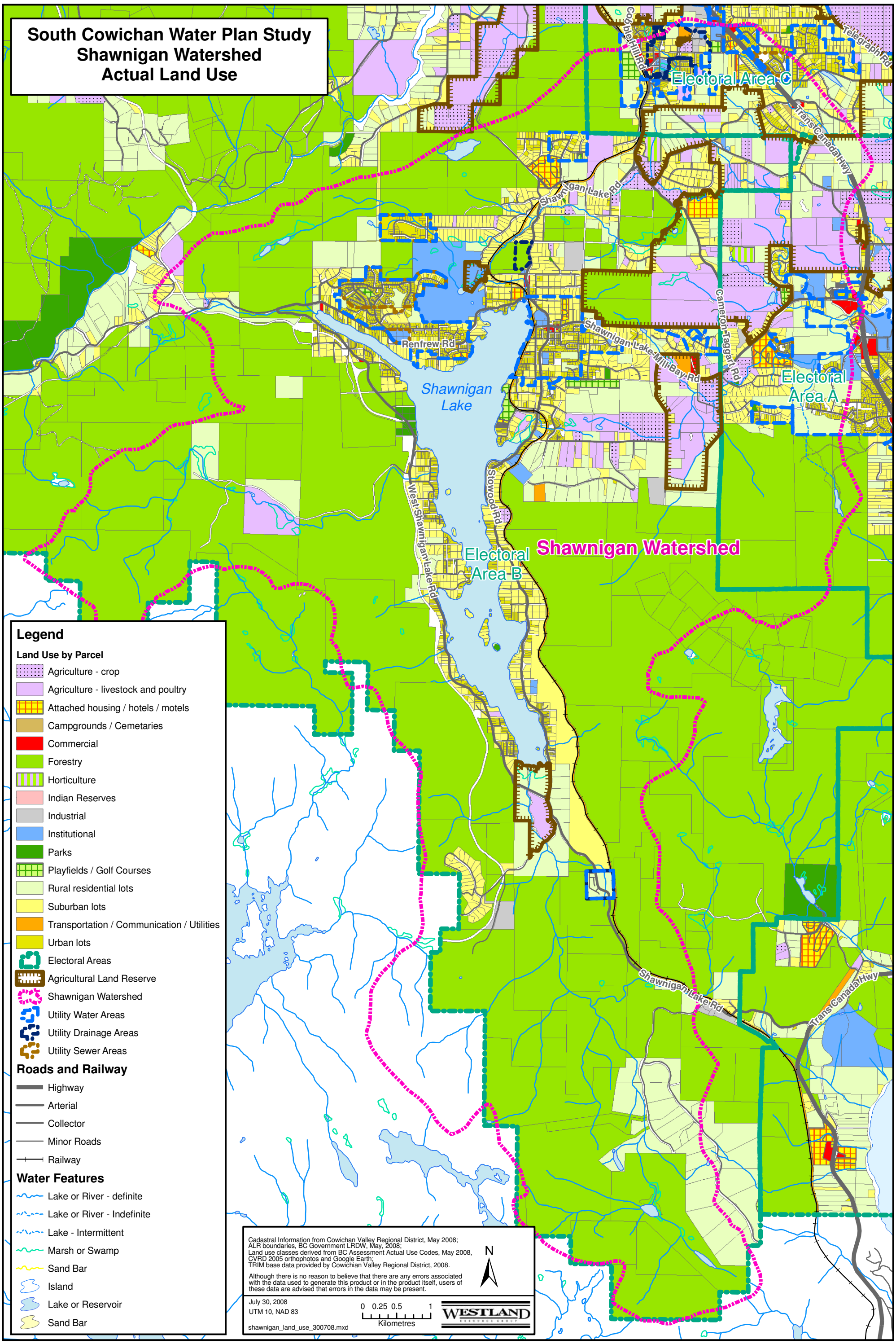


Figure12 Saanich Inlet Watershed

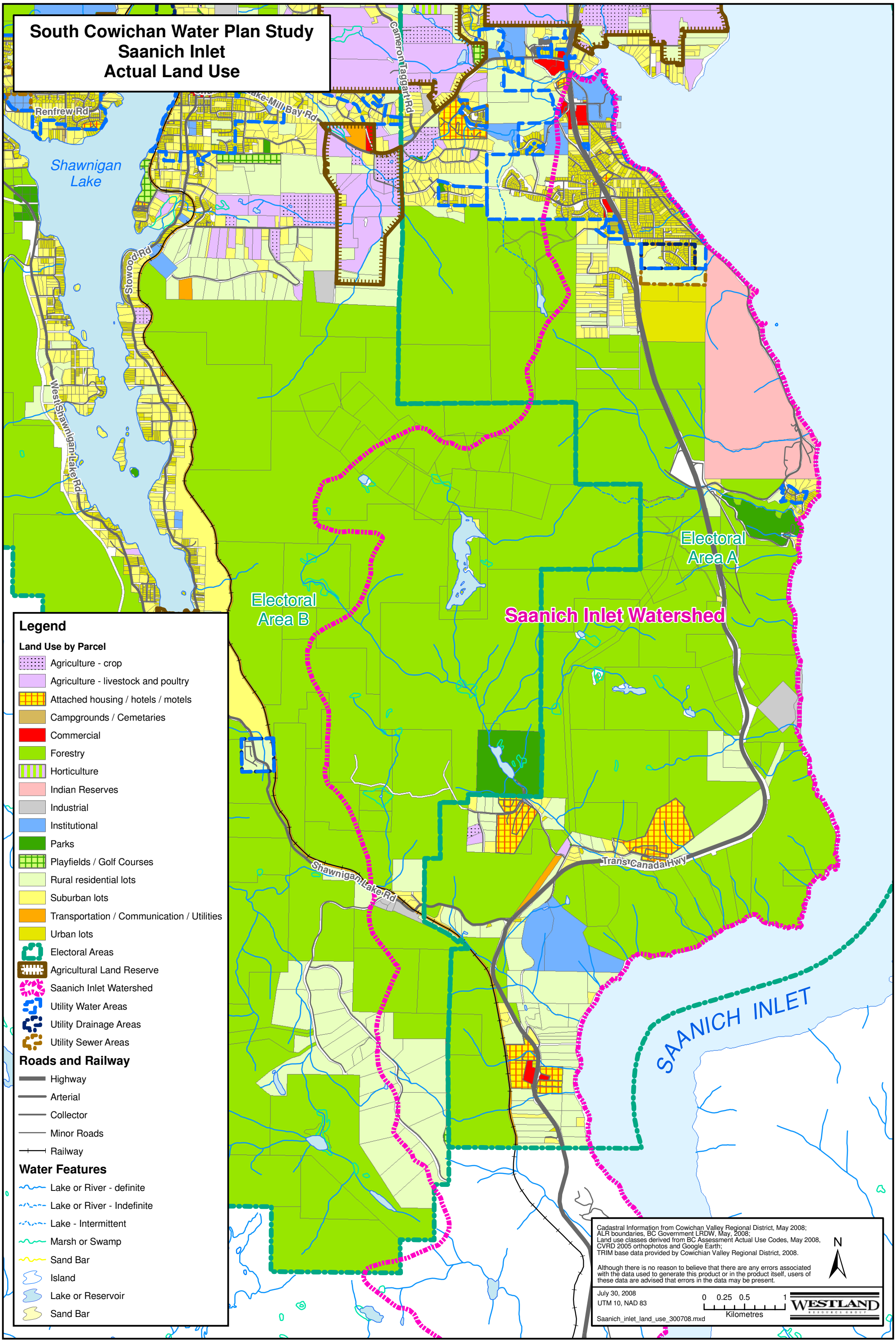
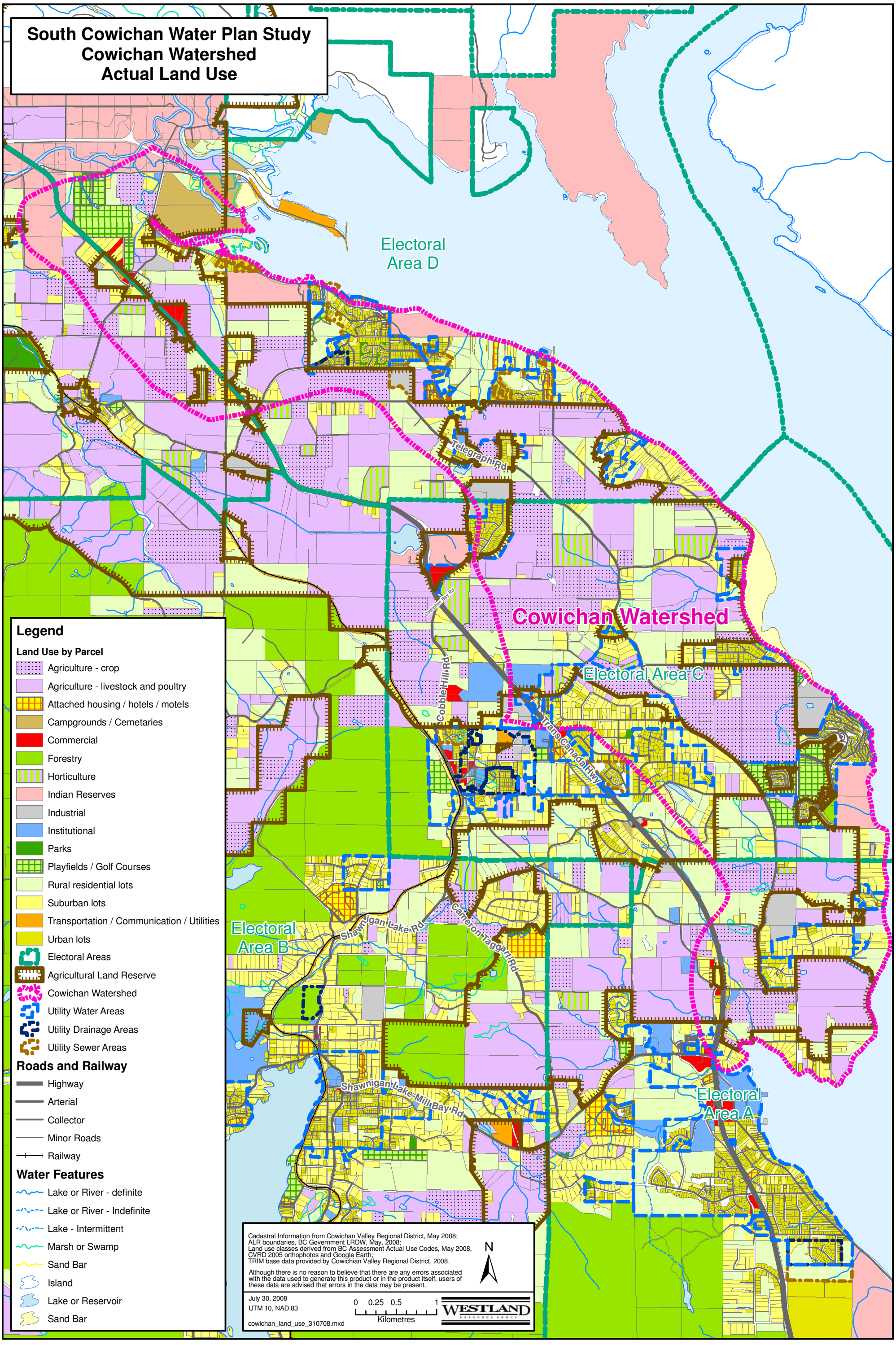
