French Creek Watershed Study

Produced By

Ministry of Water, Land and Air Protection
Ministry of Sustainable Resource Management
Nanaimo Regional Office

2001/2002

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Introduction

As the East Coast of Vancouver Island continues to develop, its lands are subject to the various demands of public need. We harvest timber, work farms, locate housing, manage waste, expand commercial and industrial opportunities against a spectacular backdrop of wilderness, faunal diversity, clear streams and open wetlands. Initially our footprint is small, but as we grow we cannot avoid indelibly changing the landscape upon which we rely. It seems prudent to periodically take stock of where we are in the developmental stage, what we have affected and what remains. The Ministries of Water, Land and Air Protection and Sustainable Resource Management are uniquely equipped to examine this issue, addressing within their respective mandates public health and safety, sustainable development and environmental stewardship. Scientific and technical staff in these ministries have a history of familiarity with the watersheds, their developments and their sensitivities. These specialists have skills in hydrology, fish biology, contaminant analysis, wildlife biology, geomorphology and the administrative processes guiding land development.

The French Creek watershed study is the culmination of eighteen months of data gathering, synthesis, analysis and report writing. It consists of several separate but related papers on (in order of appearance): surface hydrology, groundwater hydrology, water use, impervious surfaces, sewage disposal, water quality, fish and aquatic habitats, wildlife impacts, changes to sensitive ecosystems, and environmental protection within community plans. It is meant to accurately describe the current condition of the watershed based on the data that was available to the authors at the time. In some instances, developmental trends are projected forward, and the reader is introduced to several choices and concepts that may affect the integrity of the watershed tomorrow.

Study area

French Creek drains a watershed approximately 68 km^2 and is located on the East Coast of Vancouver Island near the City of Parksville. The watershed consists of steep forested headlands that drain the edge of the South Vancouver Island Ranges, 1080 meters above sea level, and the more gentle topography of the Nanaimo lowlands. The lowlands are commonly used for farmland, rural residential, commercial and urban residential as well as the main transportation corridors. The largest body of water in the watershed area is Hamilton Marsh, which drains into French Creek downstream of the Alberni Highway (Highway 4). A map showing the watershed and its location on Vancouver Island is in Figure 1.

French Creek has been a designated community watershed since June 1995 with the coming into effect of the Forest Practices Code. The Forest Practices Code Act and regulations contain provisions for protecting community water supply in the course of forest development. These include such measures as wider riparian reserves along streams. The designation affects the crown forest land portion draining into French Creek above the intake of Breakwater Enterprises Ltd., a private water utility regulated under the Water Utilities Act.

In April 2000 the Private Land Forest Practices Regulations came into effect. Under this legislation private forest lands within the Forest Land Reserve that fall within the community watershed drainage area are designated a Water Supply Area and are subject to additional regulations to protect water. The Private Land Forest Practices Regulations are administered by the Land Reserve Commission which also has responsibility for the Agriculture Land Reserve.

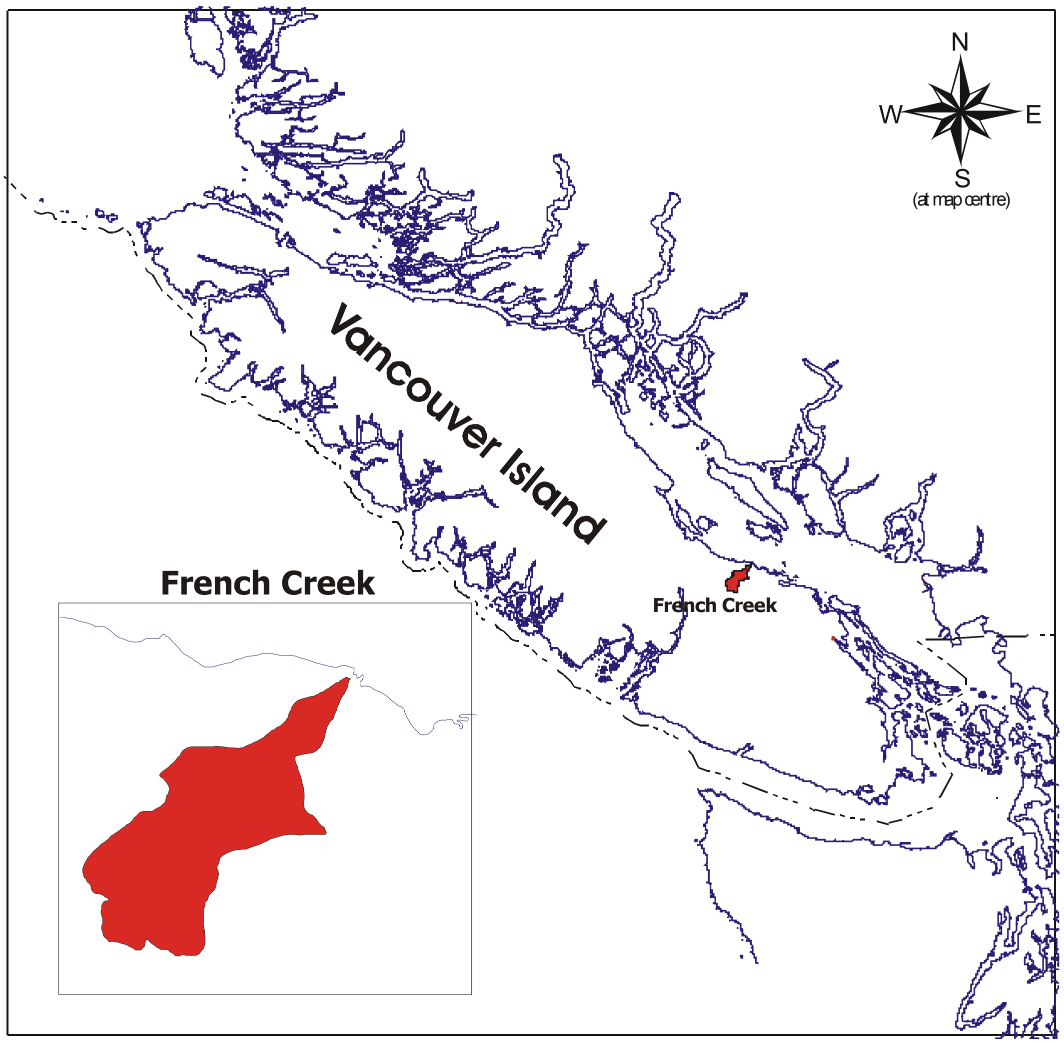

Figure 1. Location map of the French Creek watershed on Vancouver Island British Columbia.

As with many watersheds on southeast Vancouver Island, the Crown forest land occurs as small islands separated by large tracts of privately held lands that comprise the Esquimalt & Nanaimo Railway grants. Private lands in French Creek comprise the urban and rural settlement areas, agricultural land reserve, and private lands within the Forest Land

Reserve. Crown forest land makes up only 328 ha (2.3%) out of a total watershed area of 6800 ha. The land parcels range in size from 9 ha up to 155 ha. There is one crown administered woodlot license.

These parcels contribute to the forest inventory of growing stands that factor into the allowable annual cut determination for the Arrowsmith Timber Supply Area. The Arrowsmith TSA encompasses all crown forest land outside of Tree Farm Licenses on south Vancouver Island. Forest use is administered by the Ministry of Forests South Island Forest District located in Port Alberni.

The watershed is within the Leeward Island Mountains of the Georgia Depression and includes portions of the Coastal Douglas Fir (CDFmm) and Very Dry Maritime Coastal Western Hemlock (CWHxm) biogeoclimatic zones of Vancouver Island. The forests of the watershed lie within the rain-shadow of the island ranges, and typically exhibit warm dry summers and mild wet winters. Growing seasons within these forests are therefore relatively long, although moisture deficits can be a limiting factor to productivity, especially on drier sites. These zones represent the mildest climates in Canada and as a result, the French Creek basin provides prime habitat and growing conditions for many forests based wildlife species and ecosystems.

The French Creek watershed primarily overlies the Nanaimo Group rocks, a formation of Cretaceous sedimentary rocks including coal, sandstone, siltstone, shale and conglomerate that form the coastal plain from Campbell River to the Saanich Penninsula. The steeper headwaters represent a change in geology to Jurassic age Island Intrusives (granites and granodiorites) and Triassic Karmutsen Volcanics. Covering the bedrock geology is a combination of coarse glacio-marine sediments less than 2 m thick over glacial till. Fluvial and glacio-fluvial deposits are common along the lower half of French Creek including exposures of the Quadra Sands. The urban areas near the mouth sit primarily on a thin section of terraced deltaic deposits, underlain by silt and clay.

FRENCH CREEK WATERSHED STUDY
Surface Runoff Hydrology and Land Use

Warren Cooper, RPF
Ministry of Water, Land & Air Protection
Province of British Columbia

March 2002

1.0 CLIMATE AND STREAMFLOW

French Creek is located approximately 35km north of Nanaimo on the southeast coast of Vancouver Island. The watershed takes in the community of French Creek at the mouth on Hwy 19A and the village of Coombs located on Hwy 4. The watershed is approximately 17 km in length and drains an area of 68 km^2. To the northwest it is flanked by the Little Qualicum River and by the Englishman River to the east and south.

The watershed has predominantly low relief with the exception of the Rowbotham Lake plateau at approximately 950m that forms a divide with the Englishman River. The lower coastal plain has flat to gently sloping terrain with pockets of poor drainage and wetlands.

The climate is influenced by the rain shadow effect of Mount Arrowsmith and increasing coolness and wetness towards the headwaters. During the winter the climate is controlled by moist maritime air masses associated with cyclonic storms and easterly onshore winds. Approximately 80% of the annual precipitation is received between October and May. The months of July and August are dominated by high pressure systems in the Pacific that block the low pressure cells that retreat into the Gulf of Alaska. Summer months experience a growing season moisture deficit relative to evapotranspiration demand from crops and forest cover.

Climatic variation within the watershed is illustrated by the variation in biogeoclimatic classification (see Figure1). Biogeoclimatic zones are characterized by changes in forest cover and understorey indicator species that reflect climate and soil conditions. The lower watershed is within the Coastal Douglas Fir – moist maritime subzone (CDFmm). This subzone is restricted to a narrow band along the coastal plain extending from Bowser to Victoria and the Gulf Islands up to about 120-150m elevation. Coastal Douglas fir, grand fir and western red cedar occupy representative zonal sites with salal, Oregon grape sword fern and ocean spray in the understorey. Rare Garry oak and arbutus are characteristic of some dry rocky sites.

The upper watershed comprises the smaller order streams draining the steeper uplands. Between 120-140m there is a transition into to the cooler and wetter moist maritime Coastal Western Hemlock subzone. Douglas fir continues to be a co-dominant species. Western hemlock, amabilis fir together with understorey blueberry increases with elevation on zonal sites as salal and sword fern drop out reflecting cooler and wetter conditions. A very small area of the watershed occupies the sub-alpine Mountain Hemlock subzone above 900m as shown in Figure 1.

Average annual precipitation is approximately 1100mm for the lower watershed. Figure 2 shows the annual variation in precipitation at Coombs, Qualicum and Parksville. Precipitation at higher elevations is expected to be greater resulting in higher precipitation averages for the watershed as a whole. Figure 3 shows the monthly distribution of precipitation.

Eighteen percent of the watershed lies between 300m and 800m in a transitional snow zone where rain causing melting of transient snowpacks may contribute to higher storm runoff. Another 11% of the watershed is above 800 meters where snow can be expected to accumulate over the winter months contributing to spring freshets. Approximately 71% of the watershed is below 300 m where precipitation falls almost exclusively as rain through the winter months. Airport temperatures representative of the lower watershed average 2-5 degrees above freezing during the winter period.

Streamflow data for French Creek is limited to summer flows with the exception of the 1995 year. Streamflow records are available for 2 Water Survey of Canada (WSC) stations with non-overlapping periods of measurement. From 1969 to 1989 Water Survey of Canada measured daily flows over the April to September period at Coombs. From 1990 to 1995 April to September daily flow records were collected from the WSC station above the Breakwater pumphouse lower down in the watershed.

Mean Annual Discharge for French Creek is estimated at approximately 2.1 m^3/sec (74 cfs). This yields an estimate for average annual runoff of approximately 970 mm. Estimated average monthly flows are shown in Figure 4.

Low flows over the summer months have been emphasized because they are critical to over summer survival of fish populations. This is also a high demand period for other uses such as irrigation. Low flows also reduce the dilution of potential contaminants affecting water quality.

Extractive water demand is only allowed without supporting storage for streams where the natural mean monthly flow is above 20% of mean annual discharge or where the mean 7-day low flow is greater than 10% of mean annual discharge.

Figure 5 shows the frequency of flows rated according to capacity to meet fish spawning and rearing requirements. There is a progressive reduction in flows meeting fish requirements from June through September. Flows in August and September are predominantly below 10% of mean annual discharge (MAD).

The policy for meeting additional licensed water demand in French Creek is based on creating storage of water that is extracted during high flow winter months (>60% mean annual discharge) for use in the low flow period. Importantly for French Creek, this policy extends to withdrawals from lakes, ponds, swamps, and marshes that supplement low base flows. The policy for these water bodies is to prevent shoal areas from being reduced by more than 10% of MAD.[1]

Peak flows generally occur between late October and March. An estimate of return period maximum daily flows was interpolated based on the relationship between basin area and flows for other representative east coast watersheds using regionalized analysis.[2] The watersheds chosen include the Englishman River, Browns River near Courtenay, Dove Creek, Rosewall Creek, and the Tsable River. Results from this approach yield estimates of 77m^3/sec for mean annual maximum daily discharge and 96m3/sec for maximum instantaneous peak flows. Reliability of estimates based on interpolation of data from other watersheds is dependent on how well these other watersheds represent the runoff characteristics of French Creek. These estimates should be considered a rough approximation subject to further validation.

Figure 6 shows the estimated return period peak flows for French Creek.
Winter storm peak flows observed in the 1995 data tend to track closely with peaks observed in the neighbouring Englishman River because of there proximity in relation to the same storm events. The correlation of peak flows in the Englishman River with those in French Creek could improve flood frequency analysis for French Creek if more winter flow data was available for French Creek.

The lower estuary is tidal and this can cause a backwater effect raising flood levels depending on coincident timing of peak events and high tides. A 1994 assessment of flood elevations[3] concluded that a flood of 440 m^3/sec would be required to overtop the highway. This is more than twice the current projected estimates for a 1 in 200 year event used for design purposes to meet approval requirements under the Water Act. This suggests that works designed on the basis of earlier estimates provide a high factor of safety.

Stream channel stability may be affected by large return event floods. During high flow events stability of a channel requires that the processes of sediment supply, transport and deposition are in balance resulting in bed forms, channel widths, and meander patterns that are characteristic for the type of channel. Impacts may result from human activities that alter sediment inputs, that reduce channel resistance or that directly modify the channel. Examples include the removal of riparian protection and introduction of debris

Stream channels vary in response and resistance to disturbance depending on confinement and the erodibility of substrates and bank materials. Confined bedrock sections are generally stable except for localized debris accumulations. These accumulations may alter local scour and deposition. Reaches with banks of unconsolidated tills, sands, and gravels are more erodible. Floodplain terraces in the lower watershed tend to be highly erodible.

Steeper gradient streams in the headwaters are characterized by coarse boulder and cobble stream bed morphologies reflecting higher energy flows capable of transporting large material. By contrast the lower gradient coastal plain is a zone of natural deposition.

Alteration of stream course in one location from debris or bank revetments can result in a sequence of downstream adjustments whereby the stream attacks banks that were formerly stable. Cut bank locations are by their nature more vulnerable to erosion. Ability to influence erosion processes is greatest in low cut bank locations where tree rooting extends deep enough to reduce undercutting during high flows. Therefore, removal of trees and deeper rooted shrub vegetation along low cut bank sections may result in bank destabilization. Examples of stream bank erosion associated with removal of riparian vegetation are illustrated in Appendix 2.

Reported flooding and erosion problems in the lower French Creek have a long history extending back to the early 1970's. These problems have been reported around River Cresent, Mason Trail and Lee Road. Lower floodplain terraces in the Grafton Road area near the confluence of the main upper tributaries also flood.

Remedial works, such as bank protection, have been placed on several sections of lower French creek under cost-shared agreements and by private land owners at their own cost. This cost sharing between the land owner and the province does not at the present time exist in its original format. Funds are now made available to municipalities and regional districts under the Flood Protection Assistance Fund (FPAF).

The flood protection assistance (fund) program provides funds to reduce and prevent future flood damage by repairing, improving or creating permanent flood works. All local governments, regional districts and diking authorities are eligible to apply for funding on a 75 per cent provincial, 25 per cent local cost-sharing basis. This instream work requires approval under the *Water Act*

The Provincial Government promotes the development of policies, bylaws and subdivision conditions that ensure new development does not cause increases in storm runoff from the proposed development area by more than what would have been designed for a 1 in 10 year storm event prior to development. For larger storm events (up to 1 in 200 year storm), the developer must evaluate the risk to downstream properties and undertake whatever measures are necessary to protect those properties that may be adversely impacted by increased runoff from the new development.

2.0 LAND USE & VEGETATION INFLUENCES ON HYDROLOGY

Vegetation covers vary in their potential to intercept precipitation and to influence snow accumulation and melt. Conifers intercept over the winter months whereas deciduous trees, brush, forbes and grasses are effective only during leaf out in the summer growing season. Mature or closed canopy forest cover with deep, dense overlapping crowns will intercept more than low brush, forbes and agricultural crops.

The effects on runoff land cover alteration from land use are dependent on factors such as regrowth, and vegetation types. Runoff responsiveness to land cover changes is also influenced by physiographic factors such as slope, drainage density, and soil characteristics that affect routing of runoff. Increasing precipitation and snow accumulation at higher elevations contrasts with lower elevation rain dominated runoff

Man made infrastructures such as roads and drainage ditches may intercept and concentrate storm runoff. Figure 7 shows the relative effects of land cover and elevation zone on interception and snowmelt for the French Creek watershed. It is based on judgements about relative effectiveness amongst broad land cover categories and their distribution within zones known to have different hydrologic response during winter peak flow months. Land use and cover classes were digitally interpreted from multi-spectral Landsat imagery combined with high resolution (5m) IRS satellite data.

Above 800m precipitation occurs primarily as snow and accumulates over winter. Runoff from the higher elevation sub-alpine takes place in the late spring and does not generally affect the largest storm peak runoff events occurring in the late October to March period.

Flooding events typically occur when warm moist air masses originating in the tropics and carried by the jet stream move onto the coast. These events may follow a period of snow accumulation resulting in runoff from snowmelt in addition to direct runoff from the rain. Most rain-on-snow events occur in the 300-800 meter zone where snowpacks accumulate, ripen and melt throughout the winter period.

Interception may be a significant factor influencing runoff for short duration low intensity storm events in the rain dominated zone below 300m. Long duration intense storm events will tend to overwhelm the interception capacity of most vegetative cover including mature coniferous forest. Below 300m the most significant influence of vegetative cover may be its influence on evapotranspiration and soil moisture conditions during the summer months.

Land use zoning and ownership are illustrated in Figure 8. Impact of vegetation cover changes varies across the landscape. The upper and lower watershed have distinctly different land use, climate, physiography and hydrologic responsiveness. For this reason they are discussed separately.

2.1 UPPER WATERSHED

The upper watershed comprises the smaller order streams draining the steeper uplands. The upper watershed is approximately 32 km^2 making up 47% of the total French Creek. watershed as shown in Figure 1.

Private forest land makes up 89% of the upper watershed land area. This is 80% of the total Forest Land Reserve in French Creek. Most of the remaining 11% of the upper watershed is within the Agricultural Land Reserve. A very minor amount of rural residential zoning also exists.

There are two parcels of Crown forest land in the upper watershed comprising 232 ha.

Harvesting in the FLR within the last 20 years accounts for approximately 1/3 of the upper watershed area. Twenty-five percent of the total upper watershed was interpreted as either ungreened-up or in low grasses, forbs, and shrubs. This indicates that most of the harvesting has occurred recently within the 20 year period.

Steeper topography, higher expected rainfall and greater drainage density indicate the potential for the upper watershed to respond more rapidly with higher per unit area runoff than the lower watershed. The drainage density in the upper watershed is 2.4 km of stream per square kilometre compared to the lower watershed that averages 1.1 km of stream per square kilometre. This equates to approximately 2 stream crossing per kilometre of road inclusive of access roads and the hydro line right-of-way in the upper watershed

While density of roads and stream interface are of potential concern, there is insufficient information to conclude that roads in the upper watershed have adversely affected runoff. Of the total shown as ungreened-up disturbance less than 1% is road surfaces within the FLR portion. The largest effect of roads is the interception of sub-surface flow and concentration of runoff through ditches.

For logged areas other than roads the term unvegetated surface or ungreened-up includes bare soil condition or fresh logging slash. In the case of forest harvesting, areas other than roads and landings will quickly become re-invaded with low ground covers in addition to planted seedlings. Interception and influence of replanted stands on snow accumulation and melt begins to recover rapidly with stand height growth and canopy closure in young immature stands.

The total area above 800 metres that accumulates snow over the winter periods comprises only 11% of the total watershed. A total of 337 ha above 800 m (5% of the total watershed) are classified from satellite photo interpretation as having been harvested in the last 20 years. Deeper snow packs in recently logged areas may contribute to slightly greater spring snowmelt freshets or late rain-on-snow events. These are expected to be generally smaller events than the peak flows generated over November to March period. The small area involved precludes any large effect on overall runoff in the lower watershed. There may be a slight incremental effect in spring groundwater recharge.

The 300 to 800m zone in the upper watershed is considered the most hydrologically responsive because of the potential addition of snowmelt to rainfall runoff.. A total of approximately 200 ha (17% of the total rain-on-snow zone) is classified as low ground cover. This is only 3% of the watershed and is not likely to be hydrologically significant.

Concerns about water quality often relate to the condition of roads and sediment sources. Upland slopes are generally low to moderate. Steepest terrain is located in the southwest of the watershed where slopes locally get as high as 63%. Road and trail access and gully crossings on slopes of this magnitude may potentially be problematic because of steep cuts, road fills, potential erosion along ditch lines, and drainage onto steep slopes. Steeper slopes generally result in higher road densities as a result of switch-backing to maintain driveable hauling grades.

The upper watershed has high road density and high frequency of stream crossing points. Streams in the headwater locations will tend to transport any introduced small debris and sediment to downstream locations. Management of roads to prevent concentration of runoff and sediment is important in the upper watershed.

Terrain stability is also a higher consideration on steep slopes. There is no reported evidence of slope stability problems from past timber harvesting despite the locally high density of older logging access. Slopes over most of the steeper headwaters tend to average between 30-50% with the steepest slopes occurring locally along ravines and valley side slopes. These locations are potentially more prone to soil erosion and windthrow. Low gradient floodplain reaches within the coastal plain portion are also highly erodible. Eroded material gradually moves downstream in successive storms. Fine gravels and sand become transported to the lower watershed whereas larger cobble and bouldery material will tend to remain in place or move much more slowly downstream.

The steeper uplands within the upper watershed lie within TimberWest's private forest land in the FLR. Weyerhaeuser also owns private forest land in the FLR located in several parcels lower down in the watershed on relatively gentle terrain. TimberWest has installed an upgraded bridge replacement above Winchester Road. Both TimberWest and Weyerhaeuser retain professional geoscientists on staff that can review proposed forest development in the private forest lands. TimberWest screens proposed forest development through a watershed assessment procedure that examines such things as the balance between rate of cut and hydrologic recovery in reforested stands. The company also retains a contractor to monitor its operations for potential sediment, slope stability, and drainage problems. TimberWest and Weyerhaeuser have defined operating procedures to avoid and mitigate potential risk situations.

The Private Land Forest Practices Regulation introduced in April 1999 guides forest development in respect to harvesting around streams.

In conclusion the upper watershed is expected to contribute more to runoff per unit area than the lower watershed. This is a function of higher precipitation, steeper topography, higher drainage density and shallower soils. While timber harvesting may modify snow melt in this zone the total area in high response zones is low with respect to the total watershed area . Most of the past harvesting is showing advanced hydrologic recovery. Maintenance on roads and protection of streams from sediment and debris are concluded to be the highest priorities.
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2.2 LOWER WATERSHED

By comparison the lower watershed which comprises 52% of the total watershed area has a broader range of land uses as shown in Figure 10. It encompasses the lower main stem of the French Creek and most of the coastal plain area. Relief is comparatively gentle. Floodplain terraces are well developed. Drainage density is lower and the flat expressional relief supports a number of wetland areas.

Land clearing for agriculture, commercial, industrial and settlement use tends to be permanent and cumulative. Approximately one third of the lower watershed is in land use that leads to more permanent land clearing.

Approximately one half of the lower watershed is second growth forest. This forest is highly fragmented by development.

Urban settlement and Commercial/Industrial use have the highest potential impact on runoff per hectare because of roads and ditching that intercept and concentrate runoff. The construction of impervious surfaces, or the excavation and removal of surface soil horizons that may reduce infiltration may further increase local surface runoff.

The estimated area of impervious surfaces is only 4.6% [4]. An additional 12% is classed as exposed soil (including fallow or ungreened-up crops) and another 7% is in infrastructure that effectively is void of significant vegetative cover. An additional 20% is classed as low ground cover such as forbes, grasses, low shrubs or sparse forest. In total this accounts for approximately 44% of the lower watershed area. Due to zoning most of this falls within the ALR. The relatively high percent of land clearing is visibly masked by its distribution in small openings that result in a highly fragmented mosaic. This contrasts with the upper watershed where forest harvesting is concentrated in larger openings.

The lower watershed receives most precipitation as rain. The cumulative effect of land clearing or replacement of forest with low ground cover is probably greater during the summer months in reducing potential evapotranspiration and reducing soil moisture deficits. This increase in soil moisture within cleared areas may not be apparent because of surface drying during the summer months. While 56% of the lower watershed remains in a forested condition, much of this is open forest with a high component of deciduous. Dense coniferous forest only comprises 21% of vegetated land cover.

The influence of vegetation clearing on runoff from large storm events in winter may be minimal since interception will generally be overwhelmed during high intensity long duration storms. Significant loss of coniferous cover may result in increased runoff from smaller storm events of short duration or low intensity where wind caused evaporation between storms may be effective. Lower winter temperatures reduce potential evaporation. Snow accumulation and melt are not generally a factor influencing runoff in the lower watershed.

As more forest is cleared the cumulative influence of land clearing may become more evident in streamflow conditions. Land clearing that is associated with increased diversion of water from subsurface flow to surface routing through ditches and impervious surfaces may exacerbate local erosion along small tributaries and reduce the baseflow component that is important during low flow months.

The lower watershed is generally flat to gently rolling. The lowlands have three main wetland areas that potentially buffer flows during initial stages of storms up to the point of becoming full. Wetlands only account for 2% of the lower watershed. Since they buffer flows from the drainage area flowing into them their buffering capacity is larger than inferred strictly on the basis of actual wetland area. Wetlands are also important to groundwater recharge since they have the potential to leak water into the groundwater aquifers slowly over time. This slow recharging from wetlands may help to offset aquifer drawdown. This depends on rates of leakage relative to consumptive use and natural draw down from migration of groundwater following natural hydraulic gradients.

Runoff response may be increased by occurrence of poorly drained hardpans that result in surface ponding or saturated soil conditions. These generally occur below 150m in association with less permeable, fine textured marine silts and clays laid down as the ocean shoreline receded following the last glaciation.

It s difficult to conclude that the extent of vegetation clearing in the lower watershed has had a significant effect. Logical reasoning would however suggest that the cumulative effect has an increased potential to affect hydrologic regime particularly within the smaller tributaries.