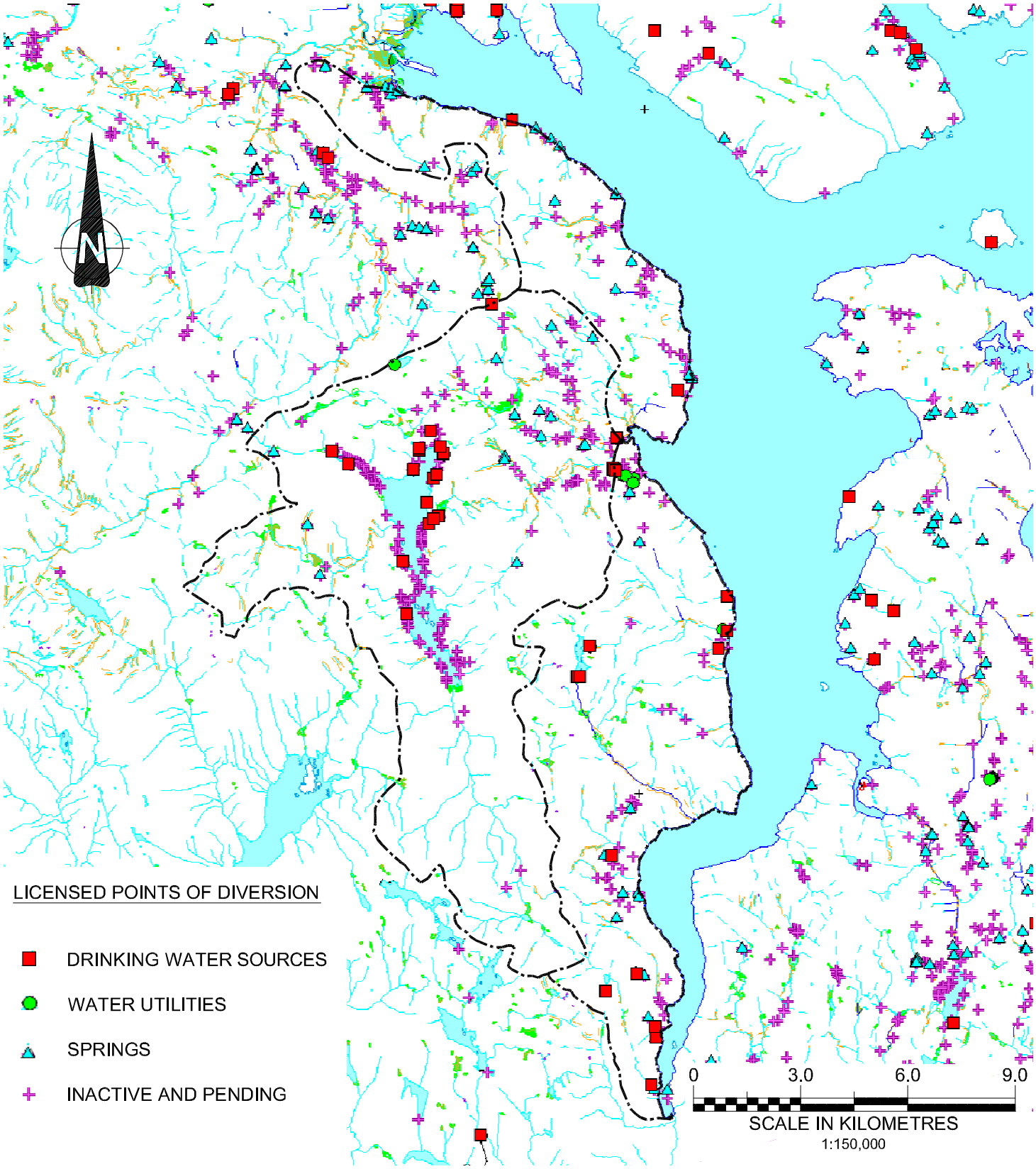


Figure13 Cowichan Watershed





Data Source: BC Water Resource Atlas http://www.env.gov.bc.ca/wsd/data_searches/wrbc/index.html

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SOUTH COWICHAN WATER STUDY PLAN

REGISTERED POINTS OF DIVERSION OF SURFACE WATER
IN SOUTH COWICHAN

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FIGURE: 14

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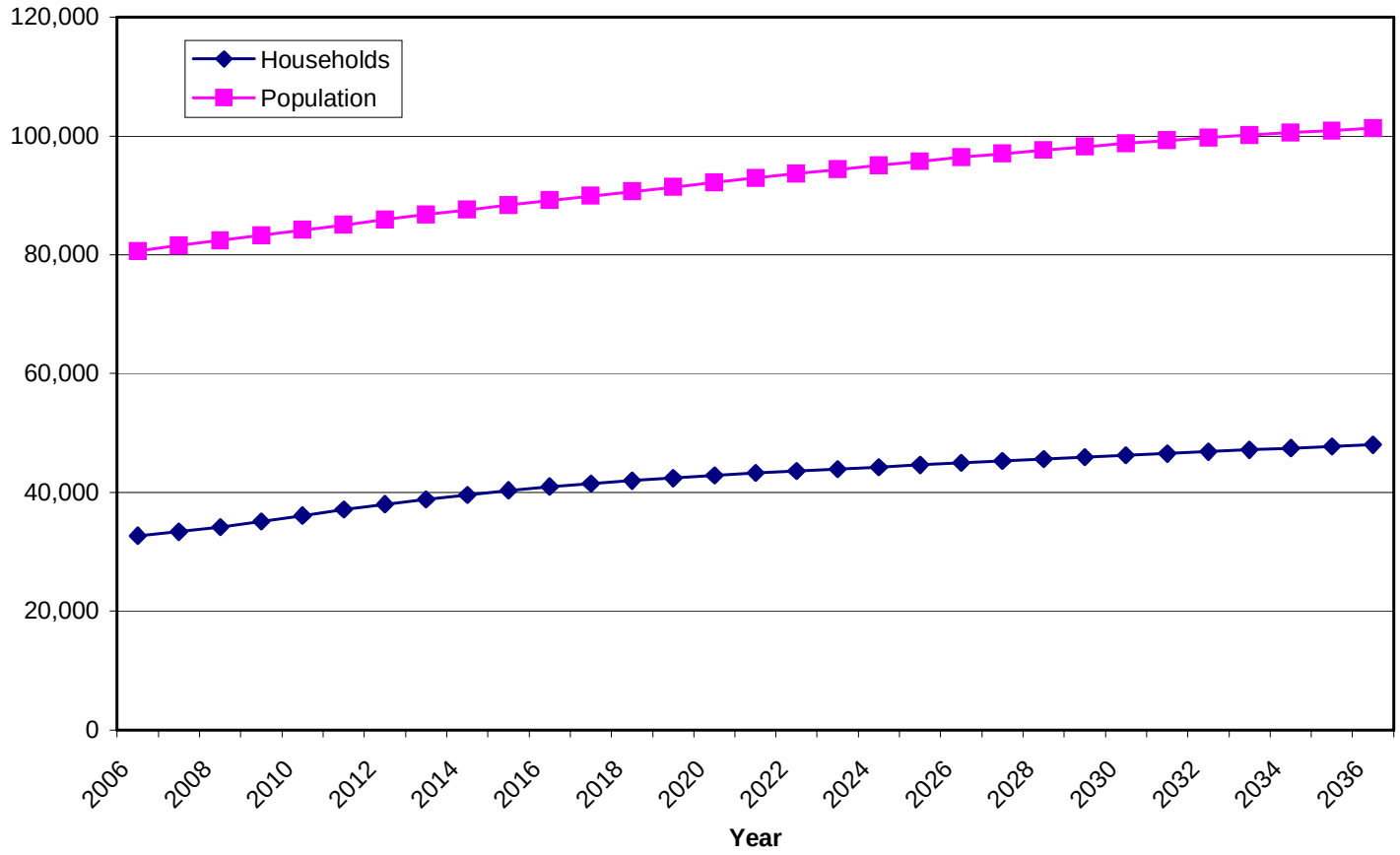

Data Source: Westland Resources Group

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COWICHAN VALLEY REGIONAL DISTRICT
SOUTH COWICHAN WATER STUDY PLAN

P.E.O.P.L.E. 32
POPULATION AND HOUSEHOLD GROWTH PROJECTION
ESTIMATES FOR CVRD (2006 - 2036)

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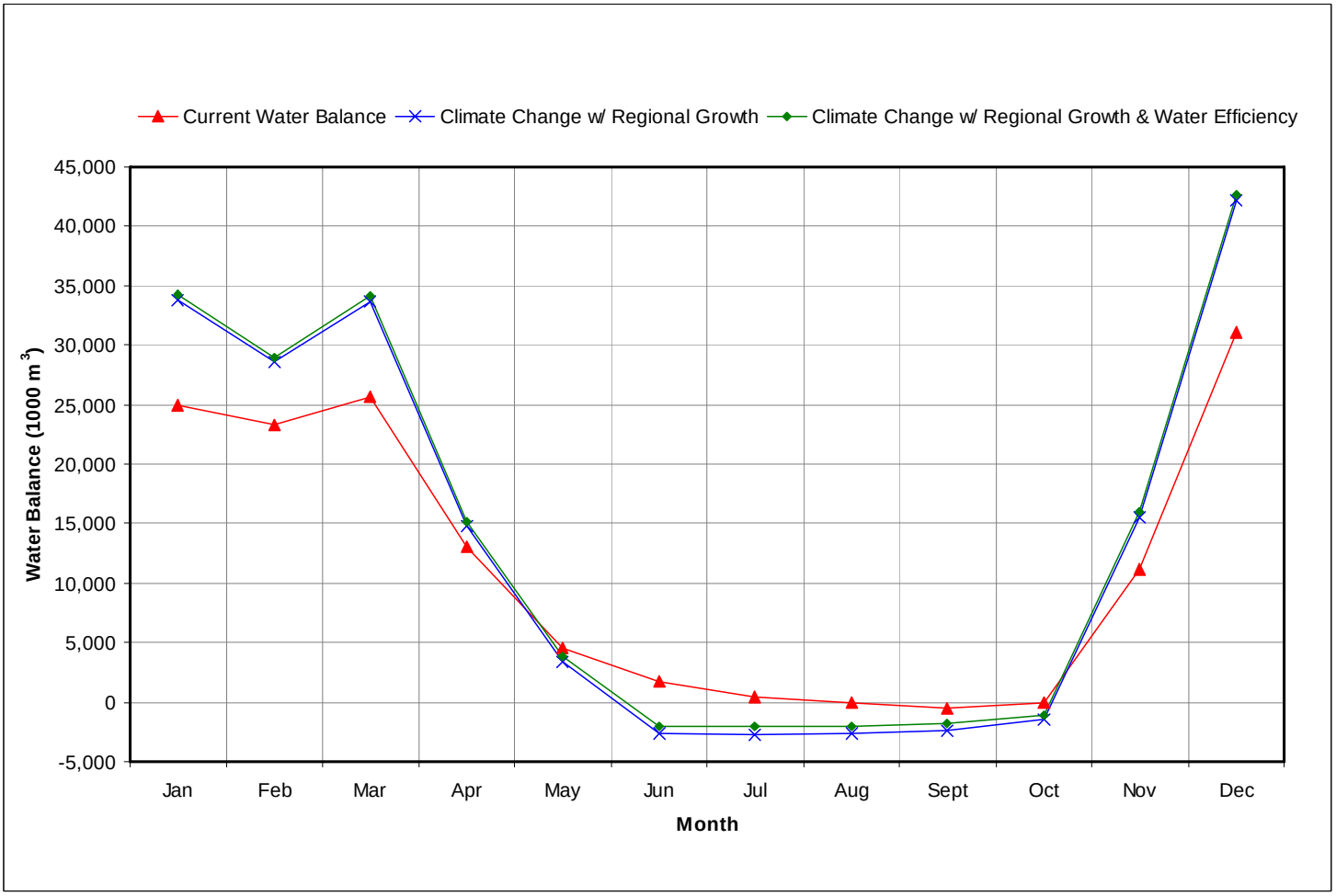
2009-02-11	date	edited by	OTHERS	drawn by	JB	app by	PROJECT NUMBER: V19830100	FIGURE: 15