Maintaining and restoring healthy riparian areas within the erodible floodplain locations stands out as a priority together with protection of wetlands that may be critical to supplementing groundwater recharge and stream baseflows.

3.0 CONCLUSIONS

Low relief, gentle topography and generally low stream densities combined with wetland detention storage and rain shadow effects from Mount Arrowsmith moderate runoff response in the watershed. Only a very low proportion of the watershed falls within the rain-on-snow zone that normally contributes to flooding on south east Vancouver Island. This zone begins at the lower boundary of the Coastal Western Hemlock very dry montane (CWHxm2) and extends upward into the lower half of the moist montane (CWHmm2) shown in Figure 1.

Infrastructure development such as roads, ditches and high density development may affect storm water routing. More rapid concentration of runoff within small tributaries may be locally significant.

The upper watershed is comparatively more responsive to storm events than the lower watershed because it has a higher proportion of steeper slope, receives more precipitation, and has a higher frequency of streams that can route water quickly to main channels. The rate of recovery within plantations relative to rates of harvest in the upper watershed may influence runoff. However, the potential for increases to be adversely large remains low given the small harvestable area within the rain-on-snow zone. Associated roads and trails that potentially concentrate runoff are likely to be more significant. However, much of the road access for harvesting already exists and therefore additive impacts on runoff are not likely to be significant if well managed.

Land clearing in the lower watershed tends to be permanent and cumulative. The lower watershed has gentle slope and has some buffering by wetlands. It’s potential to affect runoff on the basis of area cleared is more related to increased efficiency of runoff associated with infrastructure such as roads, ditches, and impervious surfaces. Wetland areas are potentially at risk from being drained by ditching or infilling. Wetlands are a potential source of groundwater recharge.

Most land clearing effect will be evident during the low precipitation summer months where removal of vegetation reduces evapotranspiration losses. This may reduce summer soil moisture deficits potentially increasing water available to groundwater recharge and river base flows. This effect is likely to be small given the low amounts of precipitation.

Irrespective of consumptive use, stream flows should be expected to remain critically low during the summer.

There is insufficient information to draw conclusions on the magnitude of consumptive use of water on stream flows during the critical low flow summer months. Actual use is not monitored.

Most of the bedload and sediment observed in French Creek originates within the erodible floodplain and at steep cutback locations in highly erodible deposits such as the Quadra sands. The steeper slopes of the upper watershed appear to be generally stable. Coarser sediment settles out at the base of the steeper headwaters but small and intermediate sediment will transport through the system from all sources. The potential for increases in high flows from land use is generally low. However, small increases in high flows would be expected to exacerbate inherent erosion and transport of sediment. Aggrading of the river system from all sources will exacerbate de-watering and reduction of fish habitat.

Maintaining healthy mature riparian forest along erodible floodplain is important to maintaining bank stability and fish habitat.

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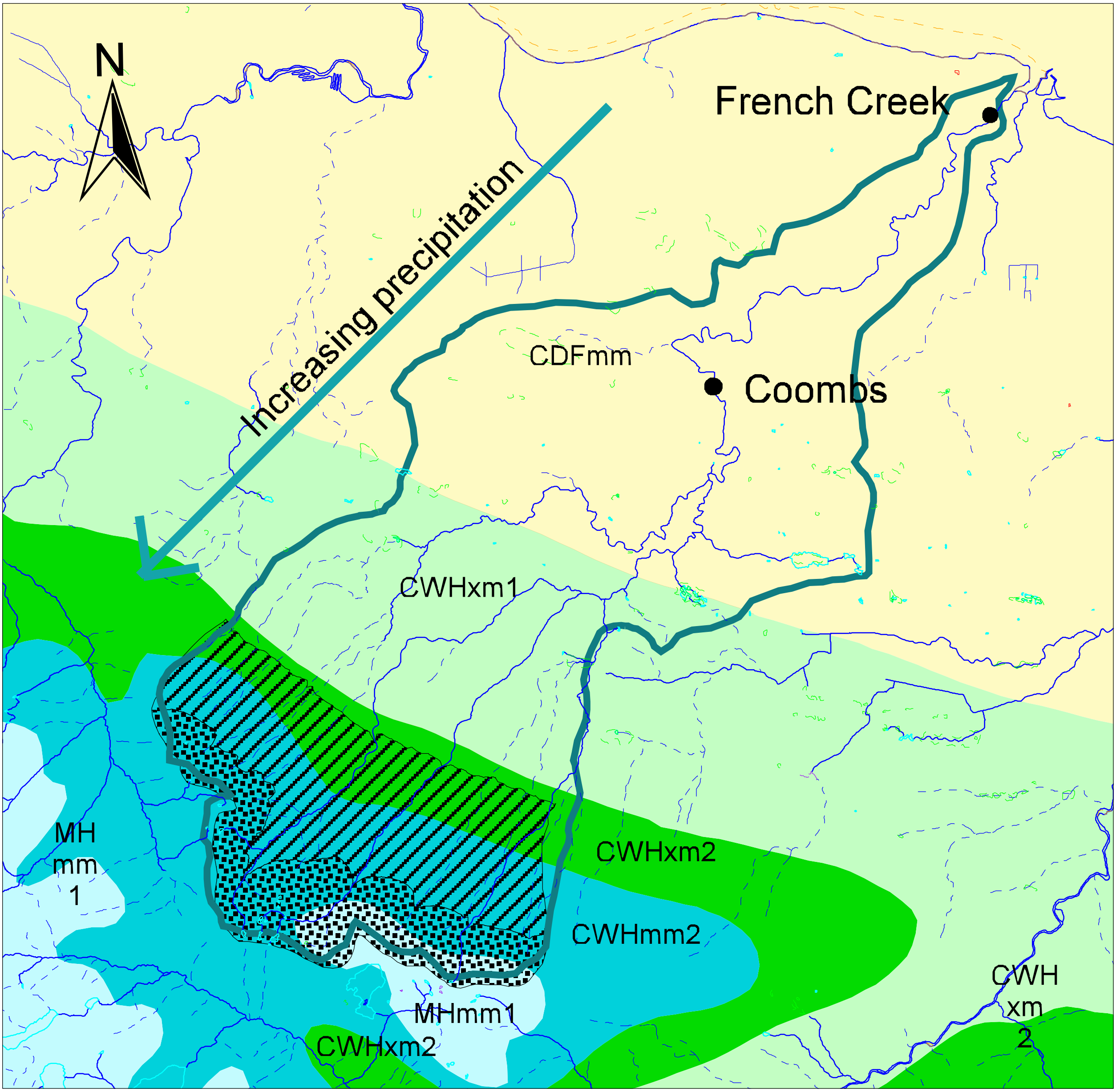
Appendix I Figures

Figure 1

Biogeoclimatic zones and winter precipitation type



1:100,000

1 0 1 2 3 4 5 Kilometers

Ministry of Water, Land & Air Protection

British Columbia

- Coastal Douglas-fir moist maritime
- Coastal Western Hemlock very dry maritime submontane
- Coastal Western Hemlock very dry maritime montane
- Coastal Western Hemlock moist maritime montane
- Mountain Hemlock windward moist maritime
- rain-on-snow zone approx. 300-800m elevation
- Snow may accumulate over winter above 800m primarily spring runoff

Figure 2 Comparison of annual precipitation for Coombs, Qualicum and Parksville

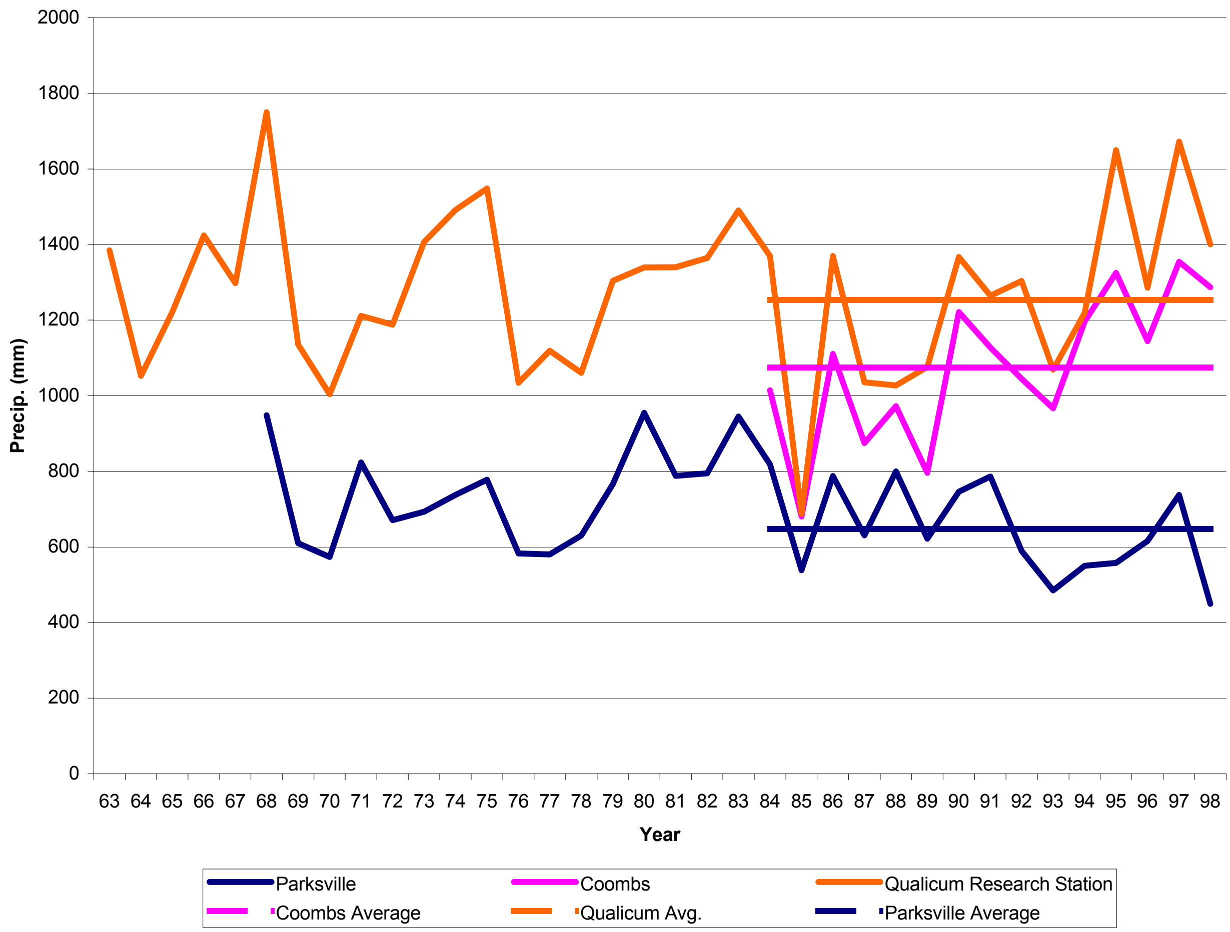


Figure 4

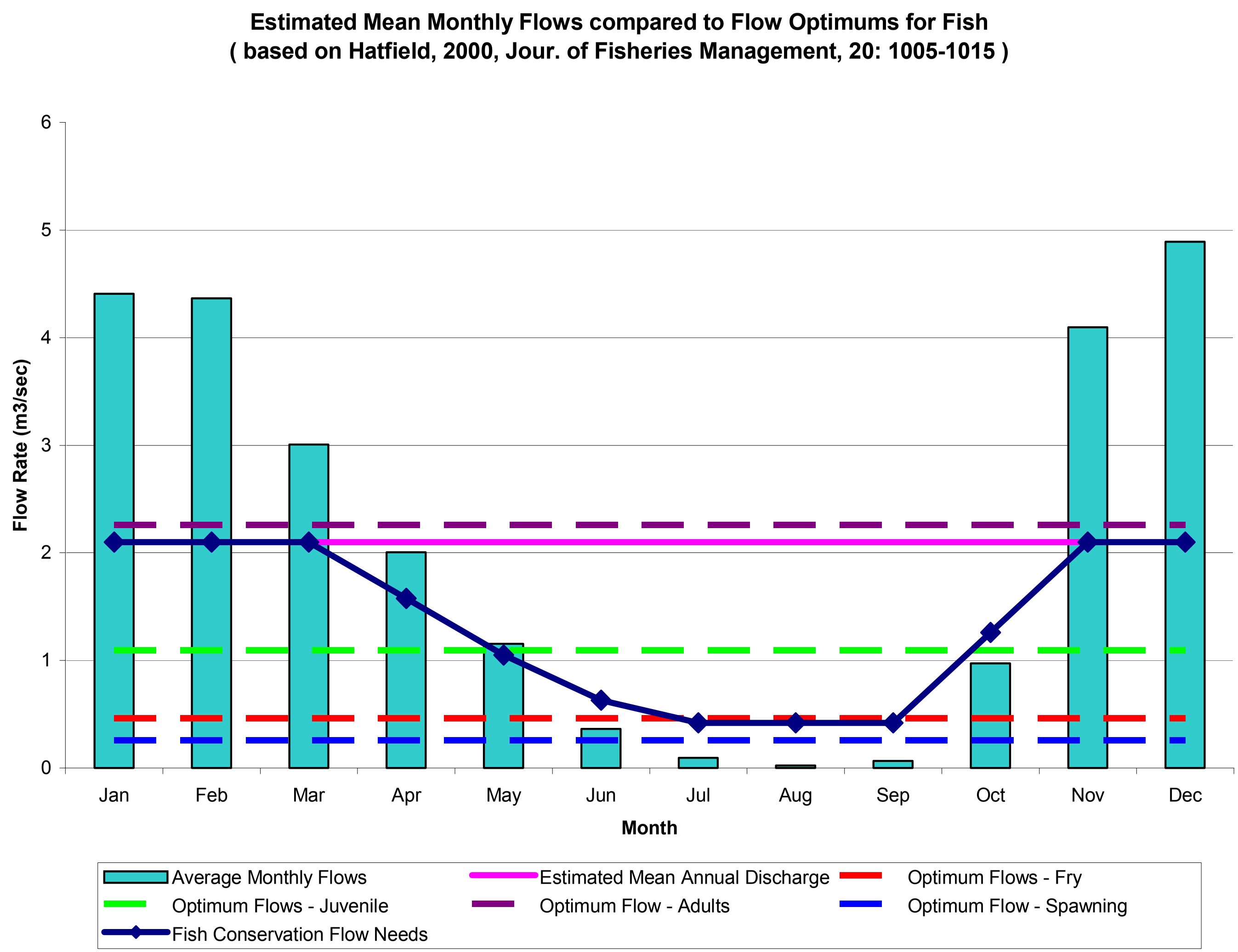
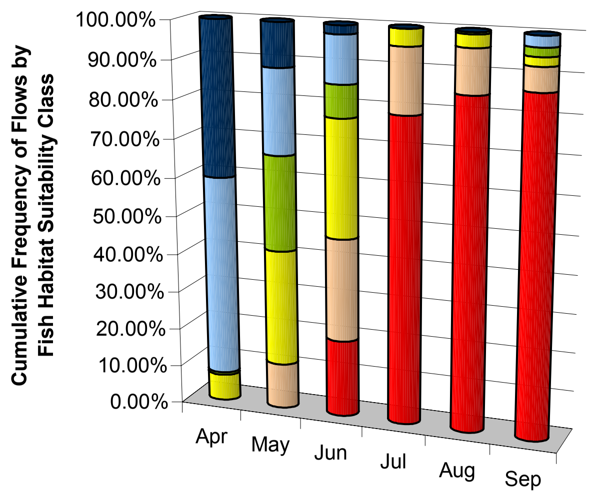

Estimated Mean Monthly Flows compared to Flow Optimums for Fish
(based on Hatfield, 2000, Jour. of Fisheries Management, 20: 1005-1015)
Flow Rate (m3/sec)
0
1
2
3
4
5
6
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Average Monthly Flows
Estimated Mean Annual Discharge
Optimum Flows - Fry
Optimum Flows - Juvenile
Optimum Flow - Adults
Optimum Flow - Spawning
Fish Conservation Flow Needs

Figure 5

Frequency of Average 7 day flows relative to Mean Annual Discharge (MAD) for April to September at Pumphouse WSC Station 08HB0078 1990-1995



	Apr	May	Jun	Jul	Aug	Sep
>60% of MAD In excess of fish needs	40.28%	11.29%	2.22%	0.00%	0.00%	0.00%
30-60% of MAD Excellent	52.08%	22.04%	12.22%	0.00%	0.00%	2.78%
20-30% of MAD Good	0.69%	24.73%	8.33%	0.00%	0.54%	2.22%
10-20% of MAD Fair	6.94%	30.11%	30.56%	4.30%	3.23%	2.22%
5-10% of MAD Poor	0.00%	11.83%	26.67%	16.67%	11.29%	6.11%
< 5% of MAD short term survival only	0.00%	0.00%	20.00%	79.03%	84.95%	86.67%

Figure 6 Estimated maximum instantaneous peak flows by return period for French Creek

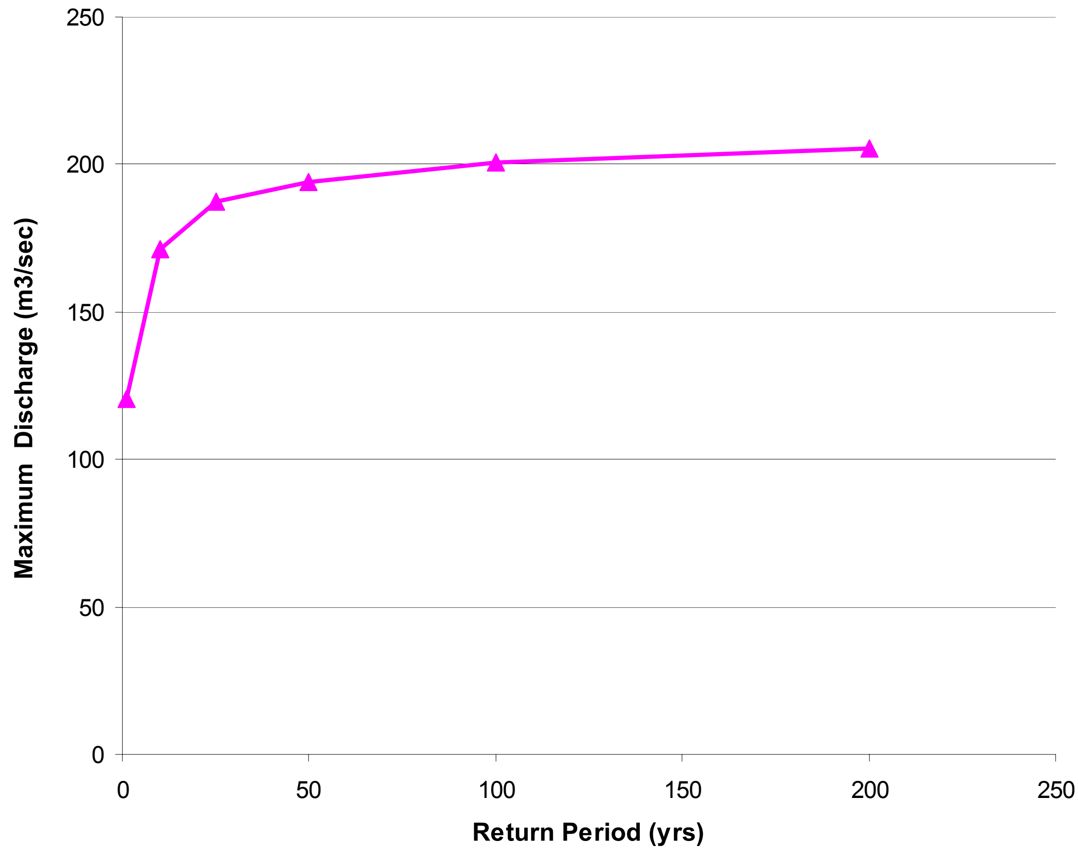


Figure 7 Relative Winter Runoff Potential inferred from Land Cover and Elevation Response Zone