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COWICHAN VALLEY REGIONAL DISTRICT
SOUTH COWICHAN WATER STUDY PLAN

SURFACE WATER BALANCE SUMMARIES
FOR ALL SCENARIOS

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2009-02-11	date	MGM	edited by	KM	drawn by	JB	app by	PROJECT NUMBER: V19830100	FIGURE: 16

FILE: J:\1976-1995\V19830100_Cowichan District - Water Plan Study\DRAWINGS\FIGURES\FIGURE 16.dwg Issued By: Victoria CAD

Appendix 1 Individual Aquifer Conceptual Models from MOE Worksheets

Cherry Point Aquifer (197)

The Cherry Point aquifer has been described by the MOE as comprising about 39 km^2, located on the south side of Cowichan Bay, extending north to Mill Bay, and to Shawnigan Creek in the southwest. Its western (possibly upgradient) boundary is the base of Cobble Hill and the Dougan Lake Aquifer, while to the east (downgradient) is Arbutus Ridge. This poorly sorted sand, gravel and silt aquifer (Vashon Drift origin) is described as having moderate productivity with a reported yield range of 0.01 to 17.35 L/s. A groundwater flow direction has not been determined but is inferred north towards Cowichan Bay. MOE information originally indicated that the Cherry Point aquifer has low vulnerability to surface contamination due to overlying Marine and Glaciomarine deposits, including clay, till and silty sand and gravel. However, this inferred degree of protection may only apply to the lower confined aquifer (see below).

Information from a groundwater characterization study completed by Thurber has lead the MOE to believe that the aquifer is more complex than previously thought, with the deep confined aquifer intersected by the Arbutus Ridge Utility operating well field corresponding to MOE Aquifer 197. Within the Strata Plan 1601 well field area there are two distinct water bearing zones (aquifers) separated by 10 to 25 m of marine clay and silt (aquitard), providing a natural protective barrier to the water bearing materials in the lower aquifer. Two of three adjacent golf course irrigation wells supplying the Arbutus Ridge Golf Course are completed in an upper (unconfined) aquifer zone. The third well is completed in both the upper (unconfined) aquifer and lower (confined) aquifer. The adjacent Granfield farm agricultural irrigation wells tap into the same lower confined aquifer as the Utility wells. Some of the domestic and irrigation wells in the surrounding area appear to penetrate only the upper unconfined aquifer, some only the lower confined aquifer while others may intersect both aquifers. The aquitard separating the shallow and deeper aquifers appears to be missing in the area near some of the Braithwaite Utility and the Cobble Hill Improvement District wells (near the Trans Canada Highway and Fisher Road / Hutchinson Road, about 3 km from Arbutus Ridge). These wells are at least 60 m deep with continuous permeable granular materials from the surface. Water levels are typically 30 to 45 m below surface. As such, the confining layer (aquitard) described above may be discontinuous. .

Groundwater from the Cherry Point aquifer is used for irrigation, commercial, municipal domestic purposes. Several water licenses also exist on many surface water sources in the area. Several residents obtain domestic water supply from the Cobble Hill, and Cowichan Station bedrock aquifers which occur beneath the Cherry Point Aquifer.

Kingburne Aquifer (201)

This is a small confined sand and gravel (Vashon Drift) aquifer of approximately 1.7 km^2 in size, overlain by thick till, clay and hardpan layers and upland swamp deposits, located west of Cobble Hill. The inferred aquifer productivity is moderately high with an estimated yield range of 0.38 to 4.73 L/s. Aquifer vulnerability is low, while groundwater flow direction has not been determined directly but is inferred west towards the Koksilah River, and recharge is hypothesized to derive from precipitation and runoff from the surrounding mountains. Water use is predominantly domestic. Two surface water licenses also exist on Heather Bank Brook.

Carlton Aquifer (205)

The Carlton aquifer is a small (2.6 km^2) confined aquifer comprised of poorly sorted outwash sand, gravel and silts (Vashon Drift) located between Shawnigan Lake and Mill Bay, and is surrounded by bedrock aquifers. Overyling deposits include thick silty sand and gravel, till, hardpan and clay mixtures resulting in low vulnerability to surface contamination. The aquifer is moderately productive with a range of reported yields from 0.19 to 3.16 L/s. Water use is for multiple purposes. Water reliance is conjunctive, water licenses exist on North and South Taggart Creek, Ericson Creek and a few springs in the area.

Mill Bay Aquifer (206)

The Mill Bay aquifer is a small aquifer (2.7 km^2) that is both confined and unconfined and comprised of coarse grained deposits. It is bound to the north by Shawnigan Creek, to the west by Handyson Creek, to the south by an upland area, while to the east it pinches out just before the Saanich Inlet. Productivity is moderate with reported yields ranging from 0.09 to 22.1 L/s. Groundwater flow and availability is concentrated in a bedrock channel where the aquifer is thickest. The vulnerability of the Mill Bay aquifer is variable but is generally classified as highly vulnerable due unconfined conditions in the upslope recharge area. In the northern central portion of the aquifer a clay layer occurs. The clay overlies a portion of the buried channel that creates artesian aquifer conditions in that area. Silty sands and gravels also confine the aquifer to a lesser degree throughout much of the area. Lowen (1994a) has determined the direction of flow as north/northeast and the recharge mechanism as infiltration from precipitation and lateral flow from upslope recharge zones in the southern portion of the aquifer. Groundwater from this aquifer is used for municipal and domestic purposes. Saline groundwater has been noted adjacent to the Trans-Canada highway (Kohut, 1987) and may be due either due to saltwater intrusion from Saanish Inlet induced by groundwater pumping in the aquifer or from application of road salt. Water reliance is conjunctive. Several water licenses exist on Handysen, Wheelbarrow, Bird, Goodhope and Wilkins Creeks. Wheelbarrow Springs are also a source for the municipal water supply. The Bamberton Aquifer (no. 207) occurs beneath the Mill Bay Aquifer and can supply additional domestic and municipal water needs to Mill Bay residents.

South Cowichan Aquifer (196)

This 45.8 km^2 shale and sandstone bedrock aquifer includes the area south of the Cowichan River to the base of the Koksilah Ridge. The eastern boundary is the Lower Cowichan River floodplain and the western boundary extends to Holt Creek. Overlying deposits include marine and glaciomarine sediments, ground moraine and glaciofluvial deposits. The aquifer is characterized by low productivity with reported well yields of 0.02 to 0.63 L/s. The direction of flow has not been determined but it is hypothesized to flow toward the Cowichan River. Recharge is suggested by precipitation, runoff from the mountains to the south and/or inflows from surficial water bearing zones. Water use is domestic while water reliance is conjunctive. Several water licenses exist on Glenora, Vaux, Holt, Motek and Kelvin Creeks. Water licenses also exist on Tattum Brook, Vaux Swamp, springs and other unnamed streams in the area. The Glenora aquifer is a confined surficial aquifer that overlies the South Cowichan bedrock aquifer.

Cowichan Station Aquifer (198)

Cowichan Station is a 6.1 km^2 predominant shale bedrock aquifer with some sandstone layers, south of the Cowichan River estuary, and east of the Koksilah River floodplain. The eastern boundary of this aquifer occurs below the Cherry Point aquifer. Cowichan Station aquifer is described as having low productivity with a reported yield range of 0.06-1.26 L/s. This aquifer is described as having low vulnerability, and the direction of flow has not been determined. Water use is domestic while water reliance is conjunctive. Water licenses exist on Treffery Creek, Koksilah River, Webb Brook and Giese Brook. Many wells in the area are completed in the overlaying Cherry Point aquifer.

Kelvin Creek Aquifer (200)

This is a 27.7 km^2 bedrock upland aquifer comprised of crystalline and volcanic rock, south of the Cowichan River valley between Koksilah River and Kelvin Creek. The western boundary is hypothesized to extent to the Koksilah Ridge. Overlaying sediments are predominantly ground moraine. This aquifer has low productivity with a yield of from 0.02 to 1.58 L/s. The aquifer has moderate vulnerability with about one third of reported wells having indicating no confining cover. The direction of flow and recharge mechanisms have not been determined. Water use is domestic and water reliance is conjunctive. Several water licenses exist on Koksilah River and Kelvin Creek. Water licenses also exist on springs and unnamed streams in the area.

North Shawnigan Aquifer (202)

The 20 km^2 North Shawnigan aquifer is comprised predominantly by volcanics and divided by the San Juan Fault with bedrock being older to the north of the fault. The aquifer is located north of the Shawnigan lake watershed basin, and bounded to west by the Koksilah River, east by Shawnigan Creek and to the north and east by Cobble Hill. This aquifer is determined as having low productivity with a range of yields from 0.02 to 5.68 L/s. The direction of flow and recharge mechanisms have not been determined. Groundwater wells in this aquifer are used for municipal and commercial purposes, water reliance is conjunctive. Numerous water licenses exist on Shawnigan Lake and other creeks, streams and springs in the area. The Kingburne aquifer occurs above the northern central part of the North Shawnigan Aquifer.

Shawnigan Lake Aquifer (203)

This 30.5 km^2 predominant gneiss aquifer is located in the Shawnigan Lake watershed basin. The productivity is reported as low with a range in yield from 0.01 to 4.42 L/s. The vulnerability of this aquifer is high with about half of the reported wells indicating no protective overburden cover. Direction of flow has not been determined however it is probable that the direction of flow is toward Shawnigan Lake. Recharge has not been determined but it has been hypothesized that precipitation and runoff from surrounding mountains provide recharge for this aquifer. Groundwater wells in this aquifer are used for irrigation and for community water supply. Water reliance is conjunctive with several licenses on Shawnigan Lake, creeks, streams and springs in the area.

Cobble Hill Aquifer (204)

The Cobble Hill aquifer is a 21.4 km^2 predominant granodiorite and quartz aquifer in the Mill Bay and Cobble Hill area. Its southern boundary is Shawnigan Creek, the western boundary is the base of Cobble Hill and the eastern boundary is Saanich Inlet, while the northern

boundary has not been delineated. Thick overburden occurs in the northern part of the aquifer. It is therefore classified as moderately vulnerable although overburden is much thinner in the southern and eastern portions of the Cobble Hill Aquifer. This is a moderately productive aquifer with a yield range of 0.03 – 8.52 L/s. The direction of flow has not been determined however it is anticipated that flow is toward the Saanich Inlet. Recharge mechanisms have not been determined, but is probably from precipitation. There are multiple users of this aquifer including domestic, irrigation, and community water supply. Water reliance is conjunctive. Several water licenses exist on rivers, creeks, and springs in the area. The Cherry Point Aquifer overlies the Cobble Hill Aquifer in the northern area of the aquifer.

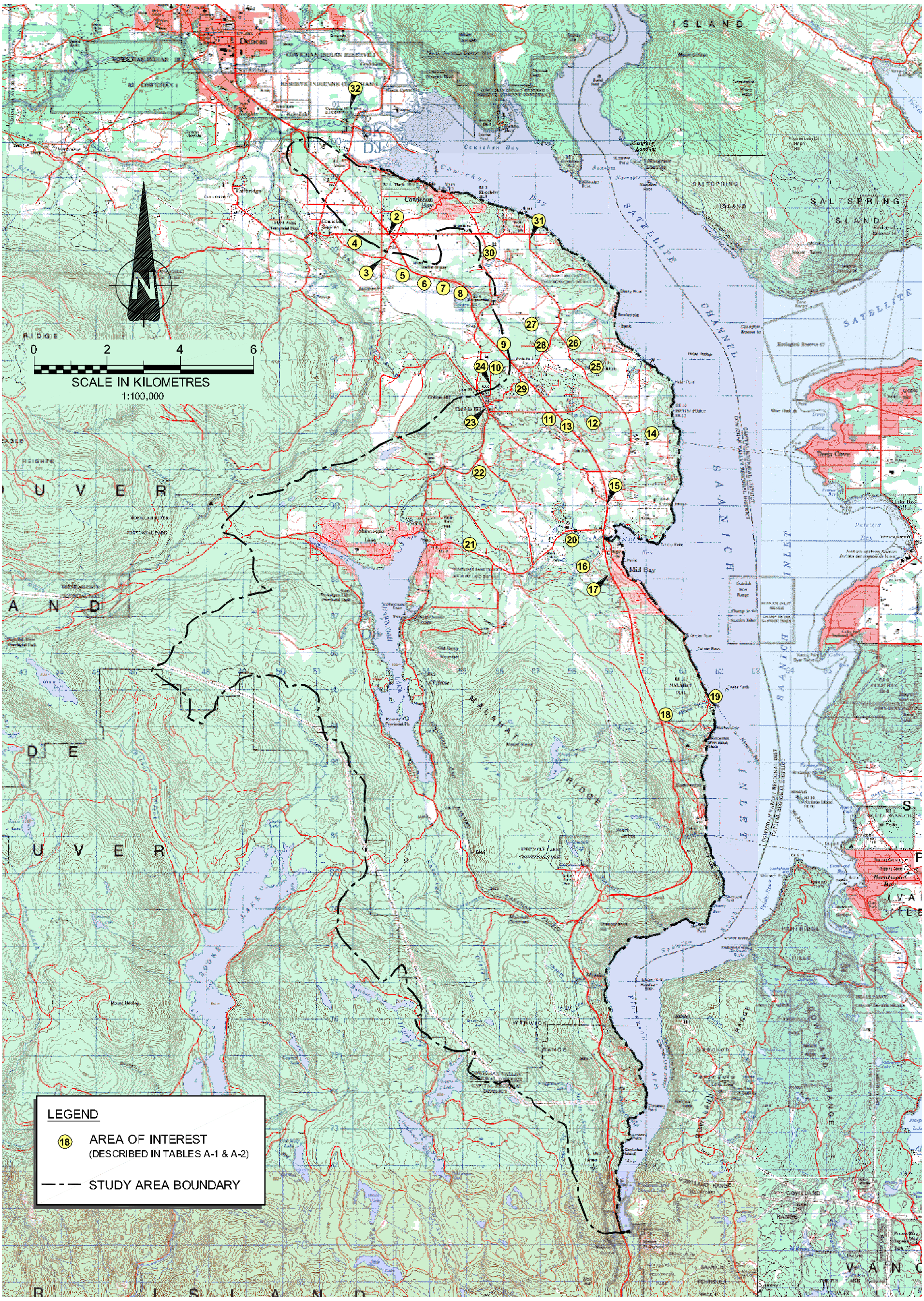
Bamberton Aquifer (207)

The 27 km^2 Bamberton aquifer is comprised of volcanic intrusives and occurs east of the Shawnigan Lake watershed. It extends to Bamberton Park in the south, Saanich Inlet to the east and Shawnigan Lake to the north. Productivity is low to moderate with a reported yield range of 0.02 to 12.62 L/s. Aquifer vulnerability is moderate. Thicker deposits including marine and glaciomarine clays and silts, and glacio-fluvial deposits of Vashon drift occur in the northern and eastern portions of the aquifer. The Mill Bay Aquifer (206) occurs above the bedrock aquifer near Mill Bay. Neither direction of flow or recharge have been fully determined, however it is assumed that the direction of flow would be east towards the Saanich Inlet and north into the Mill Bay aquifer, while recharge is likely from precipitation. Wells are used for domestic, municipal, irrigation and commercial purposes. Water reliance is conjunctive, several water licenses exist on springs and streams in the area.