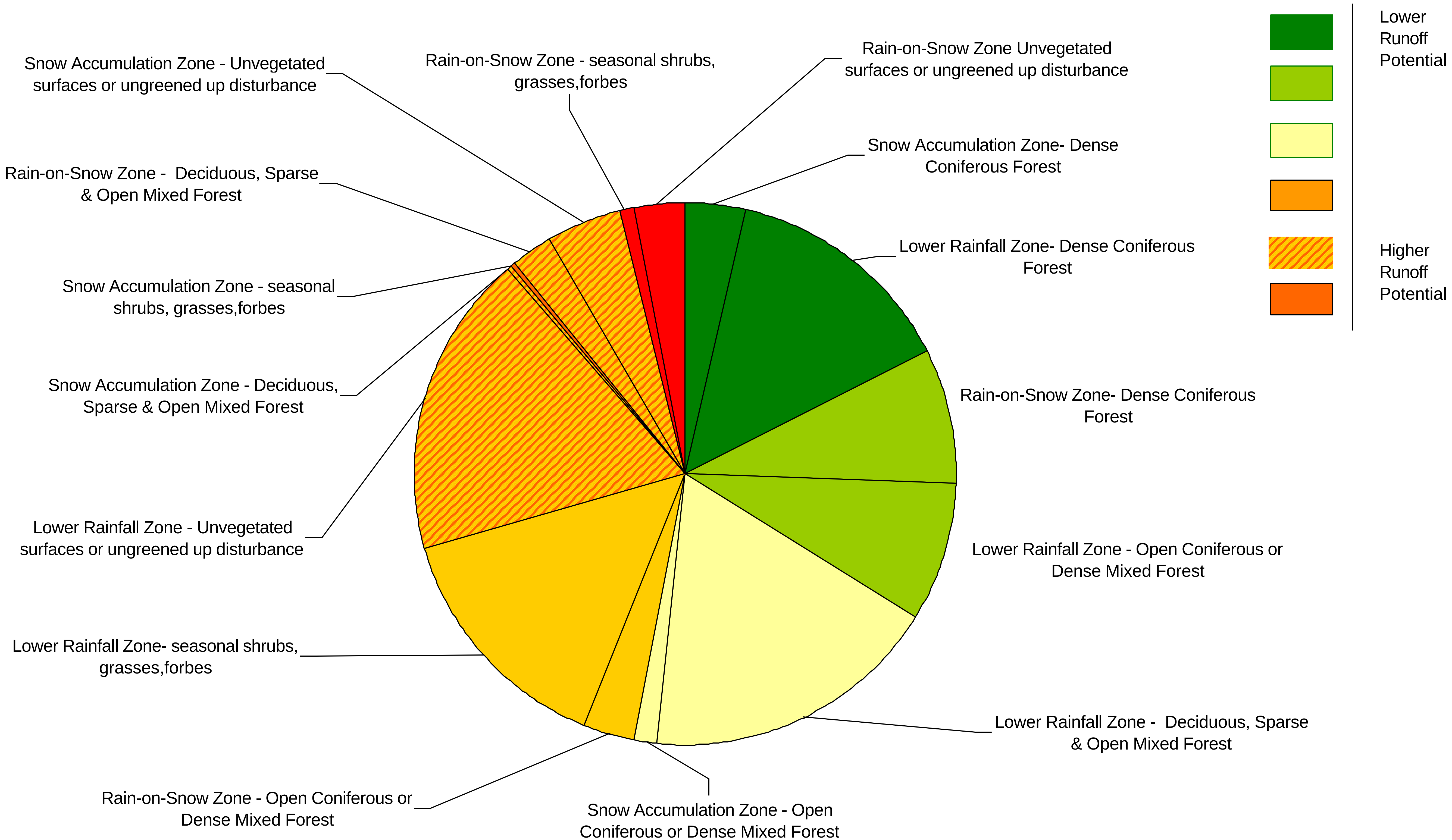


Figure 8 Land Use Zoning & Ownership

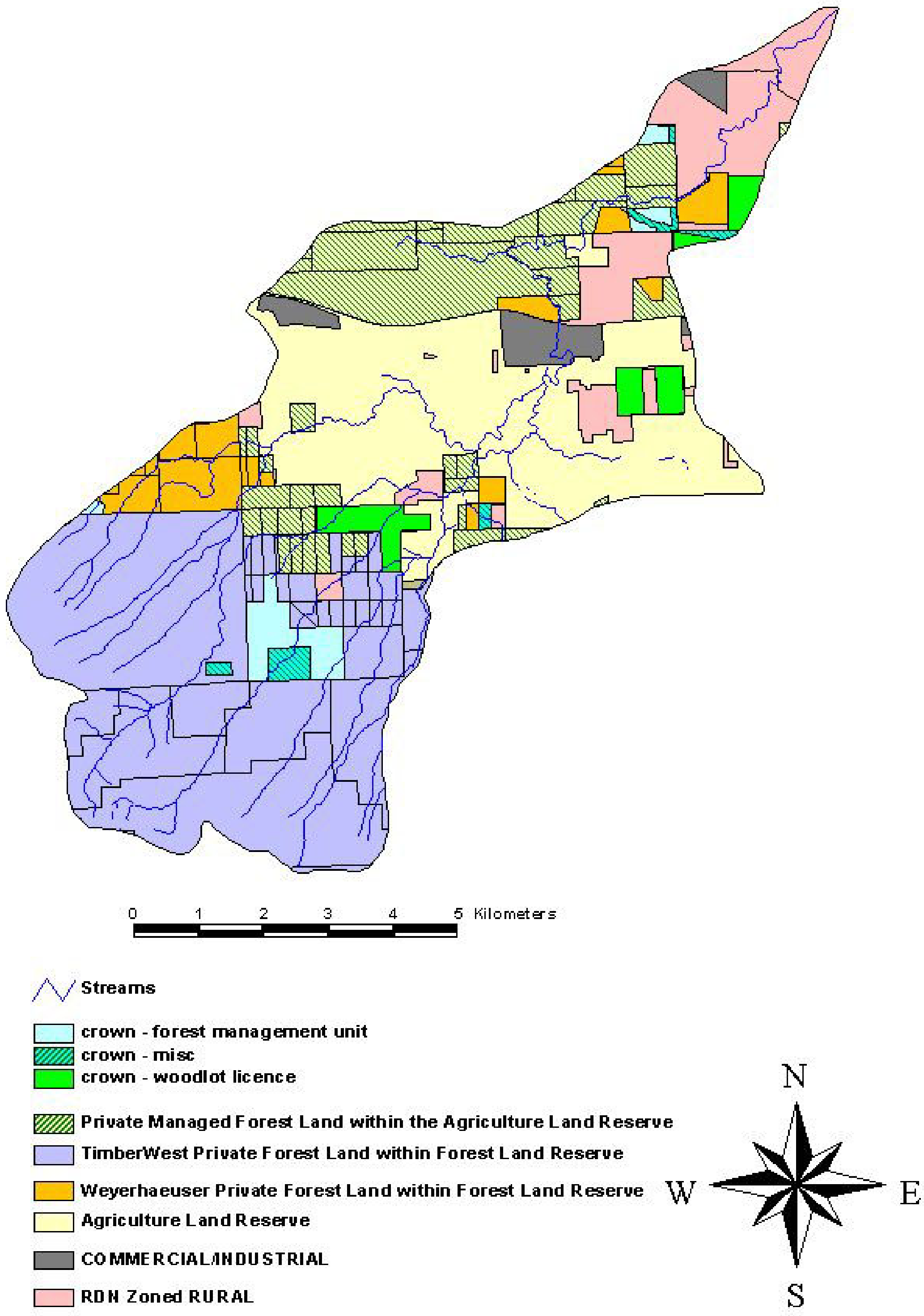


Figure 9   Upper Watershed Land Use & Cover

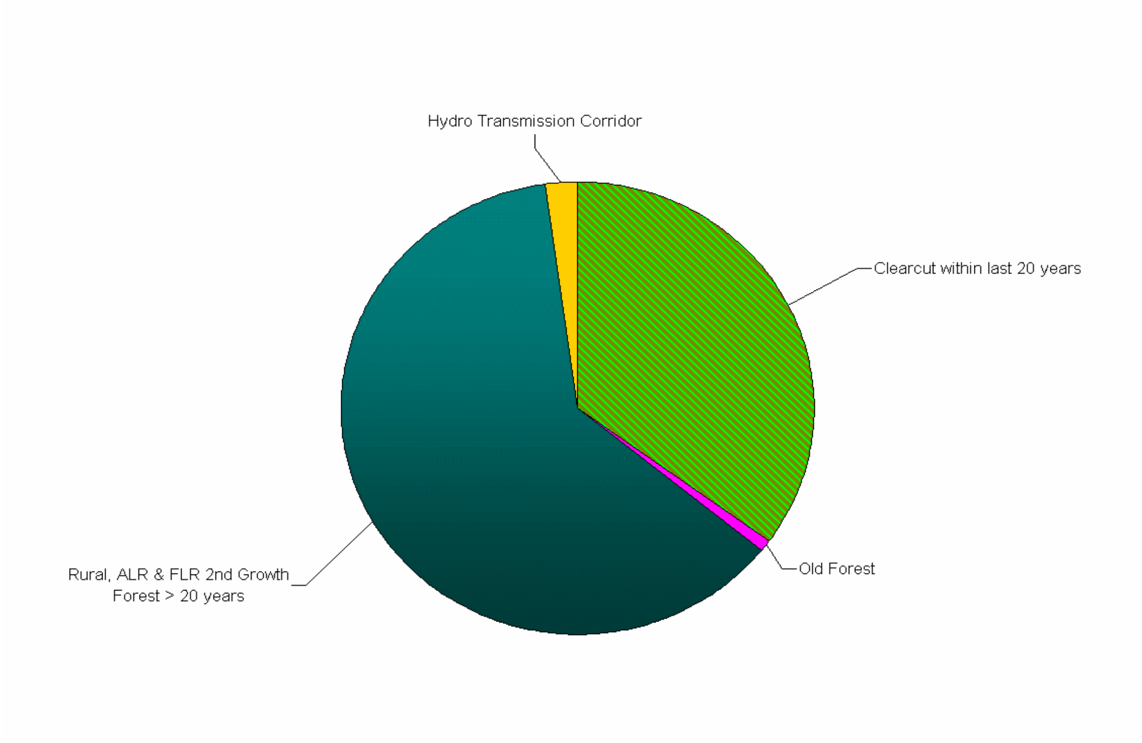
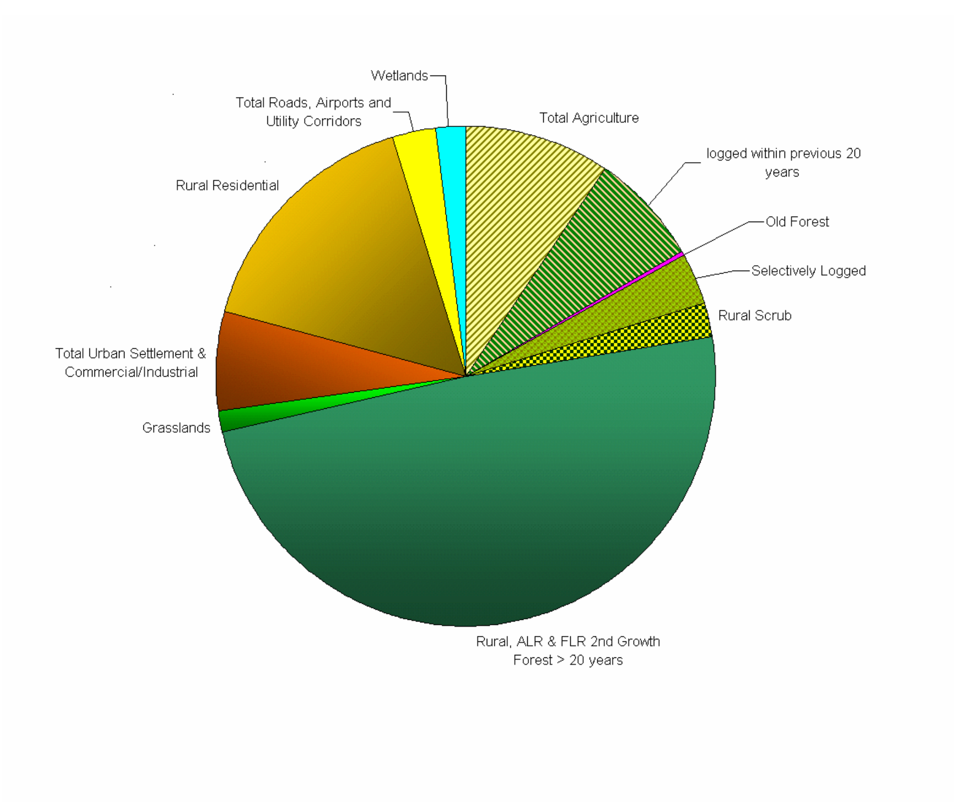


Figure 10 Lower Watershed Land Use and Cover



Appendix II Photo References

Plate 1

Severe floodplain erosion may result from loss of riparian bank protection and deflection of flow by debris. The tree length debris is unstable and subject to accumulating into shifting debris jams which may break up and re-form downstream. As debris moves, deposits of sediment stored behind the debris in may sluice out in high flows. Active migration of the river and debris inhibits creation of stable fish habitat. Structures and property within the active floodplain are at increased risk under these situations.

Plate 2

Stable bedrock section of French Creek above Coombs on south fork of river.

Plate 3

Water fall on south fork above Coombs

Plate 4

Hamilton Swamp located northwest of Coombs illustrates detention storage and buffering capacity of wetlands. These wetlands may provide slow leakage into groundwater aquifers and may be important to sustaining base flows in streams.

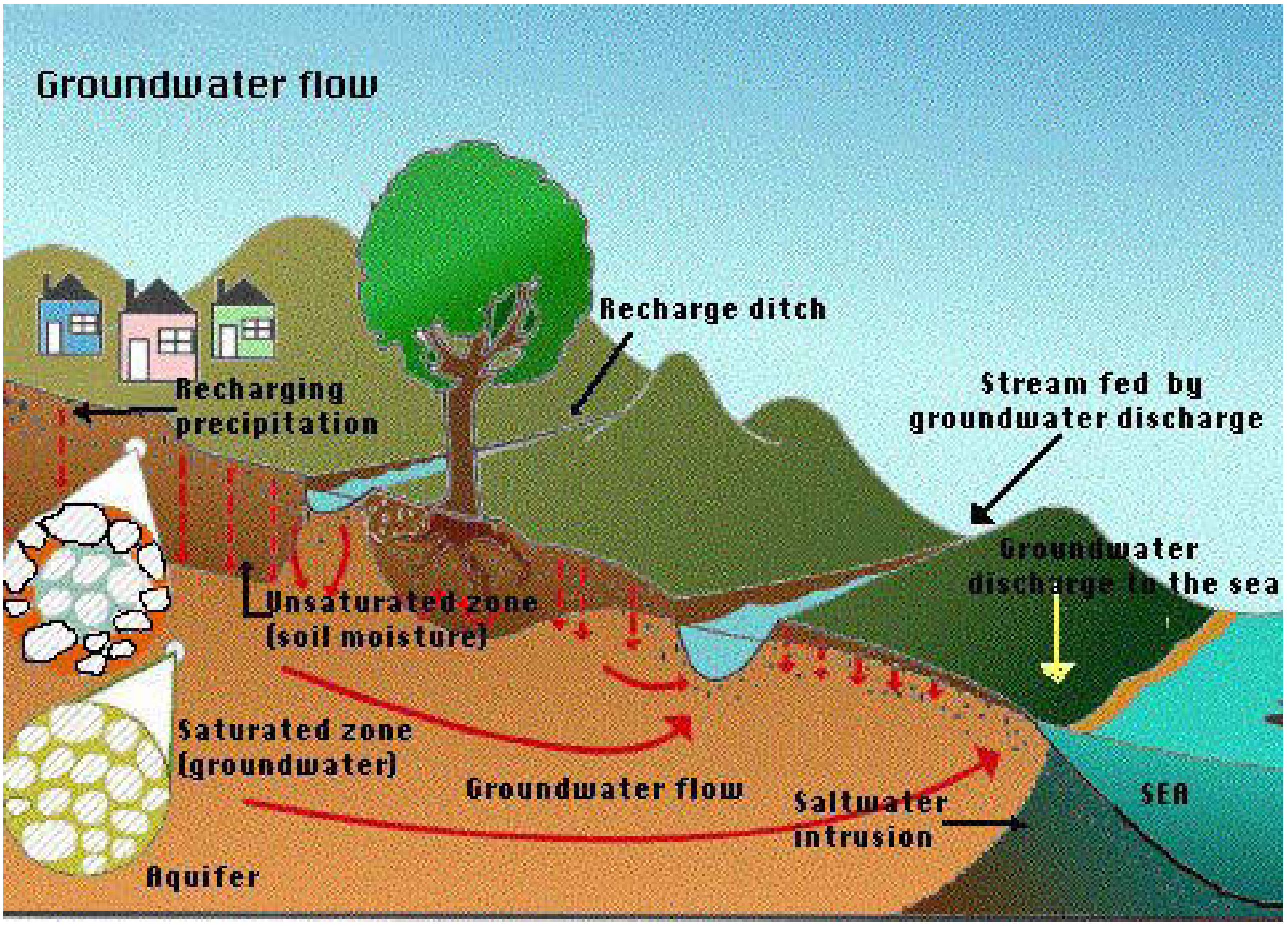
Plate 5

Ditching of wetlands and agriculture fields increases rapidity of runoff in storm events. Reduction of wetland storage and interception of subsurface flow by ditches may reduce groundwater recharge and stream base flows. Effects on peak streamflow in the main river are likely to be subtle but cumulative as land development spreads. Local effect on smaller tributaries and wetlands may be more pronounced.

FRENCH CREEK WATERSHED STUDY
Groundwater

Warren Cooper, RPF
Ministry of Water, Land & Air Protection
Province of British Columbia

March 2002



French Creek Watershed Study

Groundwater Hydrology

Availability and quality of groundwater have become of increasing concern as a result of increased pumping of aquifers and potential contamination. Under the Water Utility Act and the Utilities Commission Act, the Comptroller of Water Rights is responsible for utility regulation (a) to assure the water systems installed by land developers are properly designed and constructed and (b) to assure the customers of utilities receive acceptable water at reasonable rates. Regional Health Boards have a responsibility for community water systems under the Safe Drinking Water Regulation under the Health Act.

The Drinking Water Protection Act (April 2001) has yet to come fully into effect pending development of regulations. Prior to implementing regulations the government will review the recommendations of an independent panel appointed to assess completeness and cost effectiveness of the legislation.

Provisions of the Drinking Water Protection Act currently provide for government directed protection plans to be developed that may result in measures to reduce well interference and draw down of aquifers. Part 5 of the Drinking Water Protection Act specifically deals with wells and ground water protection providing for regulation in the following areas:

- Qualifications of well drillers and well pump installers
- water analysis for new or altered wells
- well identification
- well deactivation
- security of well caps and covers
- aquifer protection from salt water intrusion and well interference
- prevention and remediation of aquifer contamination
- relationship of groundwater to drinking water management and protection plans

However, there will be a continued onus on individual well users to protect their groundwater supplies. It is therefore important for groundwater users to be familiar with not only their own well but also the condition and influences upon the aquifers providing the groundwater.

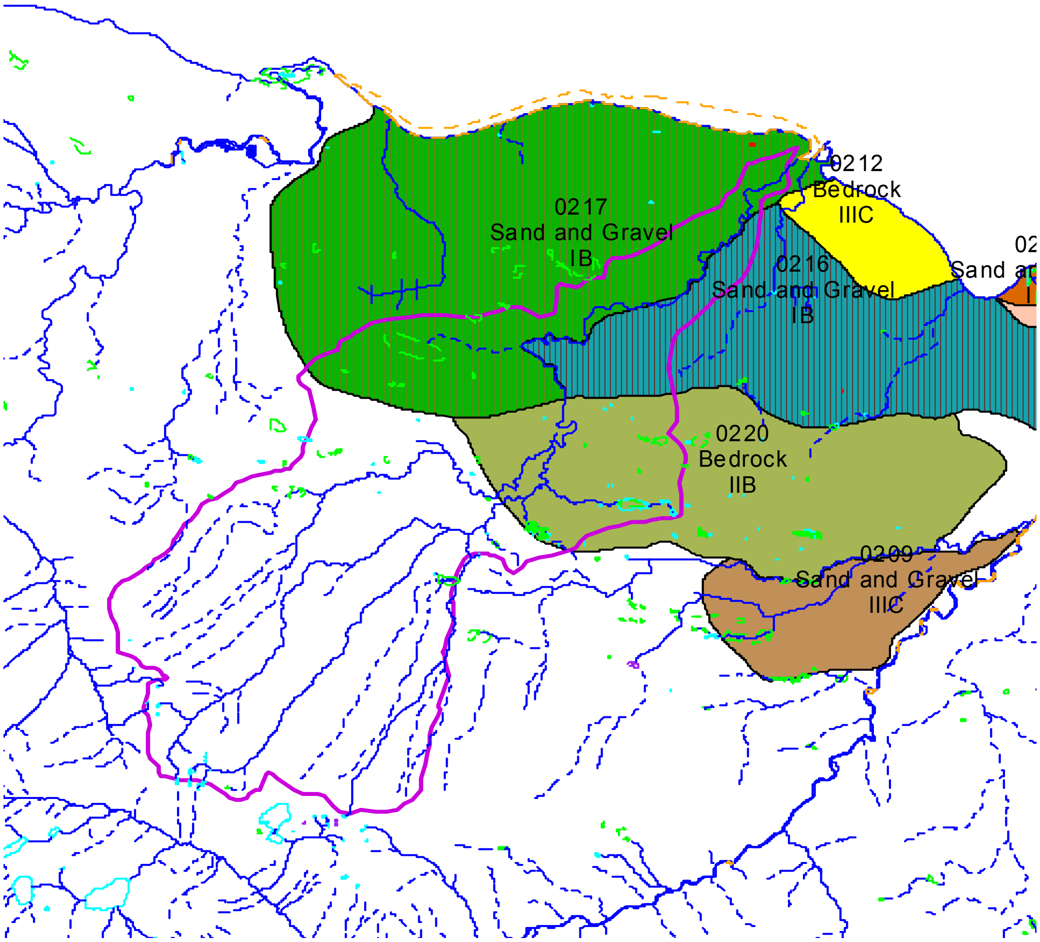
The Groundwater Section, Ministry of Water, Land and Air Protection, provides technical guidance to the utility regulators, publishes groundwater information on aquifers and protection and carries out aquifer inventory and analysis.

The publication, Groundwater Resources of BC[1] is recommended to readers wanting a basic level understanding of the principles affecting groundwater availability and water quality. It includes a synopsis of inventory information available for the Parksville-Qualicum area up to 1994, the date of publishing. This report is posted on the Ministry of Water, Land and Air Protection Groundwater website together with links to additional groundwater information sources. This information has been supplemented by more recent aquifer classification mapping in 1995 completed under funding from the Corporate Resource Inventory Initiative.

French Creek Watershed Study

Groundwater Hydrology

Figure 1 Developed groundwater aquifers in the French Creek area



Aquifer Classification

	High	Moderate	Low
Aquifer Development	I	II	III
Vulnerability	A	B	C

Source: Groundwater Section, Ministry of Water, Land & Air Protection

Groundwater Hydrology

Information for the various aquifers is also posted on the Ministry of Water, Land and Air Protection website[2].

Provincial government groundwater staff use a classification system developed by Kreye *et al.* (1994) to classify aquifers in the province. The classification system uses two components to categorize aquifers based on the level of development and the degree of vulnerability to contamination. The level of development is determined through an assessment of demand on the aquifer relative to the productivity of the aquifer. Aquifers are assessed as high (I), moderate (II), or low (III) based on the level of development.

The vulnerability of an aquifer to contamination from surface sources depends on the following characteristics: the type of aquifer, thickness and extent of overlying geologic materials, depth of water (or top of confined aquifers), and the type of aquifer material. Aquifers are classed as having high (A), moderate (B), or low (C) vulnerability. The combination of the two variables yields nine classes of aquifers, from "IA" that is heavily developed with a high vulnerability to contamination, to "IIIC" with low development and low vulnerability.

In addition to the classification, an aquifer ranking is also provided. This ranking is determined by summing the point values assessed for the following hydrogeologic and water use criteria:

- productivity
- size
- vulnerability
- demand
- type of use
- quality concerns (that have health risk implications)
- quantity concerns.

Each is assigned an equal weight of one (minimum) to three (maximum), except for quality and quantity which may have a score of zero (no concern). Ranking scores can range from five to a maximum of twenty-one, with the higher the score, the higher the provincial priority for the aquifer. The Demand rating is based on the level of reliance on the resource as a water supply.

Most groundwater contains various inorganic and organic chemicals that are derived from dissolution of minerals along the groundwater flow path to the extent they may affect water hardness, taste and smell. Contamination arises when activities at the surface introduce new or additional amounts of inorganic and organic chemical compounds and pathogens that are transported by percolating groundwater. Groundwater contamination may be from discrete point sources such as a petroleum spills or leakage from septic fields. Contamination may also result from non-point sources, such as from the broad application of pesticides or fertilizers. Impacts may be cumulative over time. At the present time only bacteria from sewage are explicitly addressed by legislation under the Safe Drinking Water Regulation.

French Creek Watershed Study

Groundwater Hydrology

Groundwater contaminants divide into 3 classes:

(a) soluble contaminants that form a dispersion plume e.g. nitrate from septic discharge,
(b) insoluble contaminants that are lighter than water and float on the water surface as a film or pool (e.g. petroleum) products, and
(c) insoluble contaminants that are heavier than water and sink to form a bottom layer or lens (e.g. chlorinated solvents and many pesticides).

The Groundwater Section has identified four aquifers in the lower watershed as part of a province wide inventory. This includes aquifers 212, 216, 217 and 220 in the provincial aquifer database. These aquifers extend beyond the topographic boundaries defining the French Creek watershed as shown in Figure 14. The boundaries of the aquifers also vary with depth. Boundaries were determined based on reported well records and published surficial geology mapping. Aquifer mapping in the French Creek area requires a good understanding of glacial history. The surficial geology of the area has been well described by Fyles[3]

Table 1 summarizes the aquifer classifications for French Creek.

Aquifers in the French Creek area are located within the Nanaimo Lowland, a narrow coastal plain comprising the unsubmerged south-western edge of the Georgia Depression that forms the strait of Georgia. The lowland intersects the steeper uplands at approximately 180 – 220 metres. Recharge to the French Creek aquifers is by direct infiltration from precipitation. Water levels closely follow seasonal precipitation patterns showing winter recharge and drawdown during summer and early fall as precipitation declines to low levels. Water levels tend to be higher inland indicating a hydraulic head that is oriented south to north and inland to the ocean following the stratigraphy and general relief of the area.

Aquifer 212 at the mouth of French Creek and Aquifer 220 are both fractured bedrock aquifers comprised of shale, sandstone and conglomerate, all belonging to the Nanaimo Group of Upper Cretaceous age. Fractured bedrock aquifers tend to have lower productivity .Aquifer 212 has been classified as lightly developed with low vulnerability (IIIC) to surface contaminants. Groundwater from both of these aquifers is generally obtained from irregular fault planes, joints and fractures along bedding planes or where the rock may be porous (e.g. poorly consolidated sandstone).

Table 1 French Creek Aquifer Classification

	Aquifer Name	Location	Materials	Litho Stratigraphic Unit	Classification	Ranking Value	General Productivity	Overall Vulnerability	Overall Demand	Type of Water Use
212		Parksville	Bedrock	Nanaimo Group	IIIC	6	Low	Low	Low	Drinking Water
216	Parksville	Parksville	Sand and Gravel	Quadra Sand	IB	14	Moderate	Moderate	Moderate	Multiple
217	Qualicum	Qualicum	Sand and Gravel	Quadra Sand	IB	14	Moderate	Moderate	Moderate	Multiple
220		Errington	Bedrock	Haslam Formation	IIB	8	Low	Moderate	Low	Drinking Water

Source: Ministry of Water, Land & Air Groundwater Aquifer Database

The proximity of Aquifer 212 to the ocean has raised some concern about potential salt water intrusion as the aquifer is drawn down. Near the coast freshwater lenses in confined aquifers may overlie denser seawater. With pumping a cone of depression forms around the intake reducing the head of freshwater. With continued reduction of the head, saline water may intrude into the freshwater lens from below. Ultimately, the freshwater cone of depression may extend into the salt water allowing saltwater to enter the intake.

Aquifer 220 in the Errington - Coombs area is described as shale which may account for generally low reported yields averaging less than 0.38 L/s. The median depth to water is approximately 4 metres. The well log for observation well 287 records black shale from 8.2m to 92.3m. Recharge and summer drawdown of water levels have remained fairly constant. Seasonal drawdown has averaged approximately 2.5 metres in this observation well.

Upland erosion during post glacial uplift resulted in the deposition of a comparatively thick layer of coarse granitic sands. This layer referred to as the Quadra Sands contain the largest and most productive aquifers. This includes aquifers 216 and 217 which cover an area of approximately 76km^2. Both aquifers have been classified as heavily developed and moderately vulnerable (IB). Both aquifers share similar lithology, mean well yields and depth to water. These aquifers are separated by French Creek and are assumed to be discontinuous at this time. Reported yields vary from less than 0.07 to 6.4L/s for Aquifer 216 and up to 31.2 L/s for Aquifer 217. Depth to water is similar for both aquifers ranging from 0-14 m for Aquifer 216 and 5 to 52m for Aquifer 217.

In the Quadra Sands aquifers (Aquifer Numbers 216 and 217) there have been sporadic reports of elevated levels of manganese and iron. The source of these has not been determined. The primary concerns due to manganese in drinking water are its objectionable taste and its capacity to stain plumbing and laundry. In aquatic environments, manganese toxicity is slight to moderate and is influenced by several factors such as water hardness, salinity, pH, and the presence of other contaminants. The drinking water aesthetic objective standard for manganese is less than or equal to 50 μg/L. Elevated iron is largely an aesthetic problem. The objective in this respect is for concentrations to be less than or equal to 0.3 mg/L.

Unconfined aquifers such as those in the Quadra Sands are the most vulnerable to contamination. Characteristics of the surficial material through which the contaminant passes affect dispersal of soluble contaminants. Highly permeable sands and gravels that characterize the surficial deposits in lower French Creek tend to result in long narrow plumes with well defined boundaries with little lateral dispersion. Flow velocities are dependent on hydraulic conductivity and porosity. The surficial deposits of French Creek are not uniform, and risk of contamination is therefore variable. Shallow surface wells and wells that are not protected from contaminants by overlying impermeable layers are most at risk for any particular surface contamination hazard.

French Creek Watershed Study

Groundwater Hydrology

Because of the high well densities within the Quadra sands aquifers many of the deeper water levels reported may be the result of pumping interference between wells. This variability in water depth may also reflect the heterogeneous nature and variable location of the Quadra Sands. The province operates 2 observation wells within Aquifer 216 (#304 and #314) and 3 observation wells in Aquifer 217 (#295, #303, and #321). Observation wells #303, #304, #314 and #321 are located in the densely populated lower watershed. They have shown a long-term pattern of groundwater level decline. This contrasts with slightly increasing water levels trends in observation well 295 that is located near the production wells for the Town of Qualicum Beach. This observation well is located near a production well and reduced pumping in the production well may account for some of the increase. Precipitation increased above the long term mean in 1994, 1995 and 1997 accounting for some of the observed increase.

Increasing numbers of production wells to service the growing population of French Creek and Morningstar combined with a pattern of decline in observation well water levels has brought about the need for a comprehensive review and proving up of groundwater quantity and quality. Breakwater Enterprises Ltd. which operates the water utility supplying sub-divisions in French Creek is required under the Water Utilities Act and Utilities Commission Act to prove up surplus availability of groundwater to meet sub-division expansion.

Before a groundwater source can be developed into a community water supply, well performance and aquifer capabilities must be adequately assessed. For individual wells this means testing the pumping rate per metre depth of drawdown (specific capacity) projected out over a 100 days of uninterrupted pumping. This is related to available drawdown being the difference between water level and well depth. Pumping from nearby wells may influence available drawdown and specific capacity. In coastal aquifers additional tests for salinity are made to determine if sea water encroachment is occurring. The Province has established guidelines for evaluating long term well capacity[4]

To address long term groundwater supply and issues such as potential well interference Breakwater Enterprises has hired EBA Consultants Limited to carry out a comprehensive groundwater aquifer assessment. Interim results have resulted in improved mapping of the aquifers at different depths that will result in 3 dimensional resolution of the aquifers. This information will form a basis for groundwater modelling that will analyse current and projected water use effects on the aquifers and show potential interactions among wells.

The Groundwater Section has shown how groundwater level in a particular well responds to precipitation. An abrupt increase in the draw down of a well in the absence of marked change in precipitation trends signals the likelihood of potential well interference. This pattern is evident in the record for Observation Well No. 303 shown in Figure 3.