Malahat Aquifer (208)

This 20.5 km^2 gneiss aquifer is located between Spectacle Lake on the north and Arbutus Creek on the south. The eastern boundary is Saanich Inlet and western boundary is the Malahat Ridge. The productivity of this aquifer is moderately low with a yield range of 0.03 to 3.79 L/s. The vulnerability of this aquifer is classified as high, with bedrock predominantly outcropping (76% of reported wells) or being overlain by a thin cover of ground moraine. The direction of flow has not been established but it is believed that water flows east toward the Saanich Inlet, and recharge is likely from precipitation and runoff from mountains to the west. This aquifer is being used for domestic purposes. Water reliance is conjunctive with several water licenses on creeks, streams, lakes and springs in the area.

Appendix 2 Summary Information from Meeting with Drillwell



Basemap Source: National Topographic Servic Map Sheets: 92-b-13, 92-b-5, 92-b-14, 92-b-11, 92-b-6 & 92-b-12

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COWICHAN VALLEY REGIONAL DISTRICT
SOUTH COWICHAN WATER STUDY PLAN

DRILL WELL TOUR MAP

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Source: Information from meeting with drillwell driller: Mr. David Slade.

2009-02-11	date	KM	edited by		drawn by	DB	app by	PROJECT NUMBER:	FIGURE:
								V19830100	A

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Map #	Description	Overburden or Bedrock	Yield (All units imperial)	Well deepening/Water Level Decline	Notes
1					
2	Hillbank Rd. 3 Wells, corner of trailer Park		30 g/min		
3	Hillbank and Lakeside	Bedrock			Modest flow. South of this area the aquifer disappears, bedrock at surface.
4	Aquifer almost non-existent.	Shale Ridge	2 g/min		Shale ridges, 400 ft of low permeability material, stinky & cloudy water
5	On west side excellent wells	Overburden	50g/min at 200 ft		
6	Good Aquifers	Overburden	50-100 g/min		
7	Well at 300 ft depth (1965)	Overburden			plugged with silts and clays, low transmissivity
8	Dougans Lake	Overburden			Water Levels don't change at Dougans lake. Example of Cobble Hill Aquifer- across from Lake, gravel pit on Indian Reserve. Layered Sands
9	Edge of Aquifer.	Overburden	Valley View: 300 g/min Seed Orchard: 200 g/min Blue Rose: 10 g/min		Contentious well in Valley View at Cowichan Bay road (300g/min) It is in the Cobble Hill municipality/aquifer and they don't want to lose it
10	Edge of Cobble Hill Water District.		200 g/min		Behind bakery putting in a production well guessed to yield 200g/min and tied into CH system
11	Decline in Cobble Hill Aquifer:	Overburden		3 wells deepened on Hutchinson Rd 3 wells were deepened (Ravencrest) Deepening wells (decline approx 25 feet in 20 years)	E on Highway 1 on Hutchinson Rd Corner of Hutch and Cowerd Rd, Cedarwood place and Cowerd #1017, #1008 200-300 feet overburden Braithwaite water system loops around Cowerd subdivision
12	Ravencrest and Chapman Road	Edge of Overburden and into bedrock		Biggest depression in Water Levels: North; Braithwaite and Agricultural users. East; Arbutus Ridge. West; Cobble Hill. Ten years ago one well went dry in this area	Edge of Cobble Hill overburden aquifer had to go into bedrock (heading S) Adjacent to Ravencrest Rd bedrock instead of sedimentary formation No snowmelt , local precip only and 2008 was a dry year
13	All wells south of here are bedrock wells (granite/limestone/volcanics) 500 ft depth	Bedrock	20g/min		
14	Mill Bay (Some Cobble Hill type ground)	Bedrock			Dairy farms in Mill Bay are the big users of the bedrock aquifer.
15	Bedrock very close to surface, exposed.	Bedrock	Petrocan Wells: 50g/min at 400 and 500 ft depth		Cobble Hill Rd. Agriculture – sprinklers George Bonner School – 400 ft well
16	Deloume Street – Well in Football Field	Overburden	200 g/min in 200 ft		Mill Bay used springs for years – artesian Bedrock is exposed 20 feet away High in Iron
17	Flowing Artesian Wells – not practical	Bedrock Perched overburden aquifers at the end of the rd	New MB Well 100 g/min at 500 ft Aerie Hotel (5 wells) 9 g/min at 1000 ft depth Stebbings Rd. 2 g/min static water level is 100 feet		300 feet away from the football field well Reaches the extent of the Mill Bay Water District South from the Aerie it is mostly bedrock, with pockets of 80 ft of overburden on hillsides Some fractured bedrock with highly productive zones Bottom part of Mill Bay is dry seasonally!

Source: Information from Drillwell driller : Mr. David Slade.

* Numbers coincide with numbers on the accompanying map.

* Please note that is information was collected from Mr. Slade's memory, and I did not see drill logs.

* Mr. Slade uploads all his information to WELLS - Ground Water Wells database (BC MOE)

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COWICHAN VALLEY REGIONAL DISTRICT
SOUTH COWICHAN WATER STUDY PLAN

DRILL WELL TOUR TABLE
PART 1 OF 2

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2009-02-11 date	KM edited by	drawn by	DB app by	PROJECT NUMBER: V19830100	FIGURE: A-1

Map #	Description	Overburden or Bedrock	Yield (All units imperial)	Well deepening/Water	Notes
18	Cement Plant for 50 years in the area	Bedrock			Poor bedrock aquifers May have not gone deeper than 500 ft Never found good yield from here to the crest of the malahat Nothing but domestic water wells
19	19).Inlet Dr.	Bedrock	In overburden: 20 g/min Many 1-2 g/min		Some salt water intrusion Perched aquifer on hillside at Mill Bay- Brentwood Ferry Many 4-500 ft 1-2g/min wells
20	Kelseys School	Overburden	Kelsey's School: 4 g/min, hydrofractured to 25 g/min Kerry Park at Wilkinson: 3 g/min		30m away from Kerry Park artesian, overburden at 100ft used for farm irrigation. 20 feet away on ridge wells are 300 ft deep in overburden ▪ Some personal wells are hand dug to 100 feet ▪ NEW water main going in here – possible major new development? ▪ Still fair way from Shawnigan Lake Water District Private well area is still pretty much bedrock outcrops
21	Fire Department in Shawnigan Lake district				New business centre 2 miles W edge of SL district High density of houses around
22	Between Cameron-Taggert and private Rd. (NW of Mill Bay)	Overburden	2g/min at 100 ft At 500 ft good producers		High iron
23	Cobble Hill Rd / Hutchinson Rd				Aquifer does not exist on the corner, wells were not successful
24	Holland and Gallier Rd	Overburden	200 g/min at 200 feet		Galliers Green subdivision with 14 homes to go in. **Best #1 Well in Cobble Hill**
25	Part of Cobble Hill Aquifer on the West side of telegraph Rd.	Overburden	Highly productive and deep		On the E side the aquifer does not exist – bedrock outcrops
26	Aros (granite) by trailhead – gravel aquifer	Overburden (Gravel Aquifer)			Between Aros and Braithwaite on East Side of telegraph Rd. Aquifer does not exist – some successful wells - shale outcrop
27	Wilder Rd. well at 70 feet deep (in field by tree line)	Bedrock 200 feet	150g/min		Artesian (3 feet above ground level) Well downslope of maine clays to 500 ft
28	**Braithwaite District Well 250 feet deep #1 WELL** • Cobble Hill Wells to the W, And Arbutus Ridge to the E = Pinch	Overburden		In the North, this well is effecting the Cobble hill Aquifer and showing local drawdown	Braithwaite Farm is a big user Densification of Cobble Hill Core by the newly proposed well at the corner of the bakery (#10) at Fisher road and Trans Canada Hwy
29	Big Greenhouse complex on Fisher Road down from the bakery (#10)	Overburden 116-137 feet			Furthest well from the local problem
30	Corner of Cowichan Bay and Telegraph Rd.		Telegraph Rd: Irrigation well – 250 ft deep 60-80 g/min		Bench Elementary School, two wells drilled one by fence 300 feet depth
31	Cherry Point Road	170 ft to Bedrock in Cow Bay (marine clays) Cherry Pt. Rd. good gravel aquifer			Cow Bay - Salty

Source: Information from Drillwell driller : Mr. David Slade.