French Creek Watershed Study

Groundwater Hydrology

Figure 2 Example of observation well hydrograph showing stable trend in seasonal recharge and drawdown since 1990. Source: Groundwater Section, Ministry of Water, Land and Air Protection

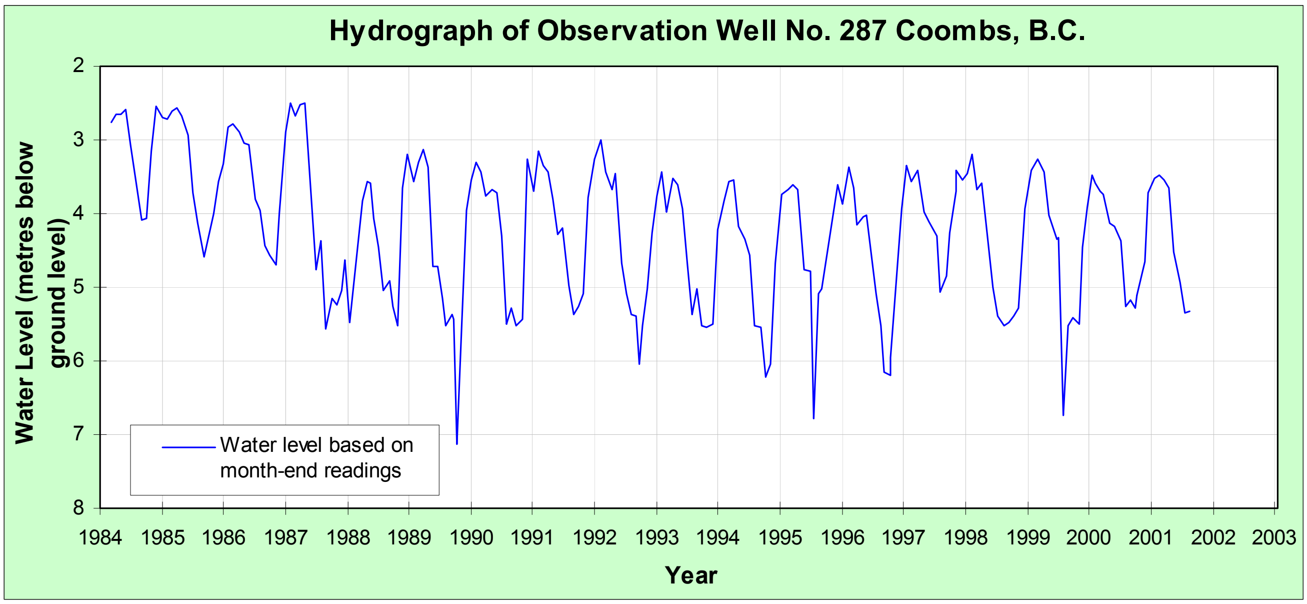
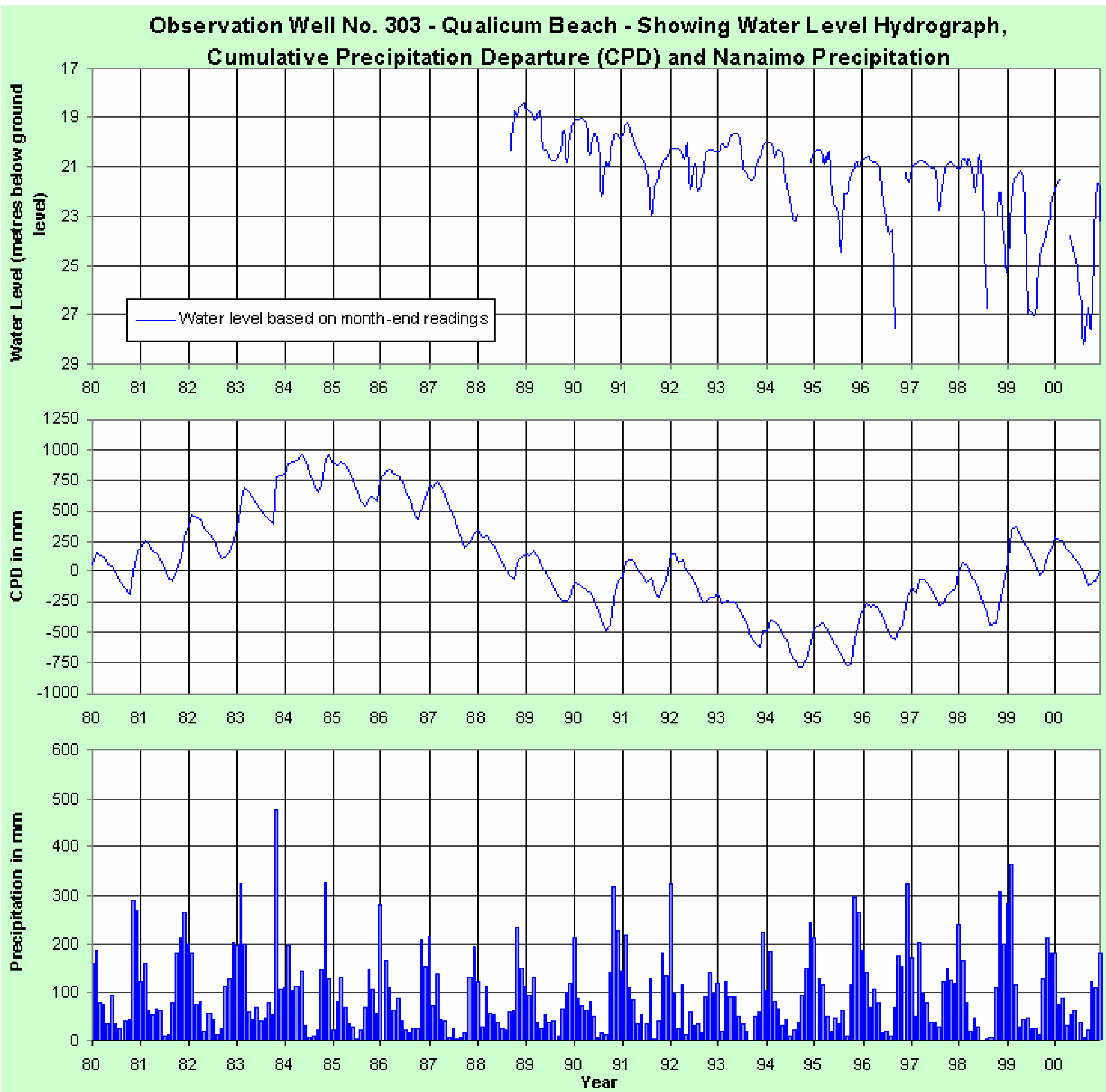


Figure 3 Example of observation well record showing trends in recharge and drawdown in relative to precipitation. Note general decline in recharge water levels despite increasing precipitation since 1994. This together with increasing depth of drawdown beginning in 1997 suggests pumping interference from other well(s).



Source: Groundwater Section, Ministry of Water, Land and Air Protection

Ultimate responsibility for protection rests with the individual well owner. The booklet, " Guidelines for Minimum Standards in Water Well Construction - Province of British Columbia" produced by the Ministry Of Environment, Lands & Parks Groundwater Section provides detailed guidance on well design and protection. The 3 basic elements for individual well water protection are: (1) an effective seal, (2) well disinfection and (3) the sampling and analysis of well water.

The Province of BC with Federal support has published a six part Well Protection Toolkit[5]. The six steps described in the toolkit are:

1. Form a community planning team
2. Define the groundwater capture zones (re-charge area)
3. Map and describe potential sources of pollution
4. Develop and implement protection measures
5. Develop a contingency plan against accidents
6. Monitor and report on effectiveness.

Further information concerning groundwater and the Well Protection Toolkit is available through the Ministry of Water, Land and Air Protection Groundwater website.

Conclusions

Groundwater movement largely reflects seasonal distribution and timing of precipitation. Maximum water levels generally occur in the December to January period. Minimum water levels generally occur in the September to early October period. A trend of increasing drawdown in observation wells from over pumping aquifers supplying the community of French Creek has raised concerns about future supply and ability to meet long term demand from an increasing population. A groundwater study is underway by Breakwater Enterprises to refine previous estimates of groundwater availability and to serve as a basis for predicting the effects of drilling new wells on existing wells. Regulation of the Breakwater utility by the Province requires a significant surplus capacity in groundwater availability relative to pumping rates in order for the utility to bring wells on stream to service community water needs.

Observation Well Number 287 at Coombs completed into shale bedrock shows no long-term rising or declining trends in recharge.

Observation well 295 at Qualicum shows an increase in water tables since 1993. This may be influenced by a reduced pumping in neighbouring production wells and an increase in annual precipitation.

Well yields are variable by aquifer and individual well. Groundwater productivity tends to be lowest in the fractured bedrock aquifers where permeability depends on fracturing of the bedrock. By contrast the Quadra Sand aquifers are generally only confined by interspersed deposits of overlying clayey till and have higher permeability and transmissivity based on the porous nature of the sands and gravels within which they are located.

In the Quadra Sands aquifers (Aquifer Numbers 216 and 217) there have been sporadic reports of elevated levels of manganese and iron. In the lower aquifer (212) there is some concern for potential salt water intrusion that potentially could result from drawdown of the overlying freshwater table and consequent rise in the freshwater / salt water interface. This has not been a problem to date and more information from the ongoing aquifer study and continued monitoring will provide a better basis for estimating the risk.

The fractured bedrock aquifer in lower French Creek is somewhat less vulnerable to surface contamination than the unconfined portions (windows) of the Quadra Sands that have no overlying confining strata. Location of land use relative to areas of high vulnerability, population density and type of land use affect the aquifers risk to contamination. The Well Protection Toolkit[5] provides guidelines to assist communities in developing a co-ordinated and comprehensive approach to protecting groundwater.

There is at this time no study that shows the contribution of aquifers to base flow conditions in French Creek. It is therefore not possible to draw any firm conclusions about the effects if any on streamflow from drilling of groundwater wells. This is further compounded by lack of pumping rate information on most wells for the periods of low flow.

References:

[1] Hodge, W.S., Kohut, A.P, and Wei, M., *et al*. 1994. Groundwater Resources of British Columbia (Revised ed.) , B.C. Environment & Environment Canada, ISBN 0-7726-2041-5 http://wlapwww.gov.bc.ca/wat/gws/gwbc/!!gwbc.html

[2] Ministry of Water,Land & Air Protection, Groundwater Information (Website: http://wlapwww.gov.bc.ca/wat/gws/gwis.html

[3] Fyles, J.G. 1962. Geology of the Horne Lake and Parksville Map Areas, Vancouver Island, BC Geological Survey of Canada Memoir 318.

[4] Evaluating Long Term Well Capacity for a Certificate of Public Convenience and Necessity. Min. of Environment, Lands and Parks Groundwater Section. ISBN 0-7726-4019-X. http://wlapwww.gov.bc.ca/wat/gws/gwdocs/eval_well/toc.html

[5] Well Protection Toolkit. 7 part booklet series, Government of British Columbia & Environment Canada ISBN 0-7726-4165-X http://wlapwww.gov.bc.ca/wat/gws/well_protection/wellprotect.html

French Creek Water Use

Bob Cook
Water Planner

Ministry of Sustainable Resource Management
Vancouver Island
British Columbia

2001

French Creek

Water Use

Water is a Crown-owned resource.

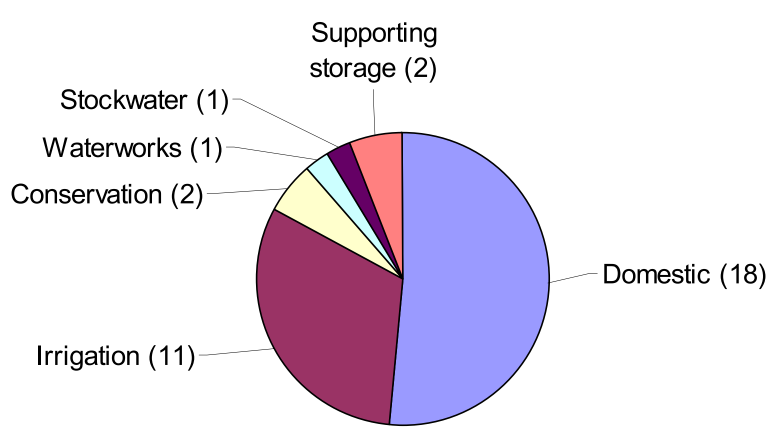
Permission to use surface water is obtained by licence issued by the Comptroller of Water Rights or the Regional Water Manager under the Water Act. Under this legislation, with a few exceptions, it is illegal to take surface water from a stream without first obtaining a water licence.

Currently, groundwater use is not directly regulated in British Columbia. A limited measure of groundwater management is provided in local government zoning bylaws and subdivision requirements. Developers may be required to prove there is adequate water supply for the proposal and to ensure that there will be no adverse impact on existing water users.

Surface Water Use

Currently, there are 32 water licences authourizing the use of water from either French Creek or its tributaries. The water licences are for 35 purposes as shown in Figure 1.

Fig 1 - French Creek Water Licences



A map of water license locations in French Creek is displayed in Figure 2.

Not all water use purposes are for “consumptive” demands that may reduce water flow during the low flow period. For instance, water use for land improvement and conservation purposes do not reduce water flow in French Creek or its tributaries. The water required for storage purpose is normally retained during the higher flow periods

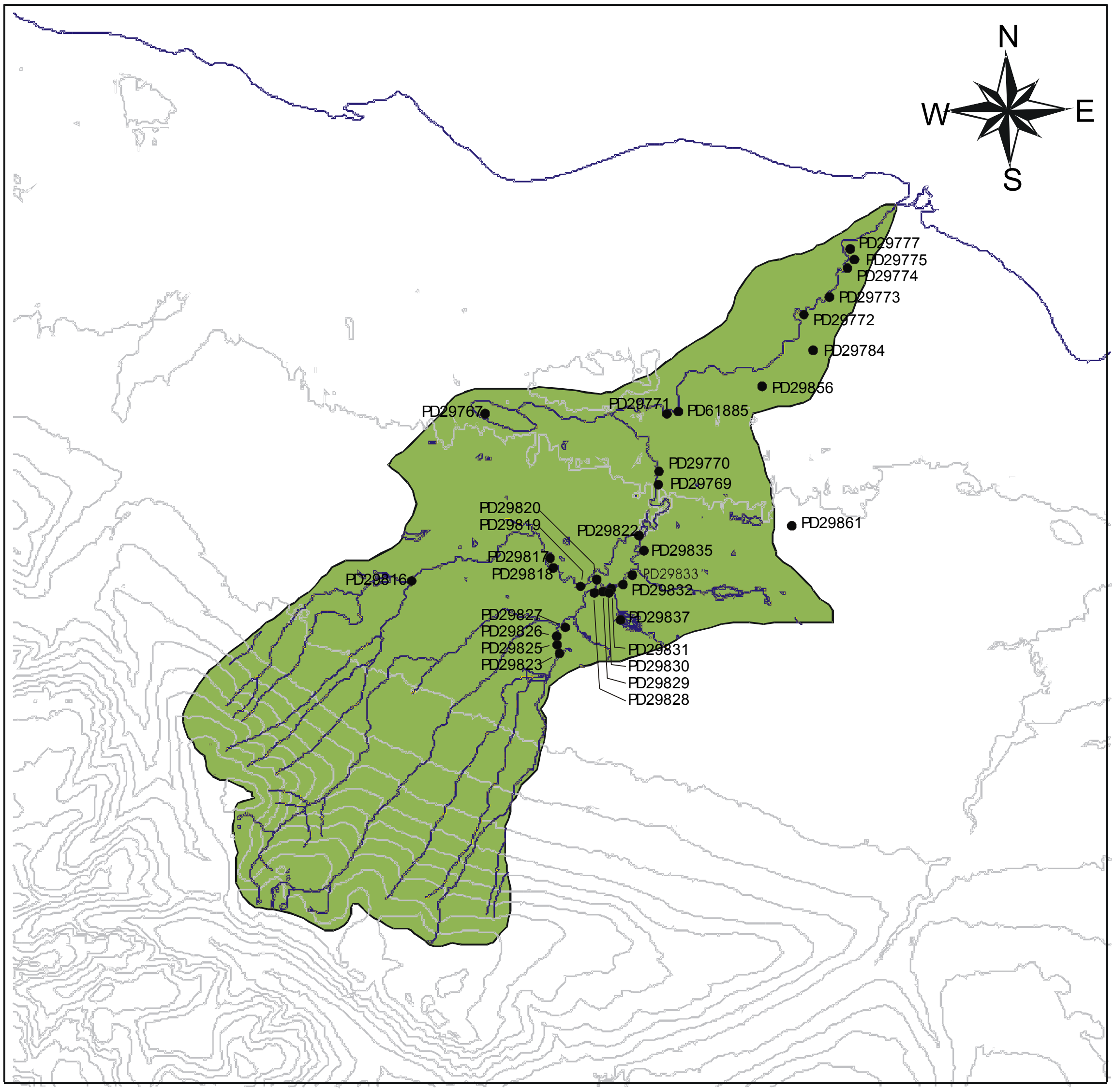


Figure 2. Water Licenses for French Creek and tributaries. The PD number may be used to obtain further information from the list of water licenses in Table 2.

and is used to support summer withdrawals so that low flow conditions are not adversely impacted.

The quantity of water allocated for “consumptive purposes” is shown in Table 1. The licenced demand is shown in equivalent units for the critical summer period when the water demands are highest and the water flow is the lowest.

Table 1. FRENCH CREEK – CONSUMPTIVE WATER DEMAND			
Purpose	Licenced Quantity Maximum Allowable	Licenced Quantity[1] Equivalent Units	
		cfs	m^3/s
Domestic	11,500 gpd	0.02	0.0006
Waterworks	125,000 gpd	0.23	0.0066
Irrigation	109.25 acre-feet	0.61	0.0173
Industrial (Greenhouse)	1 acre-feet	0.01	0.0002
	Total	0.87	0.0247

[1] Notes

- Licenced quantity for domestic and waterworks purposes are based on maximum allowable quantities.
- The equivalent quantities for both irrigation purposes and industrial (greenhouse) that are not fully supported by storage is based on the maximum allowable volume over a 90 day period.
- As there is no consumptive water demands for irrigation or stock watering purpose fully supported by storage or for conservation purpose, these demands are not shown.

Breakwater Enterprises Ltd., hold the waterworks purpose license, shown in Table 1. This private water utility serves the urban development located in the lower part of the watershed between the City of Parksville and the Town of Qualicum Beach. Breakwater's 1450 connections are provided water from a combination of surface (French Creek) and groundwater (14 wells) sources. French Creek was the initial water source developed for the water utility in the late 1960's. Further extensions to the service area have been supported by groundwater sources.

Approximately 10% of the utility's annual water demand is satisfied by the French Creek surface source. During July and August, the French Creek source provides up to 15% of the water demand. The Breakwater consumption records for 1999 show an annual water withdrawal from French Creek of 55975 m3 (12.3 million gallons) or an average daily extraction of 153 m3 (33,735 gallons). The average daily water withdrawals during the high demand summer period (July and August) was 357m3 (78,500 gallons/day). During the summer of 1988, Breakwater carried out daily monitoring of their water consumption from French Creek. The maximum daily use during this period was on Sunday July 19th with 507m3 (111,600 gallons per day) and within their authorized licenced quantity of a maximum 125,000 gallons per day.

There are several water licences for irrigation purpose. These licences authorize the use of water from April 1st to September 30th. The water volume authorized by existing licences were estimated using a typical guide of 1foot of water for each acre of land to be irrigated at any time during a 6 month period. Irrigation demands for any future irrigation licences will be based on specific crops, soil capabilities, climatic conditions, and efficient irrigation methods and equipment.

Older irrigation licences (ie prior to 1980) were issued on French Creek and tributaries without the development of supporting storage. Two of the larger irrigation licences, however, are partially supported by utilizing natural water storage in swamps that are tributary to French Creek. More recent irrigation licences were issued on condition that the water withdrawals be fully supported by the development of storage. Water may be collected for supporting storage during the higher winter flows for use in the summer low flow period. The development of off-stream storage (ie. dugouts, ponds, etc) is preferred, however, on-stream storage development is allowed where there are no significant impacts on others users including riparian owners, downstream licensees and fisheries

There are numerous water licences that authorize the use of water for domestic purposes, mainly for single family dwellings. Despite the large number, the water demand is not significant – only 2.4% of the consumption during the high demand, low flow, summer period.

Licences for conservation purpose have no adverse impacts on other water users or fish and fish habitat and are, therefore, considered non-consumptive uses. The Parksville/Qualicum Fish & Game Club operates a fish hatchery on French Creek and Ducks Unlimited (Canada) store water in Dudley Marsh for wild foul habitat development and maintenance of fish flows.

French Creek was designated a sensitive stream under the Fish Protection Act to protect a fish population whose sustainability is at risk because of inadequate flows and degradation of fish habitat. As a sensitive stream, the Comptroller of Water Rights or Regional Water Manager, when making future water licensing decisions, must be satisfied that adverse impact on fish or fish habitat is likely to be insignificant.

The French Creek Water Allocation Plan provides direction to those making application to use water from French Creek and tributaries.In the late summer months, some stream reaches are at or near zero flow. In the mainstem between the railroad trestle and the old Island Highway, water may go completely subsurface within some reaches only to reappear downstream. Therefore, additional water withdrawals during the low flow period are likely to cause adverse impacts on existing users and instream fisheries. Unless more rigorous analysis determines otherwise, any further withdrawals during the period, May through October, must be fully supported by storage. Water is available for use and storage during the high flow period, November through April.

Currently, there are no outstanding water licence applications in the French Creek watershed.

Existing water rights are secure as long as use is pursuant to the Water Act and the terms and conditions of the water licence.

Groundwater Use

Breakwater Enterprises Ltd. uses 14 wells for approximately 90% of their water consumption annually and about 85% of the water demand in the summer. The remainder is supplied by their surface water source on French Creek. The average daily consumption by Breakwater (both surface and groundwater) averages 1.23m3/connect/day (270 gallons/connect/day) which is typical for a rural residential community.

Other groundwater users are located throughout the watershed, primarily in the Coombs area. Many shallow wells near French Creek and its tributaries are used for individual domestic and irrigation purposes. Many of these wells could be hydraulically connected to French Creek and as such may indirectly withdraw water from the creek. There is, however, no regulation of groundwater use at present in BC.

Table 2. WATER LICENCES - FRENCH CREEK AND TRIBUTARIES (April 3, 2001)

PD Number	Licence Number	File Number	Source	Appurtenancy	Licensee/Applicant	Priority	Purpose	Quantity	Units
PD29767	C108916	0214001	Little Hamilton Swamp	60 ACRES OF D L 18 AND 37 NEWCASTLE D IST EXCEPT PLAN 19373	PHYE DONALD 660 HILLIERS RD QUALICUM BEACH BC V9K2H9	1956/10/29	IRR	60.00	AF
PD29769	C033493	0277522	French Creek	L A OF L 148 NANOOSE DIST PLAN 1115	GRAATEN KRISTIAN/S BOX 47 COOMBS BC V0R1M0	1968/01/26	DOM	1,000.00	GD
PD29770	F040694	0290724	French Creek	L 1 OF L 143 NANOOSE DIST PLAN 6589	BRIX ARNE 34 - 1400 ALBERNI HWY PARKSVILLE BC V9P2N6	1970/01/06	DOM	500.00	GD
PD29771	C108037	0366526	French Creek	LOT B DISTRICT LOT 141 NANOOSE DISTRI CT PLAN 50466	TRAWOGER ANTJE 3240 HUNTINGTON PL NANOOSE BAY BC V0R2R0	1980/05/09	DOM	500.00	GD
PD29772	C020120	0188579	French Creek	30 AC OF L 26 NANOOSE DIST	FRITZSCHE VOLKHARD & MON 1410 HODGES ROAD PARKSVILLE BC V9P2B5	1951/05/05	IRR	30.00	AF
PD29773	C024357	0220404	French Creek	L 1 OF L 27 NANOOSE DIST PLAN 1300	FRITZSCHE VOLKHARD & MON 1410 HODGES ROAD PARKSVILLE BC V9P2B5	1958/05/21	DOM	500.00	GD
PD29774	C065840	1001034	French Creek	THAT PART OF L A OF DL 27 NANOOSE DIST PLAN 1300 LYING NE OF E & N RWY R/W EXC PLANS 25748 & 30015	ASHWORTH HUGH R & ROSEM 879 DREW RD PARKSVILLE BC V9P1X2	1989/02/21	SW STONP	500.00 0.50	GD AF
PD29775	C063988	1000529	French Creek	THE CONS PROJECT OF THE LICENSEE WITHIN L 28 NANOOSE DIST	PARKSVILLE/QUALICUM FISH & BOX 988 PARKSVILLE B C V0R2S0	1985/09/13	CONUS	0.50	CS
PD29777	C035623	0281684	French Creek	UNDERTAKING OF THE LICENSEE AS SET OU T IN CPCN ISSUED UNDER OIC 4211/1969	BREAKWATER ENTERPRISES BOX 855 PARKSVILLE BC V0R2S0	1968/09/06	WWKLA	45,625,000.00	GY
PD29784	C064062	1000619	Whiteley Creek	60 AC OF L 26 NANOOSE DIST	FRITZSCHE VOLKHARD & MON	1986/06/13	IRR	60.00	AF

Water Licences listed chronologically by "PD number"

				EXC PLAN 23750	1410 HODGES ROAD PARKSVILLE BC V9P2B5				
PD29784	C064063	1000619	Whiteley Creek	STOR FOR C 64062 R5 WHITELEY CR	FRITZSCHE VOLKHARD & MON 1410 HODGES ROAD PARKSVILLE BC V9P2B5	1986/06/13	STONP	60.00	AF
PD29816	C054995	0366816	French Creek	L 31 OF L 8 NANOOSE DIST PLAN 1981	STADLER GAIL C MCMILLAN HELENA C 1246 MARINA WAY NANOOSE BAY BC V9P9C1	1980/06/26	DOM	1,000.00	GD
PD29817	C046473	0329108	French Creek	L 2 OF L 8 NANOOSE DIST PLAN 22131	BLOOD JOHN R & VIOLET A 1249 WINCHESTER RD QUALICUM BEACH BC V9K1W9	1975/07/04	DOM	500.00	GD
PD29818	C052866	0342458	French Creek	THAT PART OF L 43 OF L 8 CAMERON DIST PLAN 1981 SHOWN ON PLAN 1062-R	REHLINGER NICOLAUS M & LIN 1271 WINCHESTER RD QUALICUM BEACH BC V9K1W9	1978/01/13	DOM	500.00	GD
PD29819	F048233	0193517	French Creek	5 AC OF L 45 OF L 8 CAMERON DIST 1981 EXC WLY 6.9 CHAINS THEREOF	THEVENIN DOMINIQUE & JANE 2601 GRAFTON AVE QUALICUM BEACH BC V9K1Y1	1952/02/18	IRR	5.00	AF
PD29820	F052376	0263424	French Creek	THAT PART OF L 46 OF L 8 CAMERON DIST PLAN 1981 LYING S OF AND E OF FRENCH CR	GEEKIE LARRY GEEKIE LENE BOX 27 COOMBS BC V0R1M0	1965/07/16	DOM	500.00	GD
PD29822	C058040	0369640	French Creek	L 1 OF L 149 NANOOSE DIST PLAN 1917	GEEKIE LARRY BOX 27 COOMBS BC V0R1M0	1981/11/23	DOM	500.00	GD
PD29823	C107419	0340685	South French Creek	L 83 DIST L 8 CAMERON DISTRICT PLAN 1 981 EXC PLAN 24998 AND 47890	FLYNN HAROLD & SYLVIA E & I 1560 WINCHESTER RD QUALICUM BEACH BC V9K1Y2	1976/12/24	DOM	500.00	GD
PD29825	C051409	0342060	South French Creek	L 1 OF L 8 CAMERON DIST PLAN 24998	WOOLNOUGH KEVIN J & ELAIN 1530 WINCHESTER RD QUALICUM BEACH BC V9K1Y2	1977/09/16	DOM	500.00	GD

Table 2. WATER LICENCES - FRENCH CREEK AND TRIBUTARIES (April 3, 2001)

PD29826	C052799	0342483	South French Creek	L 2 OF L 8 NANOOSE DIST PLAN 19049	KROOT NICHOLAAS J & CHRIS 1513 WINCHESTER RD QUALICUM BEACH BC V9K1Y2	1978/01/10	DOM	500.00	GD
PD29827	C054428	0365694	South French Creek	L A OF L 8 CAMERON DIST PLAN 38977	SNOW DARREN 1504 WINCHESTER RD QUALICUM BEACH BC V9K1Y2	1979/05/30	DOM	500.00	GD
PD29828	C028224	0249580	South French Creek	3 AC OF L 51 OF L 8 CAMERON DIST PLAN 1981 EXC THE WLY 4.96 CHAINS	GOODLAND DOUGLAS I & CAR BOX 240 2560 GRAFTON AVE COOMBS BC V0R1M0	1963/05/07	IRR	3.00	AF
PD29829	C048691	0342519	South French Creek	0.37 AC OF L 1 OF L 8 CAMERON DIST PLAN 26524	BUTLER ROBERT A & EVELYN 4656 NORTHVIEW CRT SOUTH BURNABY BC V5H1E3	1958/06/20	IRR	0.37	AF
PD29830	C048689	0220885	South French Creek	0.38 AC OF L 2 OF L 8 CAMERON DIST PLAN 26524	WRIGHT JACK & JOAN L GD COOMBS BC V0R1M0	1958/06/20	DOM IRR	500.00 0.38	GD AF
PD29831	C048690	0342518	South French Creek	0.25 AC OF L 49A OF L 8 CAMERON DIST PLAN 1981 EXC DD 364198I	TOPLIFFE RALPH C BOX 409 COOMBS BC V0R1M0	1958/06/20	IRR	0.25	AF
PD29832	C034953	0285615	South French Creek	0.25 AC OF PARCEL A (DD 364198I) OF L 49A OF L 8 CAMERON DIST PLAN 1981	TOPLIFFE HERBERT R & GRAC BOX 147 COOMBS B C V0R1M0	1969/05/27	IRR	0.25	AF
PD29833	C024355	0220402	South French Creek	BLK 7 OF L 140 NANOOSE DIST PLAN 1918	TERRY IAN & BARBARA BOX 115 COOMBS B C V0R1M0	1958/05/22	DOM	2,000.00	GD
PD29835	C041858	0316817	South French Creek	L 8 OF L 140 NANOOSE DIST PLAN 1918	RANDALL ALFRED W BOX 3945 SMITHERS BC V0J2N0	1973/04/30	DOM	500.00	GD
PD29837	C059538	1000073	Dudley Creek	CONS UNDERTAKING OF THE LICENSEE WITHIN L 1 OF L 77 NANOOSE DIST PLAN 37746	DUCKS UNLIMITED (CANADA) BC COASTAL FIELD OFFICE 1 3033 KING GEORGE HWY	1982/09/23	CONST	51.30	AF

					SURREY BC V4P1B8				
					WILDLIFE BRANCH 2569 KENWORTH RD NANAIMO BC V9T4P7				
					ENVIRONMENT LANDS & PARKS MINISTRY OF PARLIAMENT BUILDINGS VICTORIA BC V8V1X4				
PD29856	F057301	0208076	Fabrick Brook	1 AC OF L 3 OF L 116 NANOOSE DIST	LYNCH-STAUNTON ALFRED G 1056 THAEL RD QUALICUM BEACH BC V9K1M9	1955/05/31	IRR	1.00	AF
PD29861	C048186	0330297	Binet Swamp	10 AC OF PARCEL 1 (DD 87722N) OF L 114 NANOOSE DIST	BULLOCK GEOFFREY H & BEV BOX 962 PARKSVILLE BC V0R2S0	1976/03/22	DOM IRR	500.00 10.00	GD AF
PD61885	C108038	0355984	French Creek	LOT A DISTRICT LOT 141 NANOOSE DIST PLAN 50466	LARSON ROBERT M 107 MCBRYAN DR HAY RIVER NWT X0E0R3	1980/02/01	DOM	500.00	GD

Impervious Surfaces in French Creek

Rick Guthrie, M.Sc., P.Geo.,
Regional Geomorphologist

And

John Deniseger, R.P.Bio.,
Environmental Impact Biologist

Ministry of Water, Land and Air Protection
Vancouver Island
British Columbia

2001

1.0 Impervious Surfaces

Impervious surfaces (IS) are those that resist the absorption of water into the ground. While impervious surfaces exist in nature in the form of exposed competent bedrock, their exposure on the surface is generally restricted. More commonly, imperviousness is associated with human growth and expansion. The footprint of human growth includes the mass of pavement in transportation corridors and parking lots, the buildings, from urban sprawls to garden sheds, and the many other landuses; commercial, industrial, residential and recreational that compact the soil and impede its ability to absorb water.

Recently, amount of imperviousness has been linked to the overall condition of urban watersheds (Zanderbergen and Schrier, 2000, Finkenbine et al., 2000, Zanderbergen et al., 1999, Arnold and Gibbons, 1996, Schueler, 1994 and others). Work done particularly in the past decade suggests that impervious surface coverage may be used as a key indicator to watershed health (Finkenbine et al., 2000, Arnold and Gibbons, 1996). Schueler (1994) identified several effects of changes to imperviousness. Those include subsequent changes to; runoff, stream morphology, water quality, stream warming, stream biodiversity and fish health. Schueler (1994) also proposed a relationship between impervious cover and overall stream quality (Figure 1). In this proposal, streams were considered impacted when impervious cover exceeded 10%, and degraded when impervious cover exceeded 25%. In degraded streams the pre-development status of the stream could not be maintained even with the implementation of various best management practices (BMP). Despite this, BMPs may have significant positive impacts in reducing imperviousness by as much as 50% in some cases (Schueler, 1994).

Figure 1. Relationship between impervious cover and overall stream quality (modified from Prisloe et al., 2000).

Runoff

Hydrologists and geologists have generally understood changes in runoff due to increased imperviousness for decades (Reid, 1981, Dunne and Leopold, 1978, Leopold, 1968). Generally speaking the effects are to lower groundwater levels and to increase the timing, frequency and magnitude of flood events. Roads, ditch lines and sewer drains all serve to effectively increase the drainage network, and eventually to divert water away from old stream beds to a new man made conduits. Reduced infiltration means an almost instantaneous response routing precipitation to streams as runoff. Schueler (1994) compared by way of example, an undeveloped meadow and a parking lot of the same size (0.4 ha): the parking lot produced a runoff volume 16 times greater than the meadow.

Stream morphology

It follows that with increased runoff the stream channels will undergo changes in shape and design. Increased cross sectional areas are necessary to accommodate higher flows. The stream widens, deepens or both. Increased sediment loads triggered by greater transport capability and by bank erosion further compound the changing dynamics of a stream. This cycle of changes lasts until the stream finds a balance at the new hydrological regime.

Impervious surfaces also become a proxy indicator in the context of stream morphology. Where people live near a stream, they develop, landscape, protect and construct on their properties in such a manner that may restrict, redirect or otherwise change the shape of the stream. This may have more effects than the runoff, as the change in stream morphology is immediate, focussed and generally not suited to, or designed for the natural characteristics of the stream.

Water quality

In the natural environment, rain and snow melt run over land into surface waters or seep through the soil to become groundwater. As the water seeps down it is absorbed and purified by soils, bacteria and plants. Surface water runs over the land and paved surfaces and accumulates pollutants including; suspended solids, nutrients, heavy metals, pathogenic bacteria, and organic contaminants. During storms, these pollutants are rapidly delivered to the adjacent streams and lakes. General sources of pollutants in urban runoff include motor vehicles (fuel and oil leakage; antifreeze; particles from tire, clutch and brake wear; exhaust emissions; etc.), atmospheric fallout, litter, spills (sand, dust, cement, agricultural and petroleum products), deliberate dumping, erosion, and excessive use of fertilizers and pesticides.

It has been shown that as watershed imperviousness and urbanization increase, the overall water quality of a given stream will degrade (Schueler, 1994). Fortunately, studies have also shown that overall chemical water quality of urban streams is not normally significantly impacted at relatively low impervious levels (May et al., 1997).

Stream warming

Stream temperature is affected in two ways: water runoff from a parking lot is typically several degrees warmer than runoff from a forest. The increased temperature of water entering a stream is further compounded by the increased volume (as discussed previously) of higher temperature water entering the stream (Galli, 1991).

Urbanization and land clearing activities result in riparian corridor encroachment, which exacerbates the effects of warmer water entering streams from paved surfaces. The streamside shading provided by riparian vegetation is critical in maintaining lower temperatures necessary to support the fisheries resource in coastal streams (Galli, 1991).

Biodiversity and Fish Health

Salmonid fish species (trout and salmon) are negatively impacted by increased imperviousness. Sensitive species, defined as those with a strong dependence on the substrate for feeding or spawning decline rapidly as IS increases. For example, research by Luchetti and Feurstenburg (1993) indicate that sensitive coho salmon were seldom found in watersheds beyond 10 to 15% imperviousness. Booth (1993) found that most urban stream reaches had poor fish habitat when IS exceeded 8 to 12%.

Coastal streams such as French Creek have evolved over thousands of years to form a rich, diverse, interactive biological community that can withstand or recover rapidly from natural disturbance. However, the scale, frequency, and complexity of human disturbance is often well in excess of natural variability. Our actions tend to put stream health at risk by affecting one or more of five factors: physical habitat, seasonal water flow, food base of the system, biotic interactions and chemical contamination (Karr, 1991).

Coho salmon rely heavily on smaller lowland streams and associated off channel wetlands during their rearing phase. They are the only species of anadromous salmon that overwinter in our coastal streams. They rear in pools with high habitat complexity, abundant cover, and large woody debris (LWD) as a basic structural component. They rely on an abundant diverse food source including benthic invertebrates such as mayflies, caddisflies, and stoneflies. Benthic invertebrates similarly rely on diverse habitat, leaf litter from riparian vegetation, water quality, algal growth, and suitable substrates. Algal communities rely on suitable nutrient levels, water quality, light, habitat, and substrate. Impacts on any of these will affect the entire biological integrity of the stream. Furthermore, the effects are cumulative, both temporally and spatially. Klein (1979) was one of the first to note that benthic invertebrates diversity declines sharply in urban streams. He found that diversity consistently became poor when watershed imperviousness exceeded 10 to 15%. The same essential threshold has been consistently found by all other research studies examining benthic invertebrate density in urban streams. In these studies, sensitive aquatic insect species were replaced by those more tolerant of pollutants and hydrologic stress. Stoneflies, mayflies, and caddisflies virtually disappear and are replaced by chironomids, tubificid worms, amphipods and snails. Moreover, species that employ specialized feeding strategies such as shredding leaf litter, grazing rock surfaces, filtering organic matter and preying on other species were lost.

According to Bisson et al (1988), LWD may be the most important structural component of salmonid habitat. LWD is critical in forested lowland streams in dissipating flow energy, protecting stream banks, storing sediment, stabilizing streambeds while providing instream cover for juvenile salmonids and habitat diversity, which in turn supports the underlying productivity of the stream. As development, urbanization and imperviousness increase in a watershed, the amount of LWD typically decreases.

Sedimentation of the streambed can have ramifications throughout the biological stream community. The deposition of fine sediment can dramatically affect the abundance and diversity of the benthic invertebrate. Sedimentation of spawning beds can clog gravels, which decreases salmonid egg survival. Sediment can also affect algal growth through physical abrasion and smothering as well as increasing turbidity which lowers light availability. Urban sediments transported often contain increased quantities of contaminants such as heavy metals that may further affect the benthic invertebrate community.

Other studies

Impervious surface (IS) studies are being implemented across North America. Much of the work in the United States is co-ordinated by the University of Connecticut via the NEMO (nonpoint education for municipal officials) project and involves several municipalities on across the country (Prisloe et al., 2000, Arnold and Gibbons, 1996).

Coastal British Columbia also has several examples. Impervious surface data has been generated for various watersheds in the Greater Vancouver Regional District (Zandbergen and Schreier, 2000, Greater Vancouver Regional District, 1999), selected watersheds in the Lower Mainland by the University of British Columbia (Zandbergen and Schreier, 2000) and the Millard-Piercy watershed on Vancouver Island (Zandbergen and Schreier, 2000). Several municipalities are currently interested in the application of IS as indicators of watershed health and the impacts of development.

How the information is gathered

Impervious surface data may be gathered directly through ground surveys and stereo-photogrammetry where roads, roofs, sidewalks and all other impervious surfaces are actually outlined. Alternatively IS data may be gathered indirectly by determining land use through satellite interpretation, air photograph interpretation and zoning analysis. Land use classes are then given average imperviousness values. This allows for larger areas to be dealt with more efficiently, however, requires some calibration for several of the land use classes. A more thorough discussion on direct and indirect measures of imperviousness is in Zandbergen and Schreier (2000).

Total vs. Effective

Total impervious surface is the common use of IS and it measures all areas that impede water infiltration. However, it is important to recognize that this method likely overestimates the amount of imperviousness. Effective imperviousness is the term used to more accurately describe imperviousness and incorporates the concept that some landuses are not a total barrier to water. For example, roofs may drip water onto the lawn rather than into a stormdrain system, therefore reducing the effects of imperviousness. This particular measurement, however, is not currently practical as it is to difficult to determine at a watershed scale. Similarly, if municipalities or individuals use BMPs, these practices are not resolvable at the data gathering level (at least for indirect methods) and also reduce imperviousness. This is expected to be more of an issue in the future than now, as the best management practices are still relatively new. Alley and Veenhuis (1983) worked on a relationship between total impervious area, and effective impervious area that calibrates IS to impervious areas that have direct hydrologic connection to the drainage network. That been said, however, the measures of impact have been calibrated against total imperviousness due to the relative ease with which that data is gathered.

2.0 Methods

Landuse/landcover maps

Landuse and landcover maps refer to a spatial product that shows the existing land condition in terms of an interpreted activity (commercial use, residential use and forested for example) and in ground cover (shrub, bedrock, pavement, mature timber) respectively. These interpretations are distinct from 'designated landuse' as a planning term. Landuse/landcover mapping was completed for four map sheets (92F028, 92F029, 92F038, 92F039), three by the winter of 1999, and the last in January 2001. Accuracy was confirmed by overlaying landuse polygons onto 1m resolution digital orthophotographs. Output maps are considered accurate at 1:20,000 scale.

Landuse mapping followed the classification scheme determined by Geographic Data BC and the Aboriginal Affairs Group outlining 75 possible landuse classes of which 30 were identified within the French Creek boundaries. Table 1 describes the landuse classes identified and their requirements.

Landuse classes were visually interpreted using color air photographs at 1:15,000 (1998) and 1:40,000 black and white air photographs (1987), Landsat 5 TM (1998) and Landsat 7 TM (1999) imagery with 30m resolution. Field checks and ancillary data supplemented image interpretation.

Landcover classes were interpreted according to the BC Land Classification Scheme and were digitally interpreted using the multispectral (Landsat) satellite imagery combined with high-resolution (5m) IRS satellite data. Interpretations were supplemented by field checks and ancillary data.

GIS component

The landuse and landcover maps were transferred to ArcView. The maps were clipped to determine data that remained within the French Creek boundary. The remaining landuse polygons were given IS values based on typical values for similar studies in coastal British Columbia (Zandbergen and Schreier, 2000). Table 2 shows the IS values for each landuse class. Several landuse polygons were determined directly by digitizing IS onto 1m orthophotographs (1999) for calibration of the values. This was particularly important for rural residential values and single family dwellings.

Zoning bylaws and planned property divisions supplied by the Regional District of Nanaimo (Figure 2) for the areas to which they applied (Electoral Area 'G') were incorporated into the GIS to determine future landuse-by-zoning. An Official

Community Plan and proposed landuse designations for the remaining area (Electoral Area 'F') was also supplied by the Regional District of Nanaimo (RDN) and incorporated into the GIS. We assumed the RDN guidelines would be followed in area 'F' and determined the potential landuse-by-zoning map based on a conservative estimate of what was possible within those guidelines. The data for both areas within the watershed were merged to produce a final landuse-by-zoning map.

The map was assigned IS values based on the landuse lookup table. Complex sites such as Coombs market, were assigned IS values in a weighted fashion depending on the percent of a particular use designated in the Official Community Plan.

The landuse by zoning map was merged with the current landuse map to produce a potential IS-buildout map.

Sub-basins were delineated and ordered within the watershed and merged with the IS-by-landuse and IS-buildout maps. This produced IS-by-basin and IS-buildout-by-basin maps and related data.

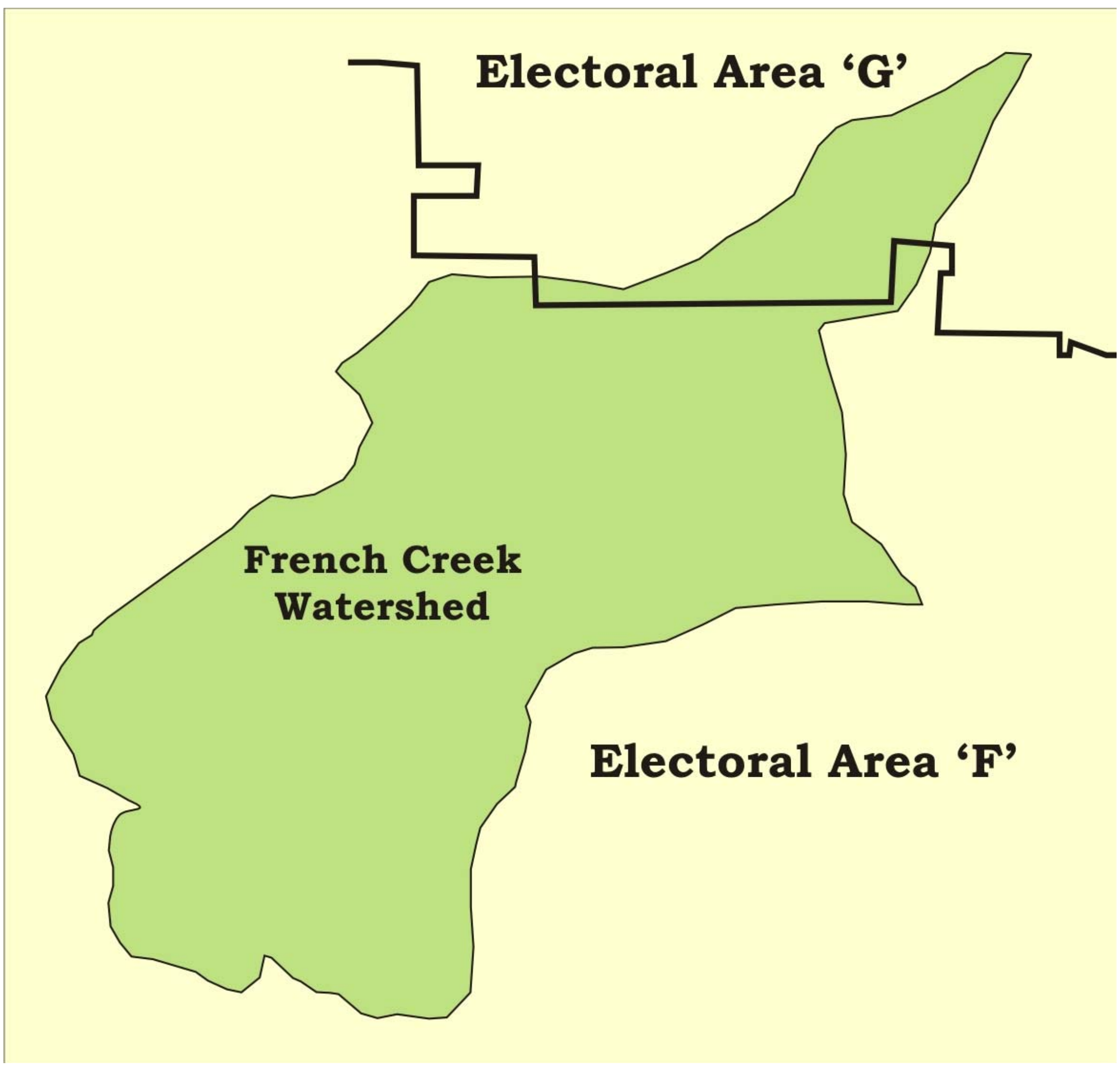


Figure 2. Electoral divisions of French Creek watershed into area 'G' and area 'F'.

3.0 Results

A detailed landuse map is shown in Figure 3. Approximately three-quarters of the French Creek watershed is forested land and about one quarter of the watershed has been logged in the last 20 years (Figure 4). Approximately 15 % of the watershed is used for agriculture and rural residential areas and only a small percentage of the watershed is actually urban residential (2.5%). Other uses include commercial, industrial and roads, and comprise another 5% of the watershed.

Urban and commercial landuse is distributed near the watershed mouth and along highway 4 in concentrations around Hilliers and Coombs. Farms and rural residences tend to be distributed fairly evenly through the middle of the watershed, while the upper third of the watershed, to the headwaters remains forested land.

Impervious surfaces range by landuse from 1% for forests up to 90% for roads and large areas of pavement such as the airport (Table 2). The percent impervious surface for the entire French Creek watershed is 4.6%. Impervious surfaces are concentrated in the developed and developing areas in the urban core leading into Parksville, and around the highway, particularly at Hilliers and Coombs (Figure 5).

French Creek is hydrologically divided into several long narrow sub-basins resulting in a forth order stream (for a discussion about stream ordering see the Coastal Watershed Assessment Procedure Guidebook (BC Ministry of Forests and Ministry of Environment, Lands and Parks, 1999)). When impervious surfaces are analyzed by watershed sub-basins, they all fall well below the 10% threshold for impacts (Figure 6). Table 3 shows impervious surface values for all the basins in the watershed.

Impervious surfaces were projected by both landuse and watershed sub-basin for the build out analysis and are shown in Figures 7 and 8. Imperviousness remains concentrated around Parksville, Hilliers and Coombs, but also in the agricultural and rural residential areas in the middle portion of the watershed. The area between Parksville and the highway changed very little in the projection due to zoning by-laws.

4.0 Discussion

The French Creek watershed is characteristically similar to many of the developing watersheds on eastern Vancouver Island. Sub-basins of French Creek are long and linear and begin in the forested headwaters. In terms of impervious surfaces, development has occurred lower in the system, primarily near the mouth of the river where it meets the sea, and along the old highway at Coombs and Hilliers. This means that the system currently has a significant buffering capacity built into it reducing potential effects of increased run-off, changes in channel morphology, water quality, stream warming, biodiversity and fish habitat due to impervious surfaces.

Overall French Creek was determined to be 4.6% impervious. This result was similar to previous results on Vancouver Island in the smaller Millard/Piercy watersheds where the results in the Millard subwatershed were 4.5% and in Piercy were 9.3% (Zandbergen and Schreier, 2000). Clearly a reflection of intensity of landuse, the results were substantially less than for urbanized areas such as Vancouver. Results from a study

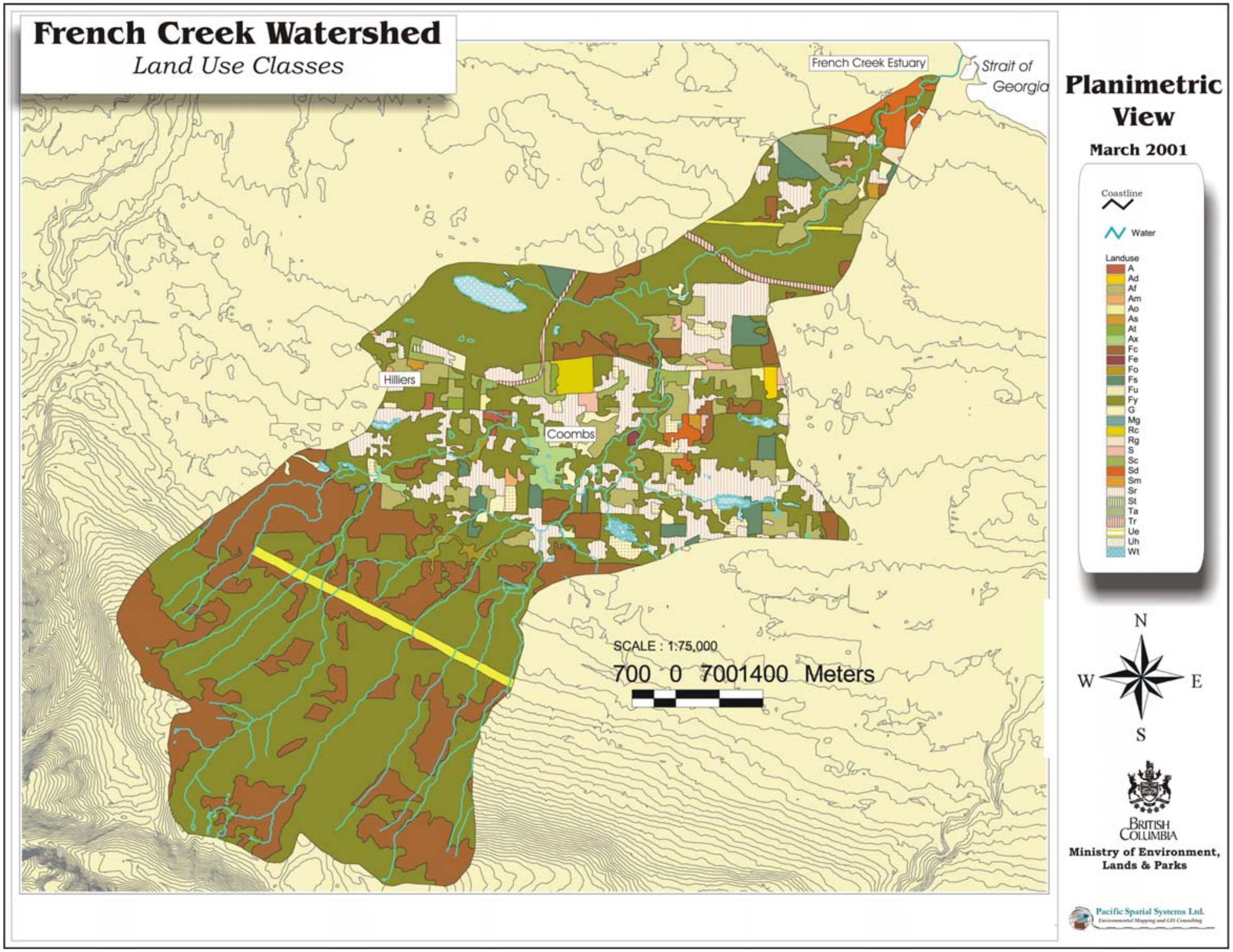


Figure 3. Landuse mapping in the French Creek watershed.

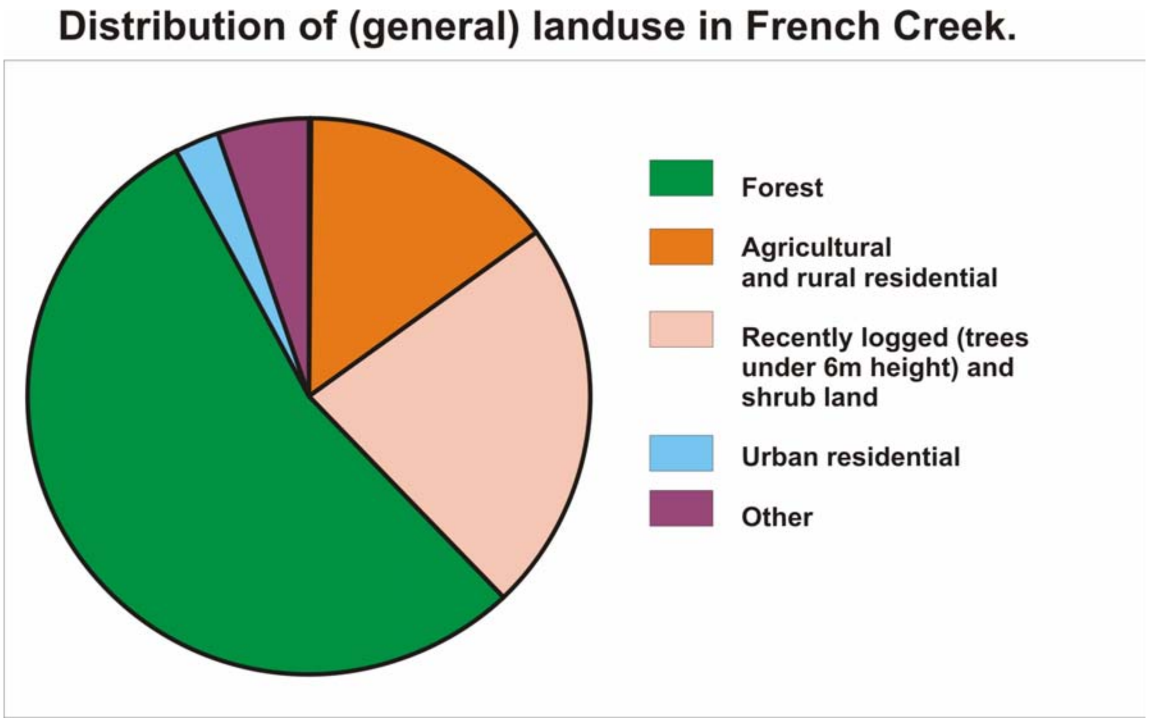


Figure 4. Generalized distribution of landuse in French Creek watershed.

in the Brunette watershed of Vancouver indicated average impervious surfaces of about 50% (GVRD, 1999).