* Numbers coincide with numbers on the accompanying map.

* Please note that is information was collected from Mr. Slade's memory, and I did not see drill logs.

* Mr. Slade uploads all his information to WELLS - Ground Water Wells database (BC MOE)

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COWICHAN VALLEY REGIONAL DISTRICT
SOUTH COWICHAN WATER STUDY PLAN

DRILL WELL TOUR TABLE
PART 2 OF 2

WorleyParsons
resources & energy

2009-02-11 date	KM edited by	drawn by	DB app by	PROJECT NUMBER: V19830100	FIGURE: A-2

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Appendix 3 MOE Hydrogeologist Review of Evidence for Declining Well Water Levels

BRITISH COLUMBIA

January 23, 2007

Gerry Giles
Director-Electoral Area C Cobble Hill
Cowichan Valley Regional District

Dear Gerry:

Re. Review of information suggesting declining groundwater levels in the Cobble Hill Aquifer

At a meeting in Duncan on June 9, 2006 I agreed to review some of the available groundwater levels in the Cobble Hill aquifer that suggested the groundwater level in the aquifer is declining presumably to unsustainable use of the groundwater resource. Subsequently, on July 4, 2006, Dave Slade (Drillwell Enterprises), Jens Liebgott (Cobble Hill Improvement District) and I spent the morning touring the area in Cobble Hill which uses the Cobble Hill Aquifer. Dave Slade has also provided me with water levels for three domestic wells that have recently been deepened, the Cobble Hill Improvement District main well and the monitoring well at the Cobble Hill Elementary School. Additionally, the Ministry has two observation wells in the aquifer (Arbutus Ridge and Braithwaite Estates) in which data is complete to the end of 2006. A report outlining the data I have examined will be forthcoming shortly.

Briefly, the three domestic wells which were deepened (located in the Cowerd Rd/Raeview Cres. Area) show declines in static level between 1.5 m and 4.0 m over 23-28 years. The Cobble Hill Improvement District well shows a drop of 2.1 m over 22 years and the elementary school well shows a drop of 0.9 m in 5 years. The Braithwaite Estates observation well (Well No. 320) between 2001 and 2006 showed a drop in peak values of 0.9 m (similar to the school well). Lastly, our observation well at Arbutus Ridge development shows a drop in peak annual values of 1.3 m over the last 4 years. While at first glance all of the data mentioned above suggests a drop in groundwater levels, it is important to note that Well 320 at Braithwaite Estates (the longest continuous record in the aquifer) also indicates a longer cycle likely related to precipitation where peak annual levels increased between 1995 and 2000, decreased between 2000 and 2003 and have been fairly steady since 2003. Clearly, this needs to be analysed further to better understand the natural fluctuations in the aquifer. Our current observations are based on very limited data and levels in the two observation wells are impacted by pumping in neighbouring wells.

Considering the possible development pressures in the region, a study examining the 'state of the aquifer' would be appropriate and timely. The scope of the study might include:

(1) Examining available groundwater levels and their change with time.
(2) Relating groundwater levels with precipitation records.

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Vancouver Island Region
Watershed Stewardship Division
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(3) Estimating groundwater usage (including groundwater used for irrigation, industry, domestic water supply etc.)
(4) Revisiting the aquifer boundaries and delineation.
(5) Assessing where the aquifer is being recharged.
(6) Developing a general water budget for the aquifer to better understand the sustainable capacity of the aquifer.
(7) Integrating projected water demand with potential capacity.
(8) Assessing measures to reduce demand on the aquifer if necessary.

Issues related to threats to groundwater quality should also be addressed; however I note that the "Vancouver Island Water Resources Vulnerability Mapping Project" which the CVRD is supporting will assess potential threats to the aquifer.

I believe that the groundwater of the Cobble Hill Aquifer is a valuable resource to residents in the Cobble Hill area and would like to assist in proactive initiatives which aim to ensure that the aquifer is used in a sustainable manner now and in the future.

Sincerely,

Pat Lapcevic, M.Sc., P.Geo.
Regional Hydrogeologist

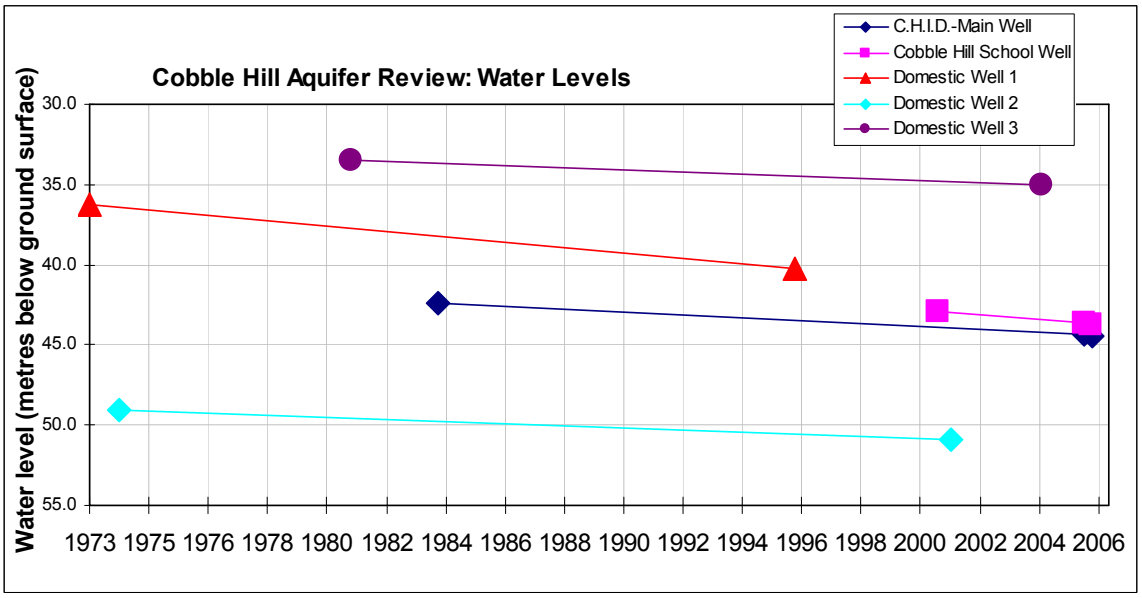

Figure 1. Water level measurements in 5 wells completed in the Cobble Hill Aquifer.

Table 1. Summary of water level changes measured in area wells.