Residents of the French Creek watershed may take comfort in the fact that the overall current levels of imperviousness fall well below the 10% threshold of a degraded system. However, comfort need not give way to complacency. There are several areas in French Creek that are or may be substantially affected by impervious surfaces. The hydrologic configuration of French Creek tends to smooth out the effects of IS in the GIS analysis. The lower third of the watershed for example is identified as a forth order stream; it contains most of the development from the areas around Coombs/Hilliers to the lower urban zone. Impervious surfaces range in areas to 90%, however, owing to the nature of the watersheds there are no sub-basins to highlight as being affected by this development. For this reason, IS are best displayed in French Creek by landuse (Figure 5). Small streams draining directly into French Creek and passing through zones of imperviousness will have effects, and some will be substantially altered. In addition, despite the significant buffering capacity of French Creek itself, some effects on the mainstem are likely to be noticed at the current levels. This is due to the fact the IS act as both a direct indicator of changes, and a proxy indicator of changes due to development. For example, while local changes in runoff are expected in the lower reaches, channel morphology changes are a certainty. These changes are not, however, simply attributable to increased runoff, but instead to the influence of human habitation. Individual landowners alter the characteristics of the stream by shoring up their property, installing gabian rip-rap and cement walls to protect against natural erosion, change the bank level to afford access to the stream or protect against flood and other such measures. These constitute massive changes in the morphology of the stream, and consequently change its behaviour as well.

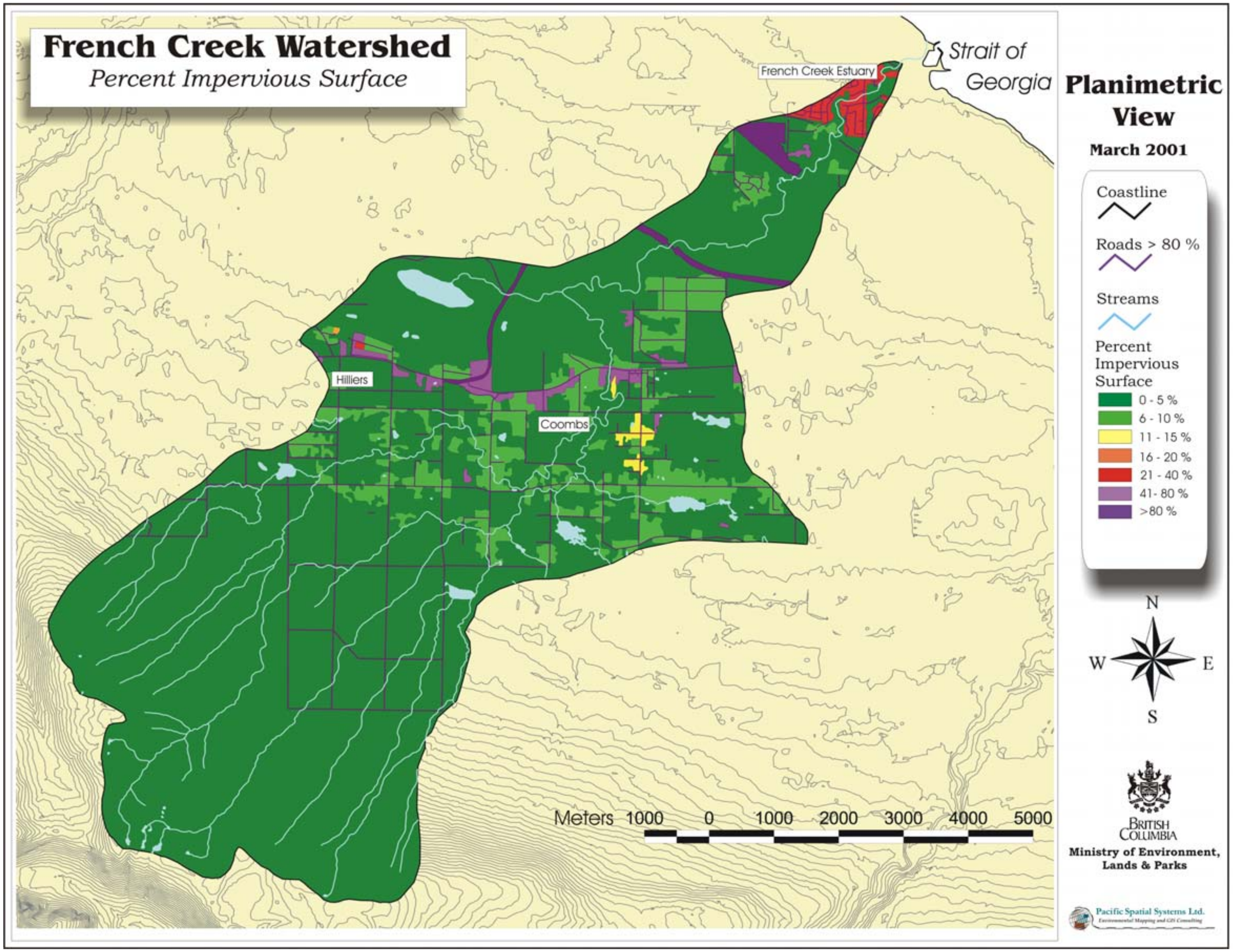


Figure 5. Impervious surfaces by landuse in the watershed. Colours gradate from low impervious cover (dark green) to high impervious cover (purple). The 10% threshold is exceeded at any colour beyond a green shade.

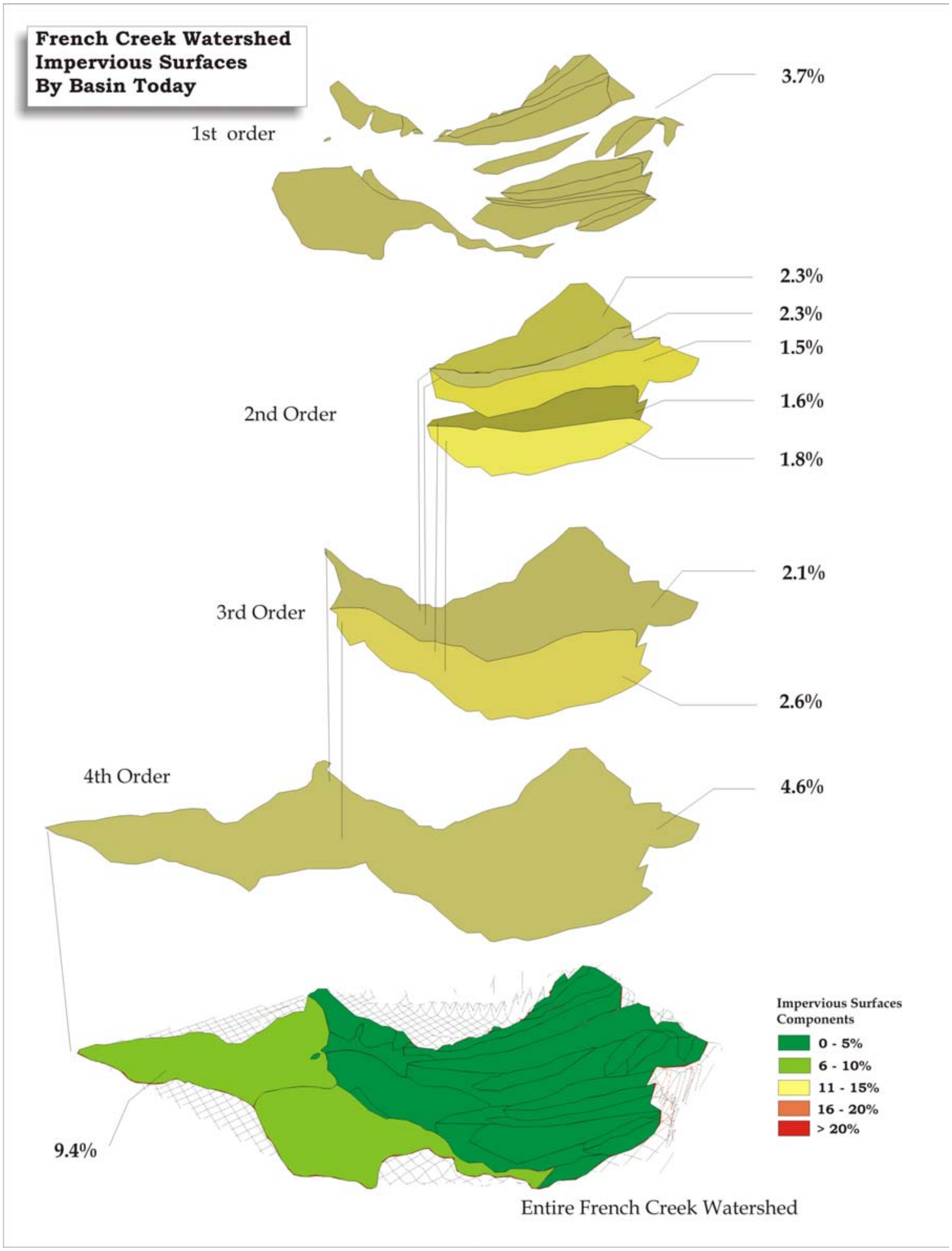


Figure 6. Impervious surfaces as they affect the hydrology of the French Creek watershed. Each basin is characterized by the overall impervious cover within (although this number is averaged for the 1st order basins). In the case of basins of 2nd order and higher, the impervious cover relates to the average value of all lower order basins nesting within, and the direct input area within the hydrologic divide of the basin. The lower part of French Creek that is directly contributing to the 4th order basin is noted separately. The bottom of the diagram shows the IS contribution by the same colour scheme as on previous figures.

In this case, the proxy changes are likely to overshadow the direct effects. The overall IS numbers are low enough for this stream that the expected changes in runoff would be hard to differentiate from changes in runoff due to changing climate patterns, or changes due to the hydrologic consequences of forest harvesting and land clearing higher up in the watershed. This is also likely true for other effects. The amount of large woody debris in areas with high percentages of impervious surfaces may be due to increased flows, however, it is more likely due to direct and indirect effects of development.

In either case, it is important to note that the land covered by IS will result in impacts to the system, and that IS remains an excellent indicator of the potential location and severity of those impacts.

The build out model estimates where growth may occur in the watershed and how that in turn may affect impervious surfaces (Figure 7). It is based on zoning by-laws (for area G) and the official community plan (for area F). Conservative estimates of buildout were used to try and achieve a realistic picture of the sort of development that may occur in the next decade. This is a coarse but reasonable predictor, and errors, particularly in the distribution of impervious surfaces will occur.

Multifamily and other residential development in lower French Creek will cause significant increases in impervious surfaces there. According to the Regional District of Nanaimo, much of the forested land between Parksville and the Coombs/Hilliers will not be subdivided in the near future. If this property remains intact, it will provide something of a buffer to the effects of impervious surfaces on the urban development downstream.

Industrial, commercial and residential development is expected to grow around the Hilliers and Coombs business centres, with consequent increases in impervious surfaces. Despite potential increases, French Creek is expected to remain resilient in the foreseeable future due to relatively low development to date (compared with major urban areas) and a strong headwater component that will remain relatively pervious for the foreseeable future. This headwater component is notable in Figures 6 and 8 that show the IS level for the entire watershed (4th order basin) compared to the individual inputs. The headwaters will help dampen extremes in runoff, during storm events and summer low flow, diluting contaminated water and supplying wood and organic material to the stream.

Effects of increased imperviousness will be evident locally as well as downstream of the development. Both direct and indirect (proxy) effects are expected on the French Creek mainstem with the overall imperviousness potentially increasing beyond 10% for the watershed. Zoning laws in area G currently restrict development between the airport and the highway. This zone of land will probably act as a buffer to the effects of development. Development in area F is based on the OCP bylaw and guidelines that are currently assumed agreed to by the community at large. If that assumption is wrong, or if members of the community should disagree, substantial land changes not predicted here are possible. A proposed zoning bylaw is currently being drafted for area F. Through the latter portion of the 20th century, the relative size of the transport component of imperviousness has steadily increased due to the ascendancy of the automobile in our culture. To be effective, restrictions on development must be accompanied by limitations on the transport component of imperviousness.

Another forgiving aspect of the French Creek watershed is the attention that has been given to leaving riparian corridors intact. Despite minor encroachments to the stream,

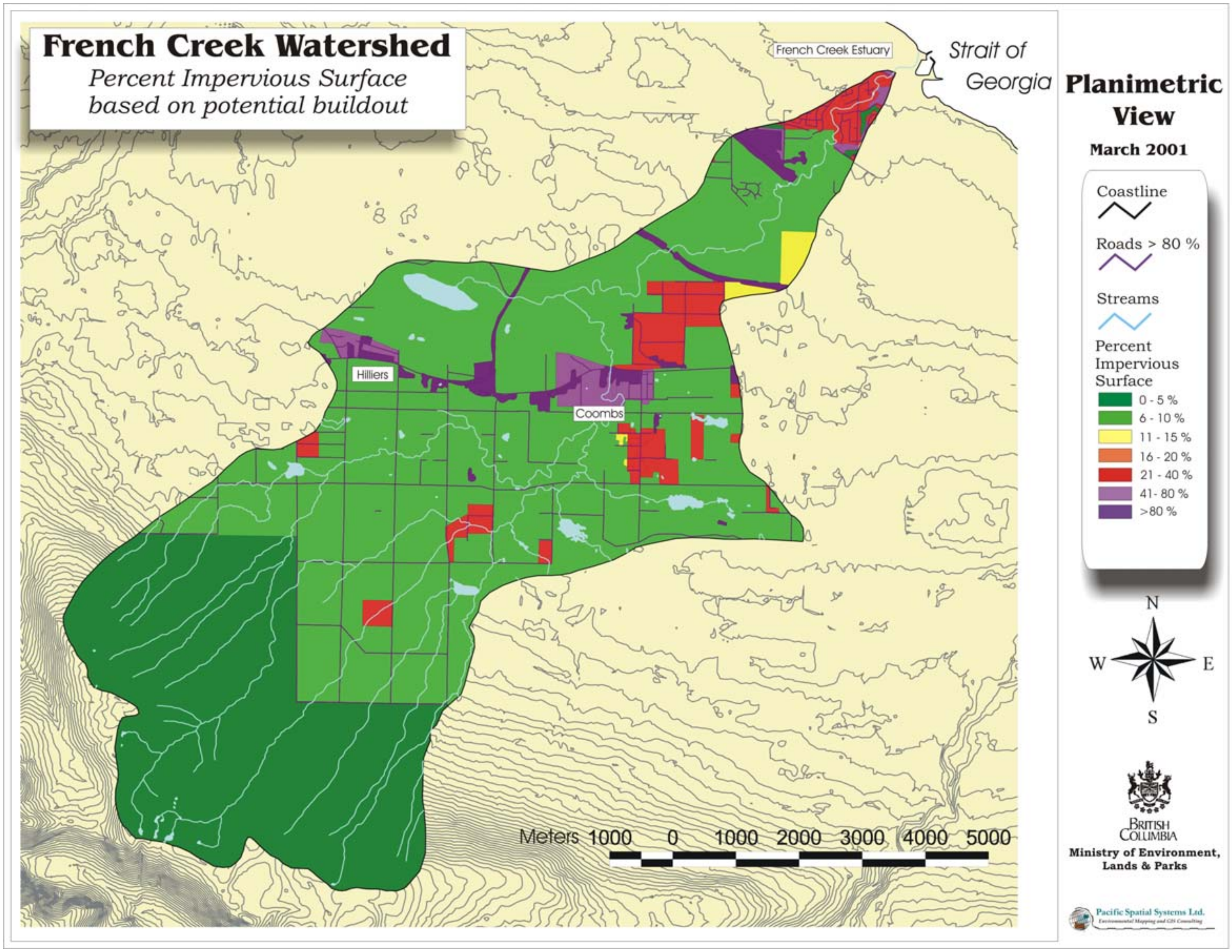


Figure 7. Impervious surfaces by landuse in the watershed as projected by potential buildout based on current zoning laws and community plans. Colours gradate from low impervious cover (dark green) to high impervious cover (purple). The 10% threshold is exceeded at any colour beyond a green shade.

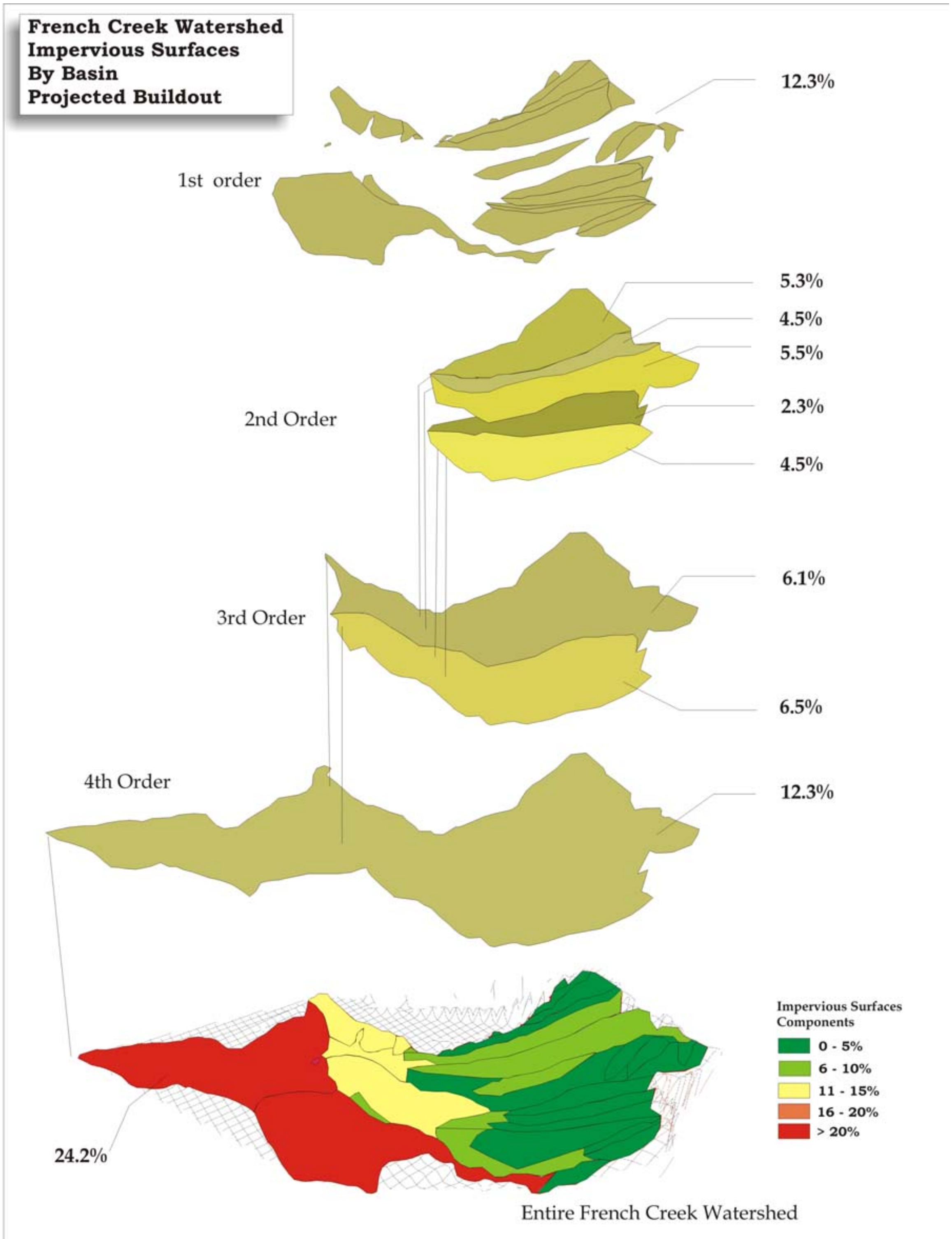


Figure 8. Impervious surfaces as they affect the hydrology of the French Creek watershed projected by potential buildout based on current zoning laws and community plans. Each basin is characterized by the overall impervious cover within (although this number is averaged for the 1st order basins). In the case of basins of 2nd order and higher, the impervious cover relates to the average value of all lower order basins nesting within, and the direct input area within the hydrologic divide of the basin. The lower part of French Creek that is directly contributing to the 4th order basin is noted separately. The bottom of the diagram shows the IS contribution by the same colour scheme as on previous figures.

and past logging practices, 92% of the riparian zone is relatively intact to 30m along the fish bearing portions of French Creek and its tributaries. This riparian strip acts as an additional buffer between human activity and the stream, reducing deleterious effects of IS on temperature change, biodiversity and fish health.

One of the key questions associated with imperviousness is how to plan future development. In many watersheds a choice is made to concentrate development in one sub-basin and let others provide the buffering effect of relatively clean water. The morphology, character and history of French Creek, however, make this kind of proposal difficult. The headwaters are likely to remain relatively untouched in the future (in terms of IS) and due to the long linear nature of the sub-basins, this will in turn provide regulating flows. Site-specific issues that may be observed in the French Creek watershed could be dealt with using various best management practices such as stormwater ponds, wetlands, filters, and infiltration basins, to minimize impacts where development is occurring. Several resources discussing ways to minimize impacts and amounts of impervious surfaces in urban settings are available (Marsh, 1998**,** NEMO, no date). BMP's are more effective as a preventative measure rather than a mitigative tool. Once a stream has "degraded", fully applied BMP's and retrofits will not be enough to return or maintain the stream's biodiversity and channel stability.

As development within the watershed continues it is critical that the existing relatively intact riparian corridor be maintained. Loss of riparian vegetation will serve to exacerbate the effects of impervious surfaces. Localized high imperviousness and loss of riparian cover can not only have significant immediate near field impacts but can also be seen for a considerable distance downstream. Each new impacted zone can exacerbate other existing downstream impacts, resulting in an ecological domino effect.

While recent research has linked impervious cover to overall stream quality, it should not be used in isolation. Simply looking at imperviousness cannot and should not replace the collection of good consistent data examining stream health. However, it is a useful tool for both resource managers and community planners in protecting urban streams, which are under development pressures.

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List of Tables

Table 1. Landuse classes and definitions.

Code	Landuse	Definition
A	Agriculture	Land and site based agricultural activities undifferentiated as to crops
Ad	Sod production	The production of turf (improved grass)
Af	Forage/Grazing	Agricultural land that is used for hay and other forage crops or grazing (ie. Pasture)
Am	Market Gardening	Agricultural land used for market gardening (ie. Vegetables, flowers and tree nurseries) activities, excluding forestry tree nurseries
Ao	Fruit, Berry, Hop and Nut production	Agricultural land used for cultivating fruit and nut trees (orchards), grapes (vineyards), berries (rasberries, strawberries, blueberries) and Hops
As	Site Based Agricultural Activities	Agricultural activities that use land as a site and not as a producing medium (ie. Housing or feeding livestock or poultry, greenhouses, crop storage, mushroom growing, bee keeping)
At	Annual Tillage Crops	Agricultural land that is tilled annually
Ax	Residiential/Agricultural Mixtures	Areas where agriculture activities are intermixed with residential and other buildings with a building density of between 0.5 to 2 per ha
Fc	Recently Logged	Timber harvesting within the past 20 years or older if tree cover is less than 40% and under 6 metres in height.
Fe	Raising Seedlings	
Fo	Old Forest	Forest greater than or equal to 140 years old and greater than 6 metres in height.
Fs	Selectively Logged	Areas where the practice of selective logging can be clearly identified
Fu	Tall or Low shrubs	naturally occurring shrub cover with at least 50% coverage. Not wetlands, shrub covered logged areas (or other man made disturbance)
Fy	Young Forest	Undifferentiated forest less than 140 years old and greater than 6 metres in height
G	Grasslands	Unimproved pasture and grasslands based on cover rather than use. Cover includes drought tolerant grasses, sedges, and scattered shrubs to 6 metres in height and less than 25% forest cover. Sparse forest stands are included with their understory of drought tolerant shrubs and herbs.
Mg	Extractive Industrial	Land used for the surface extraction of rock, sand, gravel or peat
Rc	Campgrounds and/or seasonal cottages	
Rg	Golfing	
S	Human settlement or Urban	All compact settlements including built up areas of cities, towns and villages as well as isolated unites away from settlements such as manufacturing and military plants. Generally residential use. Includes some open space.
Sc	Urban Commercial	Retail, office and personal service including hotels and motels. May include a mix of residential and commercial uses.
Sd	Urban Residential Detached	Land used for residential activities that includes high-rise apartments greater than 5 stories

Table 1 continued. Landuse classes and definitions.

Sm	Urban Manufacturing or Industrial	Includes all processing and manufacturing activities, warehousing, tank farms and log storage. May include minor commercial activities
Sr	Rural residential	Single detached dwellings on large lots (>0.5ha)
St	Trailer Parks	
Ta	Airports	
Tr	Roads	
Ue	Electrical generation	Power transmission line corridors
Uh	Waste handling facilities	landfills, dumps, junkyards, wreckers, recycling activities
Wt	Wetlands	

Table 2. IS values by landuse type.

Code	Landuse	Percent Impervious Surface
A	Agriculture	3
Ad	Sod production	3
Af	Forage/Grazing	3
Am	Market Gardening	3
Ao	Fruit, Berry, Hop and Nut production	3
As	Site Based Agricultural Activities	3
At	Annual Tillage Crops	3
Ax	Residiential/Agricultural Mixtures	6
Fc	Recently Logged	3
Fe	Raising Seedlings	3
Fo	Old Forest	1
Fs	Selectively Logged	2
Fu	Tall or Low shrubs	3
Fy	Young Forest	1
G	Grasslands	3
Mg	Extractive Industrial	5
Rc	Campgrounds and/or seasonal cottages	3
Rg	Golfing	3
S	Human settlement or Urban	80
Sc	Urban Commercial	80
Sd	Urban Residential Detached	25
Sm	Urban Manufacturing or Industrial	80
Sr	Rural residential	8
St	Trailer Parks	23
Ta	Airports	90
Tr	Roads	90
Ue	Electrical generation	3
Uh	Waste handling facilities	80
Wt	Wetlands	0

Table 3. Summary of IS values by stream order. Note that this is substantially different than by landuse due to the diluting effects of incoming water to a particular site.

Stream order	% Impervious surface	
	Current	Buildout
1*	3.7	9.2
2a	1.5	5.5
2b	2.3	5.3
2c	1.6	2.3
2d	1.8	4.5
2e	1.7	4.5
3a	2.6	6.5
3b	2.1	6.1
4	4.6	12.3
Below junction of 4th order	9.4	24.2

*Combined first order streams (29 of them)

Sewage Disposal in the French Creek Watershed

John Deniseger, R.P.Bio.,
Environmental Impact Biologist

Ministry of Water, Land and Air Protection
Vancouver Island
British Columbia

2001

Sewage Disposal in the French Creek Watershed

In our homes, we generate significant amounts of sewage, through human excrement and the use of water within our homes for bathing, laundry and other domestic uses. Pollutants in domestic sewage include but are not limited to total suspended solids, biological oxygen demand, fecal coliforms, nitrogen and phosphorus.

Biochemical oxygen demand (BOD) is a measure of the organic matter content within sewage. As the organic matter breaks down, it consumes oxygen in the water. Improperly treated sewage can deplete oxygen levels in streams, affecting fish survival. Nitrogen and phosphorus can enter streams causing significant algal blooms and can cause toxicity if ammonia nitrogen levels are extreme.