Well Identification	Period of Record (yr)	Total Change in Water Level (m)	Rate (m/yr)
Cobble Hill Improvement District-main well	22	-2.06	0.09
Cobble Hill Public School Monitoring Well	5	-0.85	0.16
Domestic Well #1	24	-3.96	0.17
Domestic Well #2	28	-1.83	0.07
Domestic Well #3	23	-1.52	0.07

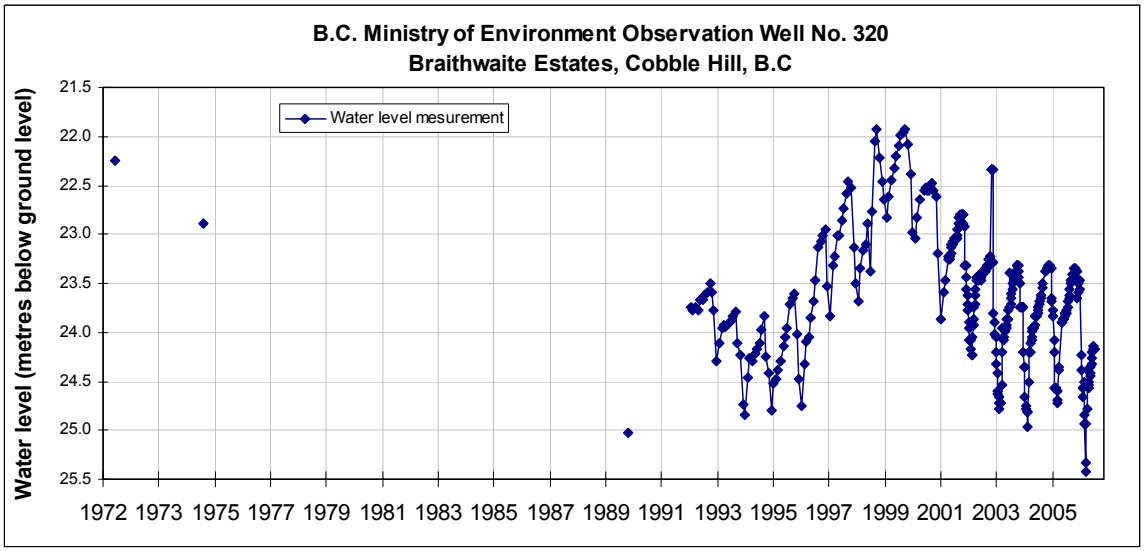

Figure 2. Water level measurements in Braithwaite Estates monitoring well (B.C. Ministry of Environment No. 320) over last 34 years.

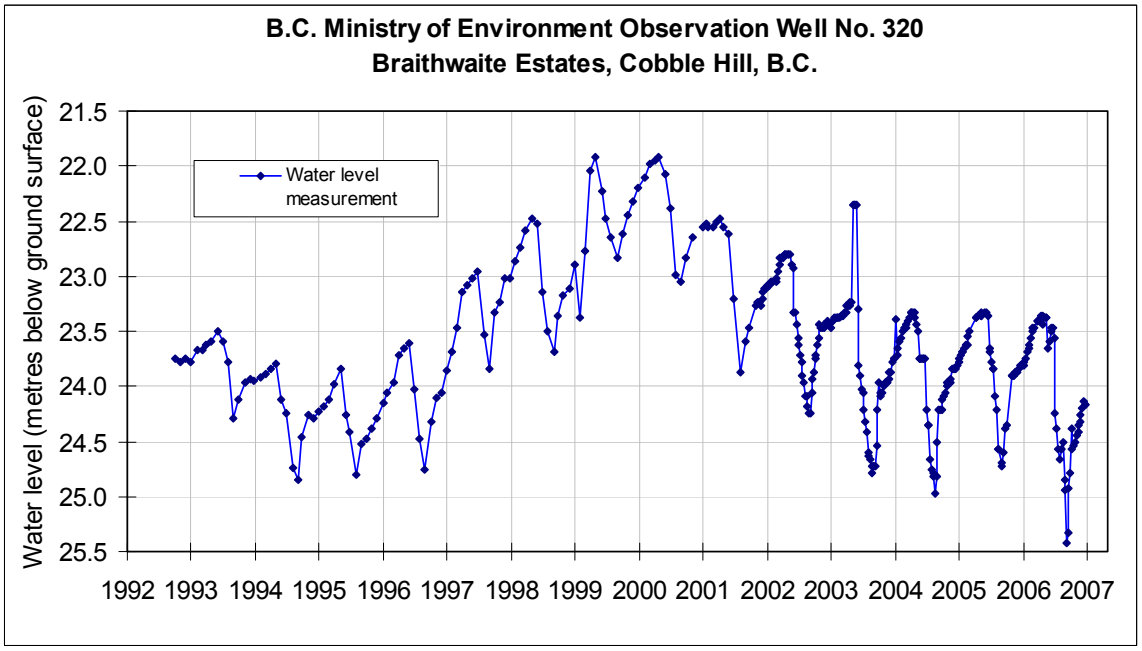

Figure 3. Weekly measurements of water level in Braithwaite Estates monitoring well (B.C. Ministry of Environment No. 320) over last 15 years.

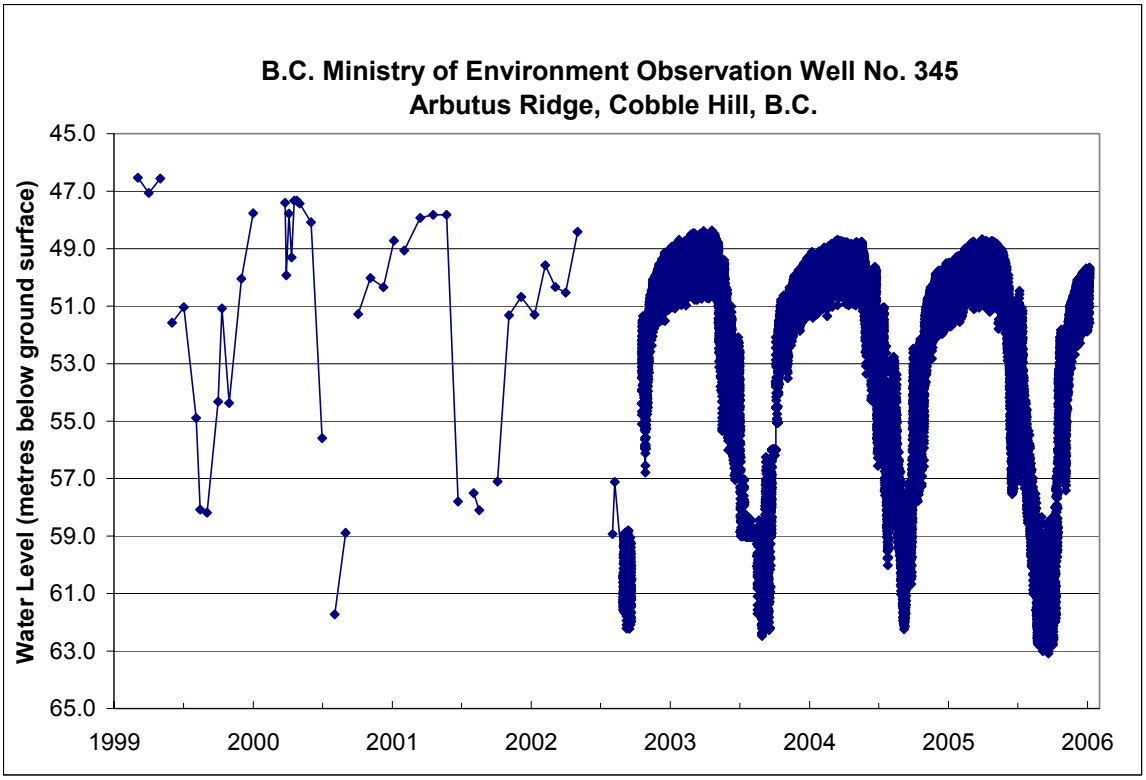

Figure 4. Water level measurements in Arbutus Ridge monitoring well (B.C. Ministery of Environment No. 345) over last 7 years.