Sewage also contains disease causing organisms or pathogens. Fecal coliforms are a group of bacteria found in the intestinal tracts of all mammals including humans. They are used as an indicator of sewage presence and the risk of pathogen contamination. When fecal coliforms are present, there are restrictions placed on the suitability of that water for drinking water or other uses such as recreational use. Shellfish such as oysters, clams and mussels tend to accumulate pathogenic bacteria. Contamination from sewage discharges can lead to shellfish harvesting closures, as eating contaminated shellfish can make people sick.

Sewage is not just made up of human excrement and water. It can also contain toxic chemicals and metals from solvents, detergents, cleansers, pesticides, and many other household products. Food waste from sink garburators also adds significant organic material to the mix.

The French Creek Water Pollution Control Center serves the majority of the urban population within the lower portions of the watershed (Figure 1). The wastewater entering the Center undergoes secondary treatment prior to being discharged via a 2,440 meter long ocean outfall into the Strait of Georgia at a depth of 61 meters. However, substantial urban areas and virtually all of the rural areas within the French Creek watershed are not hooked up to the Water Pollution Control Center. These areas dispose of their sewage via on-site sewage systems, typically through the use of septic tanks and tile fields. Untreated or inadequately treated sewage can pose a significant threat to local waterways and to human health

On Site Sewage Disposal

A septic tank is a chamber for the retention and partial treatment of domestic wastewater. Effluent from the tank is discharged to a ground disposal field through underground tiles. Septic tanks themselves do not achieve a high degree of treatment. Their main purpose is the settling of solids so that there is less clogging of the disposal field. The solids in turn decompose anaerobically in the tank.

Further treatment of the sewage is accomplished through the subsurface tile field, which generally consists of a series of underground pipes with holes in them that let treated liquid from the tank soak into the ground below the surface. The degree of treatment is a function of the chemical, physical and biological characteristics of the soil, the depth of soil above the groundwater table, local climatic conditions, and vegetation. As the effluent percolates through the soils, varying degrees of pathogens, nutrients and solids are removed.

Improperly designed, installed, or maintained septic systems can lead to premature and costly failures which can contaminate surface and ground water with nutrients and pathogens. The solids contained in a septic tank must be pumped out every 3 to 5 years. If not, the solids and scum can flow out of the tank, clogging the tile field. Untreated wastewater can rise to the surface threaten your family's and neighbours health, reduce your property value and create odours and the need for costly repairs. If you use too much water in your home, the septic tank may not be able to function properly and solids may flow into your tile field causing it to clog. It is important to understand how your system operates, to use and maintain it properly to protect your investment and the environment.

Unfortunately, any ground disposal field has a finite life span of typically 15 to 20 years given our climate and soils.

What can you do to maximize the life span of your tile field?

-take the time to be aware of your system. Create a map of your property showing the location of the septic tank and tile field and leave it for the next owner.
-have your septic tank pumped out every 3 to 5 years by a septic service company.
-practice water conservation – use water wisely. Use low-flow toilets and showerheads.
-don't use garburators – they add more solids to your system and may increase the frequency at which your tank might need to be pumped.
-handle your system with care. Think of it as a living being - be careful with what goes down your drain. Toxic chemicals such as bleach, detergents, and solvents can kill the beneficial bacteria at work in your system, resulting in contaminated groundwater or surface water. Use biodegradable household cleaners instead of bleach or other hazardous products.
-avoid planting trees or shrubs near the tile field because the roots may clog the pipes.
-avoid using septic tank "starters" or similar products. Allow the bacteria to act naturally.
-do not let any vehicles drive or park on any part of the disposal system
-do not allow roof or perimeter drains, or any surface water, to discharge on or near the sewage disposal system

What are the warning signs of a failing tile field?

-unusually green or spongy grass over the tile field
-toilets, showers and sinks back up or take a long time to drain
-sewage surfacing on your lawn or nearby drainage ditch
-sewage odours around your yard, particularly after heavy rain

Who do I contact?

Remember you must obtain permission from the Central Vancouver Island Health Region's Public Health Inspector prior to installing, repairing or upgrading an onsite sewage system. Their contact information is as follows:

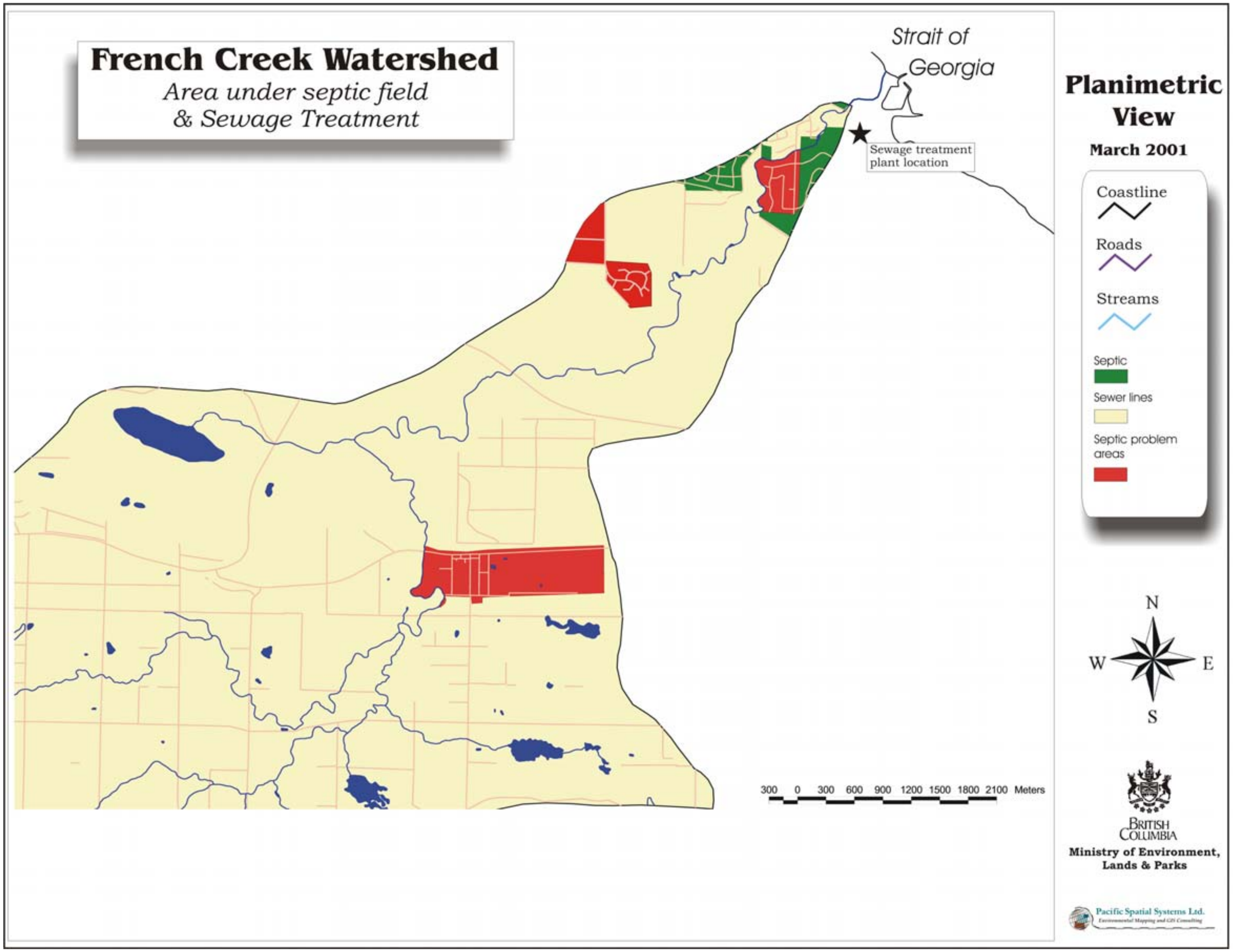
Central Vancouver Island Health Region
Glenn Gibson, Environmental Health Inspector
249 West Hirst Ave.
Parksville, B.C.
V9P 2H2
250 248-2044

Are there problem areas within the French Creek watershed?

According to the Central Vancouver Island Health Region and the Regional District of Nanaimo, there are a number of areas within the French Creek watershed where the majority of tile fields are failing. These areas are shown on Figure 1. The two most significant areas of concern are the Barclay Crescent area and the area around Coombs.

Barclay Crescent is located in the lower portions of the watershed, adjacent to the sewage treatment plant. This residential area was constructed prior to the completion of the plant and relies entirely on individual residential septic systems. These homes and systems are typically over 20 years old and these systems are reaching or have reached the end of their lifespan. An additional contributing factor is the high level of the water table during the winter. As a result, the area is dotted with emerging groundwater (springs) and surfacing sewage. A recent referendum in the Barclay Crescent neighbourhood resulted in the residents voting no to connect to the community sewer. Cost was cited as the primary factor.

The area around Coombs is characterized by failed tile fields. The area is a mixture of residential, semi-rural and commercial development. Many of the properties were developed a number of years ago on smaller lots unsuitable for ground disposal. As a result, sewage frequently surfaces in some areas during the summer months. Seasonal flow increases caused by tourism have also become an issue in the Coombs area. In response, the Coombs Market area is now on a “pump and haul” system which prevents sewage disposal to ground during the busy tourist season.



French Creek Watershed
Area under septic field
& Sewage Treatment
Strait of
Georgia
Sewage treatment
plant location
Planimetric
View
March 2001
Coastline
Roads
Streams
Septic
Sewer lines
Septic problem
areas
300 0 300 600 900 1200 1500 1800 2100 Meters
N
W
E
S
British
Columbia
Ministry of Environment,
Lands & Parks
Pacific Spatial Systems Ltd.

French Creek Water Quality

John Deniseger, R.P.Bio.,
Environmental Impact Biologist

Ministry of Water, Land and Air Protection
Vancouver Island
British Columbia

2001

French Creek Water Quality

Within the French Creek watershed there are no permitted discharges of industrial or municipal waste. Yet pollutants continue to enter French Creek, potentially altering the water quality and affecting aquatic life. People often assume that water pollution is caused by large scale industrial development. They often forget about water pollution caused by smaller non-point sources – especially pollution at the household level.

Non-point source pollution is in fact the leading cause of water quality degradation within French Creek watershed.. While each individual household may add only minor amounts of pollutants, the cumulative effects of an entire neighbourhood, retail development or small scale agriculture can significantly affect water quality. Residential areas can contribute to polluted runoff in many ways:

- Nutrients from lawn fertilizers, agricultural activities and septic system runoff
- Pathogens from septic system runoff, pet waste and livestock waste
- Sediment from construction, road sand, and erosion from gardens and lawns
- Toxins from household products such as pesticides, solvents, cleansers, etc.
- Litter and Illegal dumping
- Runoff from roads and parking lots can contain contaminants such as oils and grease, PAH's , and metals
- Removal of streamside vegetation which act as buffers to development, while filtering or trapping particulates

To assess water quality in French Creek a water quality monitoring program was initiated in the fall of 2000. The program focused on nutrients, metals and fecal coliforms. Five sampling locations were established thoughout the watershed as follows:

i. French Creek at Grafton Rd. – this is the south fork of upper French Creek and is located on the upstream side of the Grafton Road bridge. The area upstream of this site is dominated by rural/agriculture.
ii. French Creek at Winchester Rd. – this is the north fork of upper French Creek and is located on the upstream side of the Winchester Rd. bridge. The area upstream of this site is dominated by private forest lands.
iii. French Creek at Coombs – this is located well below the confluence of the south and north forks of upper French Creek. The sampling point is located approximately 300 meters downstream of highway 4.
iv. French Creek at Highway 19 – this site is located just upstream of the highway 4 bridge crossing.
v. French Creek at Barclay Crescent – this site is located at the Barclay Crescent footbridge. The area is dominated by residential development.

Through the fall and early winter, samples were taken 6 times at each site. The intent of the program was to assess the water quality during the higher flow period of the year. Given the lack of historical data, the focus of this study is to examine changes in water quality as one moves downstream through the watershed and to compare the water quality data to the provincial criteria for the protection of aquatic life. The data has been summarized in Table 1.

Nutrients

Nitrogen and phosphorus combine to support the basic productivity within a stream. On Vancouver Island, concentrations of these nutrients are naturally low due to the geology and high rainfall. Nitrogen is found in inorganic forms (nitrate, nitrite and ammonia) and in organic forms. It is the inorganic forms which are essential to algal growth in streams. In extreme cases, nitrate, nitrite and ammonia can be toxic to aquatic life. However, levels in French Creek were well below these levels. Sources of nitrogen can include fertilizers, agricultural runoff, sewage and land disturbance.

In French Creek, of the five sites sampled, the north fork at Winchester Rd. should represent near background conditions. Levels of total nitrogen ranged from 0.10 to 0.22 mg/L, averaging 0.16 mg/L. Nitrate ranged from 0.023 to 0.082 mg/L, averaging 0.042 mg/L. While these levels did vary with rainfall events (higher during following heavy rains), they were nevertheless substantially lower than each of the other sites.

The south fork at Grafton Rd., which is influenced by upstream agricultural activity, was characterized by substantially higher levels of nitrate than found at Winchester Rd. Nitrate ranged from 0.094 to 0.141 mg/L, averaging 0.113 mg/L, or 2.7 times that of the north fork. Total nitrogen levels were only slightly higher at Grafton Rd., averaging 0.21 mg/L, an increase of 31% relative to the north fork.

Continuing downstream, French Creek at Coombs, partially reflects the combined water quality of the north and south forks, with nitrate averaging 0.090 mg/L. However, total nitrogen averaged 0.207 mg/L, which reflects additional sources of organic nitrogen entering French Creek in the Coombs area. Both nitrate and total nitrogen levels continue to increase downstream as nitrate averaged 0.105 mg/L at highway 19 and 0.165 mg/l at Barclay Crescent. Total nitrogen averaged 0.27 mg/L at highway 19 and 0.34 mg/l at Barclay Crescent. From Winchester Rd. to Barclay Crescent, the cumulative effects of land use practices throughout the French Creek watershed have resulted in a 3.9 times increase in nitrate levels and a 2.1 times increase in total nitrogen levels. While the downstream increases in nitrogen may be indicative of nutrient input, it is not a direct threat to water quality. The levels in French Creek are well within the provincial criteria for aquatic life. Rather, nitrogen is transported relatively easily to surface waters. As such, it is an indicator of land disturbance, agriculture and urbanization.

Phosphorus is normally the nutrient limiting the growth of algae in streams such as French Creek. While phosphorus is not transported to streams as readily as nitrogen, algal growth in creeks such as French Creek will respond to even relatively minor sources of phosphorus. Increases in phosphorus can rapidly result in excessive quantities of algal growth which affect recreational use and the fisheries resource. The principle man made sources of phosphorus in French Creek include surfacing septic field runoff and fertilizers.

The sampling results for the fall/winter of 2000 indicate a slight increase in total phosphorus as one moves downstream in the watershed. At Winchester Rd., total phosphorus averaged 0.013 mg/L, while at Grafton Rd. the average was 0.011 mg/L. Further downstream, total phosphorus averaged 0.014 mg/L at Coombs, 0.016 mg/L at highway 19 and 0.017 mg/l at Barclay Crescent.

The overall effects of the downstream increases in nutrients are relatively minor during the winter months. If these trends continue during the spring and summer months, phosphorus increases may result in substantial growths of algae. Slight increases in algal biomass are in fact beneficial to the fisheries resource. However, excessive algal biomass can affect streams such as French Creek by affecting recreational use, aesthetic appearance as well as the fisheries resource through impacts on spawning gravels and aquatic insects. Follow-up sampling during the summer months should include temperature, dissolved oxygen, nutrients, and algal biomass.

Heavy Metals

Levels of metals throughout the French Creek watershed tended to be consistently low. Concentrations of cadmium, chromium, copper, lead, nickel, and zinc were well within the provincial guidelines for the protection of aquatic life (see Table 1.) French Creek at Winchester Rd and at Grafton Rd are thought to represent baseline or near baseline conditions in the watershed. However, with increasing distance downstream from these sites, concentrations of all metals gradually increased. At highway 19 and at Barclay Rd., levels of all metals were approximately double that found in the upper watershed.

Within the French Creek watershed, copper appears to be the heavy metal of potential concern at present. For example, copper averaged 0.49 ug/L at Grafton Rd, 0.60 ug/L at Winchester Rd., 0.72 ug/L at Coombs, 1.08 ug/L at highway 19 and 1.39 ug/L at Barclay Rd. To meet the provincial criteria for aquatic life, average concentrations cannot exceed 2 ug/L copper, with no individual value greater than 4 ug/L copper. While copper levels at all sites within French Creek meet the aquatic life criteria, there is an unmistakable trend to increasing levels of copper within the lower watershed. The increase is of concern as it reflects changing land use patterns and increasing urbanization. Potential sources of metals within the watershed include lawn fertilizers, septic runoff, parking lot and road runoff associated with motor vehicles, construction sediment, and erosion. As population growth, urbanization and development continue, the trends to higher metal levels are likely to increase.

Overall, of the 30 water samples taken within the French Creek watershed during the fall and early winter of 2000, there was only 1 individual heavy metals result which exceeded the aquatic life criteria. Total cadmium was measured at 0.02 ug/L at Winchester Rd on December 18th. While this does exceed the criteria of 0.01 ug/L, it represents the only exceedance found in the watershed. As such, it is not viewed as an environmentally significant result at this time. However, individual exceedances such as this are likely to become more prevalent and more extreme as urbanization and development continue into the future. Sampling for metals should be repeated during the summer low flow period.

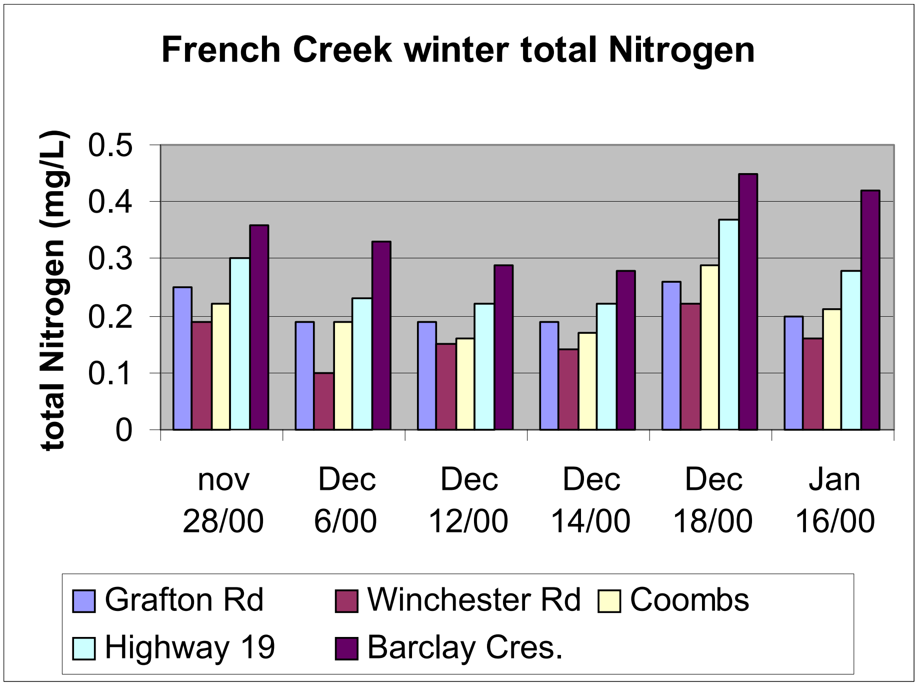
Fecal coliforms

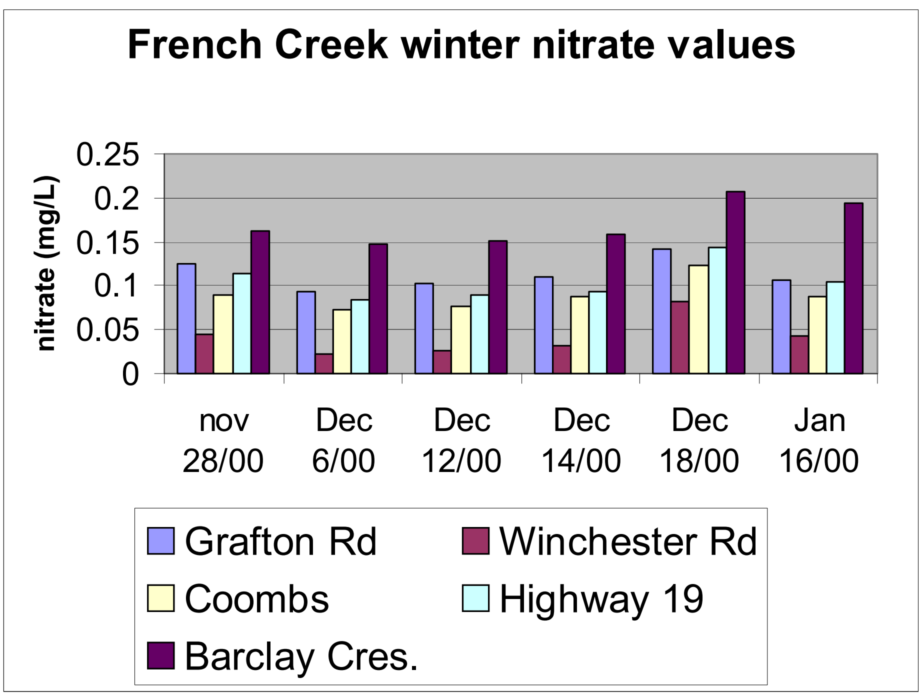
The direct monitoring of all potential human pathogens is neither practical or economically feasible. Microbiological water quality is commonly estimated or monitored using a group of indicator organisms commonly known as fecal coliforms. These indicators are meant to be indicators of human and animal feces. However, fecal bacteria from animals indicate less risk of disease to people than do those from humans. Fecal coliform criteria depend upon repeated sampling as coliforms are not uniformly distributed and may be subject to considerable variation.

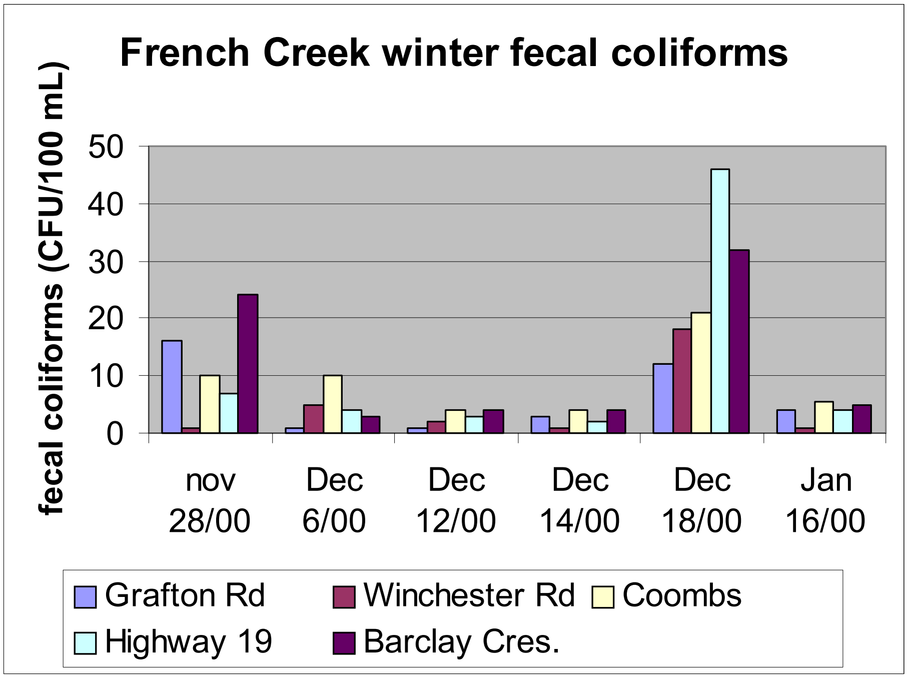
There are a number of provincial fecal coliform criteria depending on the water use. For example, raw drinking water with no treatment should not have any detectable fecal coliforms present. Drinking water with disinfection only should be $\leq$ 10 CFU/100 mL (90^{th}percentile), while swimming areas should be $\leq$ 200 CFU/100 mL (based on geometric mean).

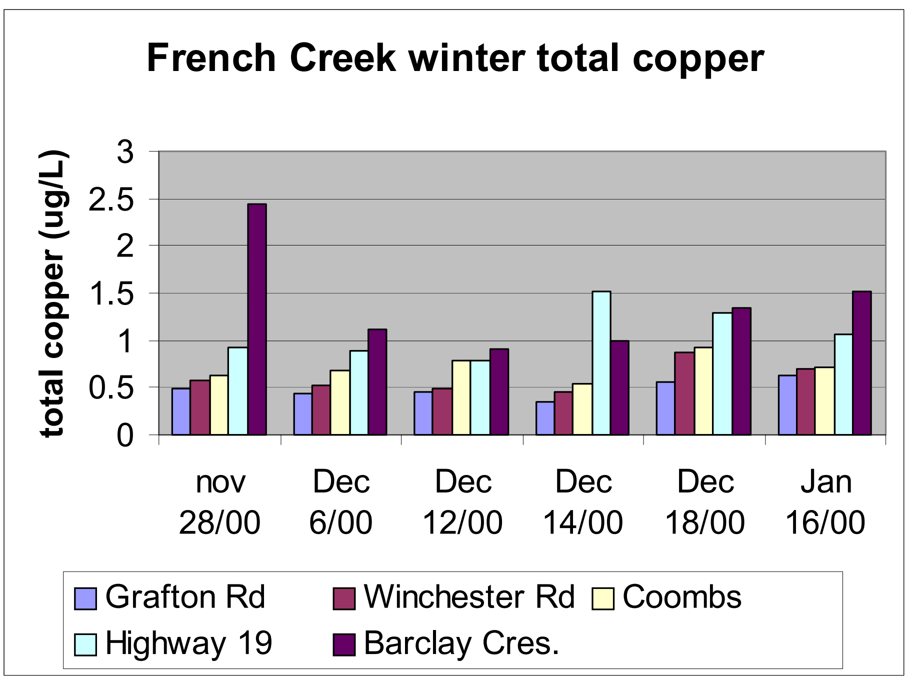
Fecal coliform sampling for this project was limited to last fall and early winter. Of the 36 samples taken at the 5 sampling sites throughout the watershed only 1 sample indicated a result of <1 CFU/100 mL. A total of 9 samples were $\geq$ 10 CFU/100 mL. Overall averages were 6.2 at Grafton Rd, 5 at Winchester Rd, 9.1 at highway 4, 11 at highway 19, and 12 at Barclay Rd. (all units in CFU/100mL). Overall, the data indicate the overall presence of fecal coliforms and an increasing trend downstream through the winter months. Levels through the winter indicate the need for disinfection of any drinking water withdrawls from French Creek.

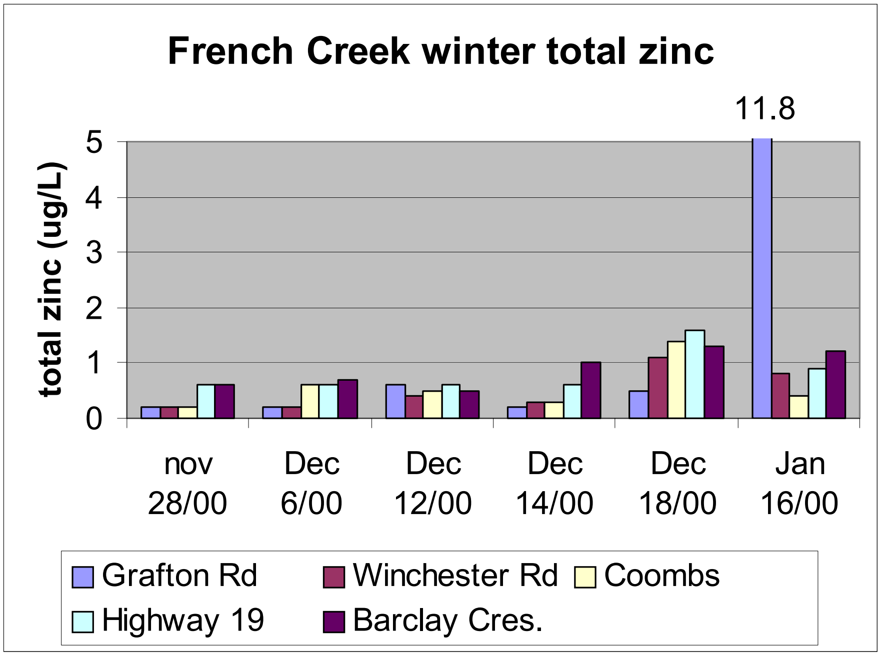
As discussed elsewhere in this report, sewage disposal is a significant concern in portions of the French Creek watershed. High winter water tables may lead to surfacing of sewage and lateral sewage transport to French Creek. On the other hand, higher creek flows result in significant dilution and lower water temperatures result in only short term survival of pathogenic microorganisms. Sampling should be repeated during the summer months when dilution is minimal, warmer temperatures permit longer survival time of pathogenic microorganisms and recreational use is at its peak.

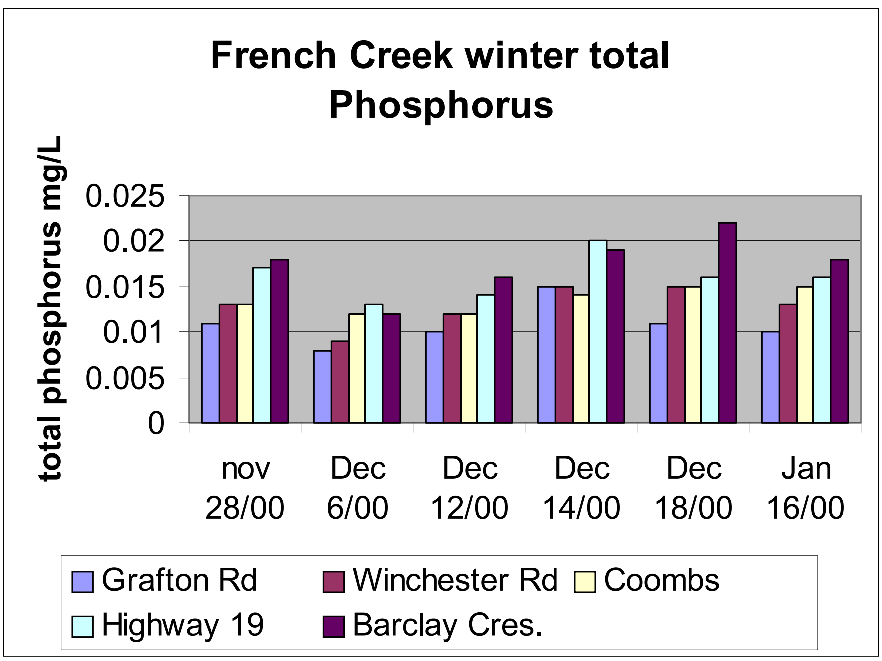

French Creek winter total Nitrogen
total Nitrogen (mg/L)
0.5
0.4
0.3
0.2
0.1
0
nov 28/00
Dec 6/00
Dec 12/00
Dec 14/00
Dec 18/00
Jan 16/00
Grafton Rd
Winchester Rd
Coombs
Highway 19
Barclay Cres.


French Creek winter nitrate values
nitrate (mg/L)
0.25
0.2
0.15
0.1
0.05
0
nov 28/00
Dec 6/00
Dec 12/00
Dec 14/00
Dec 18/00
Jan 16/00
Grafton Rd
Winchester Rd
Coombs
Highway 19
Barclay Cres.


French Creek winter fecal coliforms
fecal coliforms (CFU/100 mL)
50
40
30
20
10
0
nov 28/00
Dec 6/00
Dec 12/00
Dec 14/00
Dec 18/00
Jan 16/00
Grafton Rd
Winchester Rd
Coombs
Highway 19
Barclay Cres.


French Creek winter total copper
total copper (ug/L)
3
2.5
2
1.5
1
0.5
0
nov 28/00
Dec 6/00
Dec 12/00
Dec 14/00
Dec 18/00
Jan 16/00
Grafton Rd
Winchester Rd
Coombs
Highway 19
Barclay Cres.


French Creek winter total zinc
11.8
total zinc (ug/L)
5
4
3
2
1
0
nov 28/00
Dec 6/00
Dec 12/00
Dec 14/00
Dec 18/00
Jan 16/00
Grafton Rd
Winchester Rd
Coombs
Highway 19
Barclay Cres.

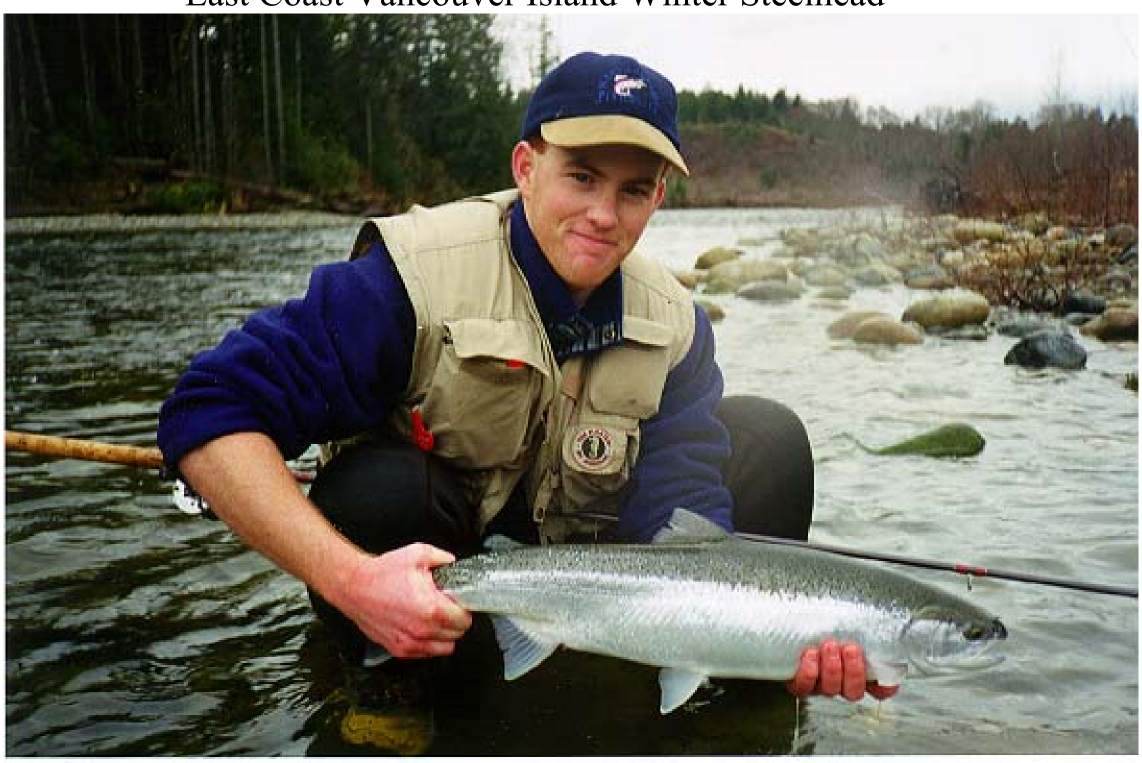

French Creek winter total Phosphorus
total phosphorus mg/L
0.025
0.02
0.015
0.01
0.005
0
nov 28/00
Dec 6/00
Dec 12/00
Dec 14/00
Dec 18/00
Jan 16/00
Grafton Rd
Winchester Rd
Coombs
Highway 19
Barclay Cres.

French Creek
Status of Fish and Aquatic Habitat

By:
Rick Axford, Senior Fisheries Technician
Water, Land and Air Protection (WLAP)
Nanaimo Regional Headquarters

2001

East Coast Vancouver Island Winter Steelhead



Introduction

The Ministry of Water, Land and Air Protection has classified French Creek as a sensitive watershed. French Creek shares a number of physical similarities to several other medium-sized Georgia Basin watersheds, and is experiencing a combination of land use activities common in this region. These land use activities are altering the availability of fish habitat, affecting the production of fish and the viability of local fisheries. The objective of this section of the report is to outline the current status of fish habitat, fish populations and fisheries of French Creek. A review of land use activities at various locations within the watershed was conducted. Examples of these activities are presented in Appendix I. Impacts of these activities on fish and fish habitat are discussed below. Also presented are long-term detailed fish data including annual fence counts, data from the annual Steelhead Harvest Analysis completed by the ministry, and escapement data from Fisheries and Oceans Canada (DFO) that illustrates fish population status and trends in the creek. Conclusions and suggestions for future fish habitat and fish monitoring studies, as well as planning initiatives are found at the end of the report.

Status of Fish Habitat

From a fish habitat perspective, land use activities can be divided into two main categories, each having specific impacts on the stream, the availability and quality of fish habitat, fish populations and fisheries. Activities that occur outside of the stream change the landscape around the stream and ultimately alter the availability and quality of habitat within the stream. These activities include road building, logging, wetland removal/infilling, and riparian vegetation removal for urban and agricultural development. In contrast, instream activities occur within the stream channel and include channel entrainment or the creation of single, simplified stream channels, the removal of large woody debris (LWD) through deforestation or direct removal from the stream, water withdrawals and inputs of point and non-point source pollution. Land use activities outside and inside the stream channel have direct and indirect impacts on fish habitat, fish and fisheries. These impacts are cumulative and difficult to quantify.

In the French Creek watershed, landuse activities that have occurred outside the stream channel include, but are not limited to, logging and road building. Like other East Coast Vancouver Island streams, French Creek was logged to the stream banks, however most of the mainstem channel has regenerated since the initial old growth logging. It is estimated that approximately eighty to ninety percent of the stream length has stable banks with suitable cover to shade the stream and provide instream habitat for fish and terrestrial habitat for other organisms including invertebrates. Second growth logging is occurring and may be reducing the speed of natural recovery in some areas of the watershed. This logging is, however, being conducted more carefully than in the past due to the implementation of some streamside protection directives protecting fish habitat and downstream water quality.

Other land use activities that have altered the landscape around French Creek include riparian vegetation removal for agriculture and small hobby farm development throughout the middle reaches, and residential and urban development in the lower reaches of the stream. Although much of the urban and agricultural riparian areas are still intact, in several locations the natural vegetation along the stream has been removed and replaced with grass. Consequently, several properties have or have had severe bank erosion and are introducing sediment to French Creek (see Appendix 1). In addition to these areas, several other locations were identified on smaller tributaries and wetlands, including Dudley and Hamilton Marshes, where impacts have occurred from land use disturbances (Appendix 1). Additional impacts to the watershed include estuary entrainment, and a highway bridge that has confined the river to a single channel at the high tide zone.

Activities that have directly affected the instream character and availability of fish habitat are found throughout French Creek. Channel entrainment has occurred in the urban and agricultural sections of the stream, while removal of LWD due to land clearing and direct removal from the channel has occurred along the entire length of the stream. These activities have significant impacts on the availability and quality of fish habitat. Channel entrainment simplifies the stream channel thereby reducing the number of deep pools and edge habitat critical for rearing fish. LWD removal has similar consequences, as this component of fish habitat is most often associated with deep pool formation necessary for rearing and larger fish. LWD also provides cover for fish and substrate for invertebrates thereby increasing the trophic complexity of an area, and traps and retains sediment in the stream margins. Sediment retention is important in creeks such as French Creek where higher rates of sedimentation are occurring in agricultural and urban areas (Appendix 1). Erosion and runoff from agricultural and urban developments, especially upstream of Coombs, have been responsible for the introduction of sediment, which has degraded the quality of fish habitat and impacted fish production. In addition to specific fish habitat limitations, there is an overall lack of old growth habitat attributes including logjams and multiple channels, especially in the lower reach of the stream and estuary. Point and non-point source pollution from farms and the lower urban area could impact fish at certain times during the year, however, water quality data collected in 2000/01 did not indicate water quality problems that would impact fish (Deniseger, 2001).

Low flow is by far the biggest limiting factor to aquatic productivity throughout French Creek. While low flows are characteristic of many East Coast Vancouver Island streams, land use activities, particularly urban and residential development, exacerbate this situation. In 1971, Burns surveyed the French Creek watershed and found flow at less than 1 cubic foot per second which lead him to conclude that flow was key in limiting aquatic productivity in the watershed. The French Creek Water Allocation Plan completed by the ministry in 1994 notes that stream flows are normally below 20% of mean annual discharge for four months of the year (Bryden, 1994). Flow data collected by Water Survey Canada at the lower river/hatchery station during the summers of 1995 and 1996 recorded zero flow in both years, and in 2000, Ptolemy found that flows in French Creek were significantly below those of neighbouring streams. In the fall of 2000, the Parksville Streamkeepers Society documented zero flow downstream of Coombs (Adams, 2001) and in October 2000, Axford observed that the stream was dry below the Old Island Highway near Coombs.

Urban and rural farm development throughout the watershed has increased in the last thirty years and water use within the watershed has increased. Most of the water usage has converted to streamside wells, therefore the total water use is likely considerably higher than the licensed withdrawal. Water withdrawals from instream and near-stream wells, combined, may be the main contributing factor to low flows and the availability of aquatic habitat in French Creek. An adequate supply of water, especially during summer months, is critical for fish such as coho, cutthroat and steelhead as these species rear in the stream over one or more summer seasons before migrating to sea (Fig.1). Increased mortality during summer low-flow results because fish are crowded and become stressed, especially if there are extended dry periods as is common in this area. Although some fish may adapt to periodic low flows, competition for space, high temperatures, and lack of food combine to increase mortality. Those fish that do not die may suffer long-term effects due to the stress resulting from competition for space and food. Stress impacts the rate of growth, which in turn dictates how long it takes to smolt. The longer fish stay in the river, the lower their chances of survival to the smolt stage. Fish that do smolt are likely in poorer condition than fish from a stream with adequate rearing space and food. The condition of fish migrating to sea is especially important given the less than optimum ocean conditions that have, until recently, resulted in reduced ocean survivals.

Status of Fish Stocks and Fisheries

Annual fence counts, the Steelhead Harvest Analysis and DFO escapement data as well as data and information from historic studies were used to determine fish populations and fishery trends in French Creek. This information illustrates that freshwater productivity and the fishery values of French Creek were high at one time, but have declined steadily. The lower numbers of coho, steelhead and cutthroat observed are a probable consequence of instream impacts compounded by poor ocean survival. Indications of recovery has not been observed despite reduced harvests by commercial and sports fisheries.

Coho population data is collected annually by visual observations. These data show that coho populations have been consistently below the mean for the last twenty years, indicating that the population was declining prior to any decreases that might be related to low ocean survival (Fig.#3). Marine survival for 1991 and later years decreased to an average of less than 20% of that seen in the 1977-90 period, and less than 10% of that calculated for the period prior to 1997 (Wightman, 1998). Species declines initially were likely related to freshwater production and over-harvesting. More recently, declines are related to freshwater production and ocean survival (increased predation as well as environmental conditions). In the late summer-early fall of 2000, stream flows dropped to zero and coho returns were very low. Small returns and the subsequent lack of recruitment may contribute to reduced returns to the creek in future return years.

Hatchery coho production started in 1982 with the goal of seeding the headwaters and productive marsh areas of the French Creek watershed (Table 1). Declining coho returns have impacted hatchery production, only 29,160 and 13,100 fry were stocked in the past two years (Table 1). The hatchery program has a target of 75,000 fry, the shortfall is related directly to the low numbers of spawners returning to the system (Greenway, Jack, 2001).

Figure 1. Life history and timing of three species of salmonids utilizing French Creek for spawning, incubation, and year round rearing.

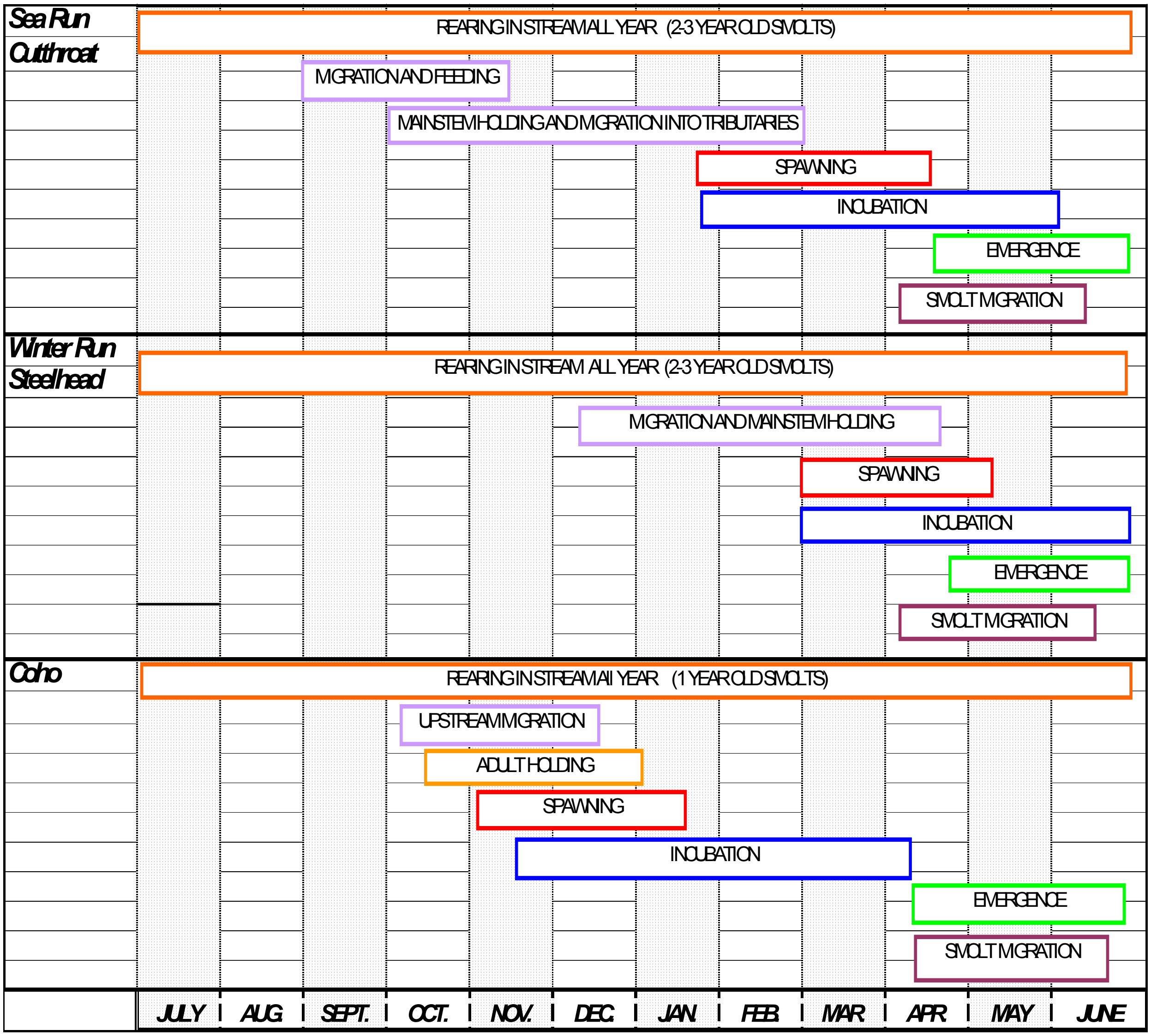


Figure 2. French Creek flow (Cooper, 2001).

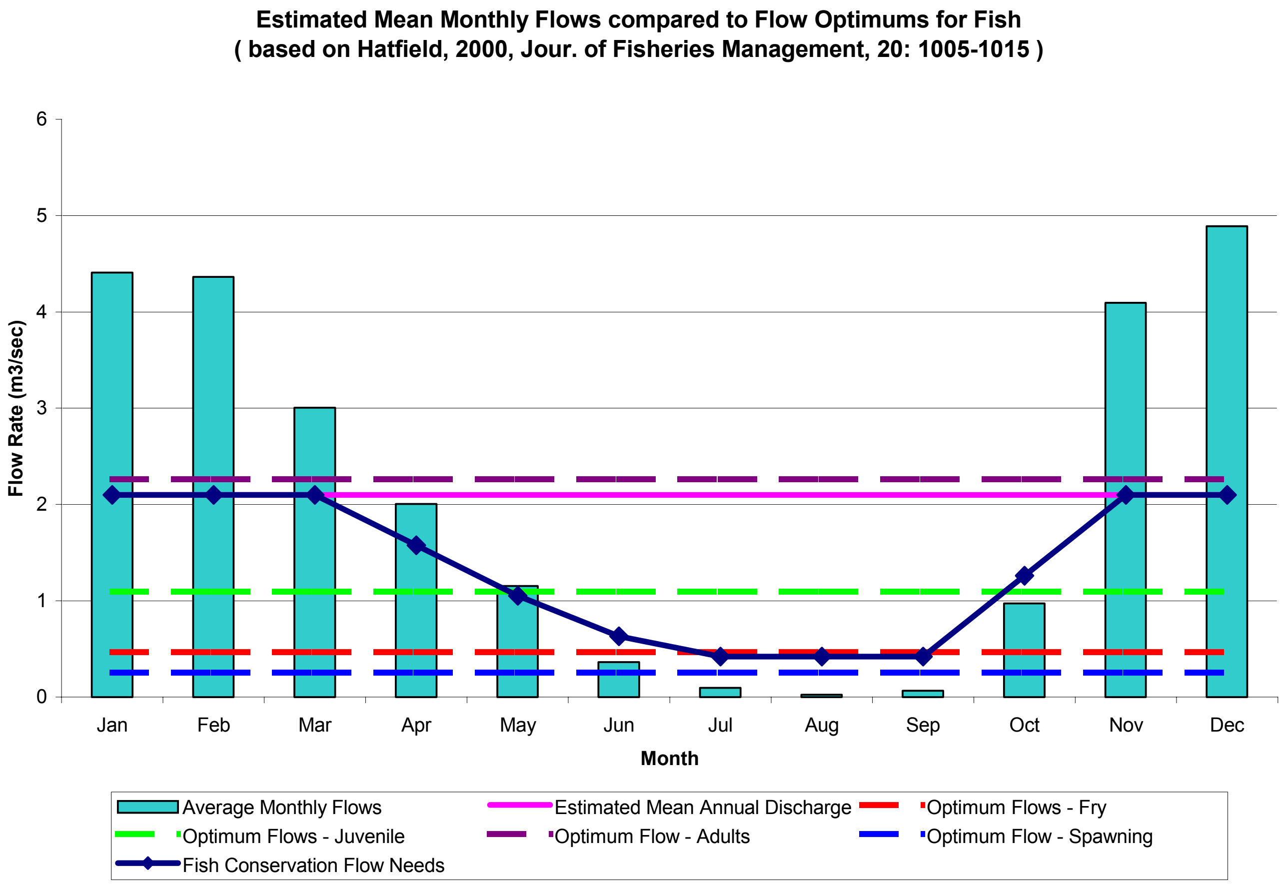


Figure 3. Adult coho escapement demonstrated as numbers observed and variation from the mean.

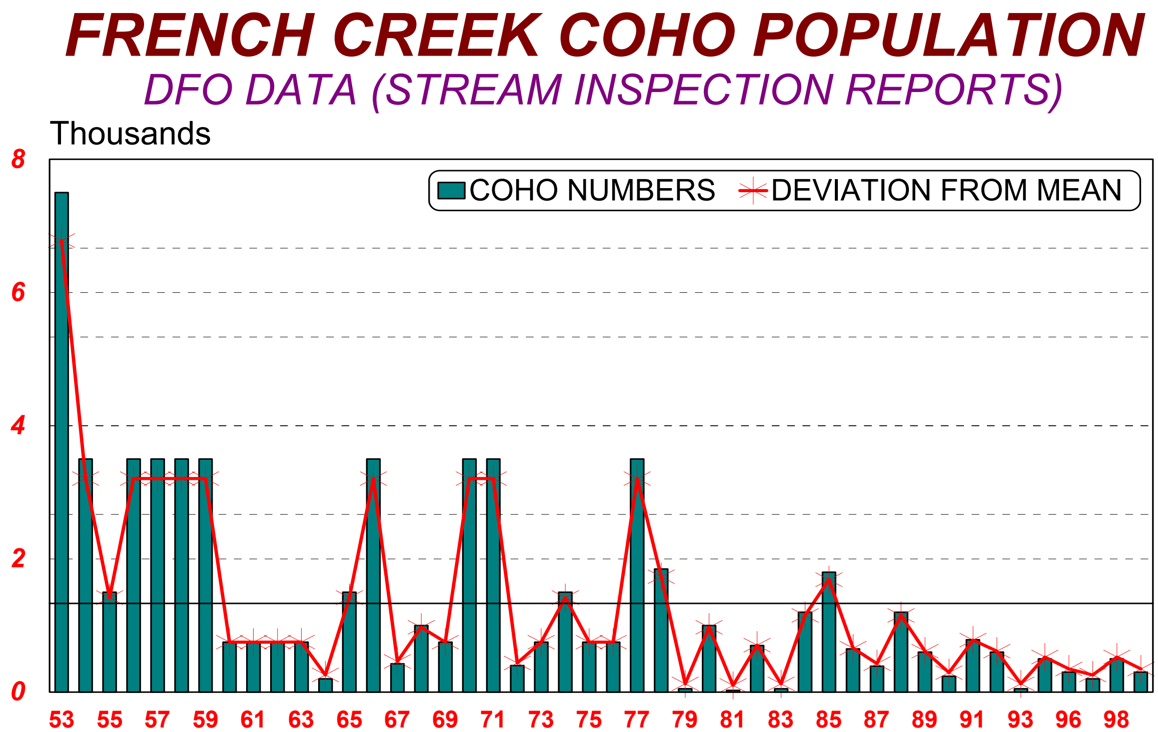


Table 1. Coho stocking records for past tens years, areas and numbers, (Greenway, 2001).

STOCKING LOCATIONS	YEAR 2000	YEAR 1999	YEAR 1998	YEAR 1997	YEAR 1996	YEAR 1995	YEAR 1994	YEAR 1993
HATCHERY TO TRESTLE	8,200	800	10,000	11,000	15,000	9,400	14,000	4,000
GEEKIE POOL	4,000	3,000	3,000	9,000	15,000	8,000	4,000	0
WINCHESTER RD. BR.	1,920	1,500	2,500	5,000	11,000	7,000	8,300	5,000
PRAT ROAD BRIDGE	2,080	0	2,500	5,000	11,000	7,000	8,300	6,000
GRAFTON ROAD	2,960	1,500	3,000	7,500	11,000	7,200	8,300	6,000
DUDLEY MARSH	10,000	5,850	8,000	10,000	11,000	8,350	8,000	10,000
MORNING STAR	0	450	1,000	2,500	2,500	3,000	1,000	500
TOTAL	**29,160**	**13,100**	**30,000**	**50,000**	**76,500**	**49,950**	**51,900**	**31,500**

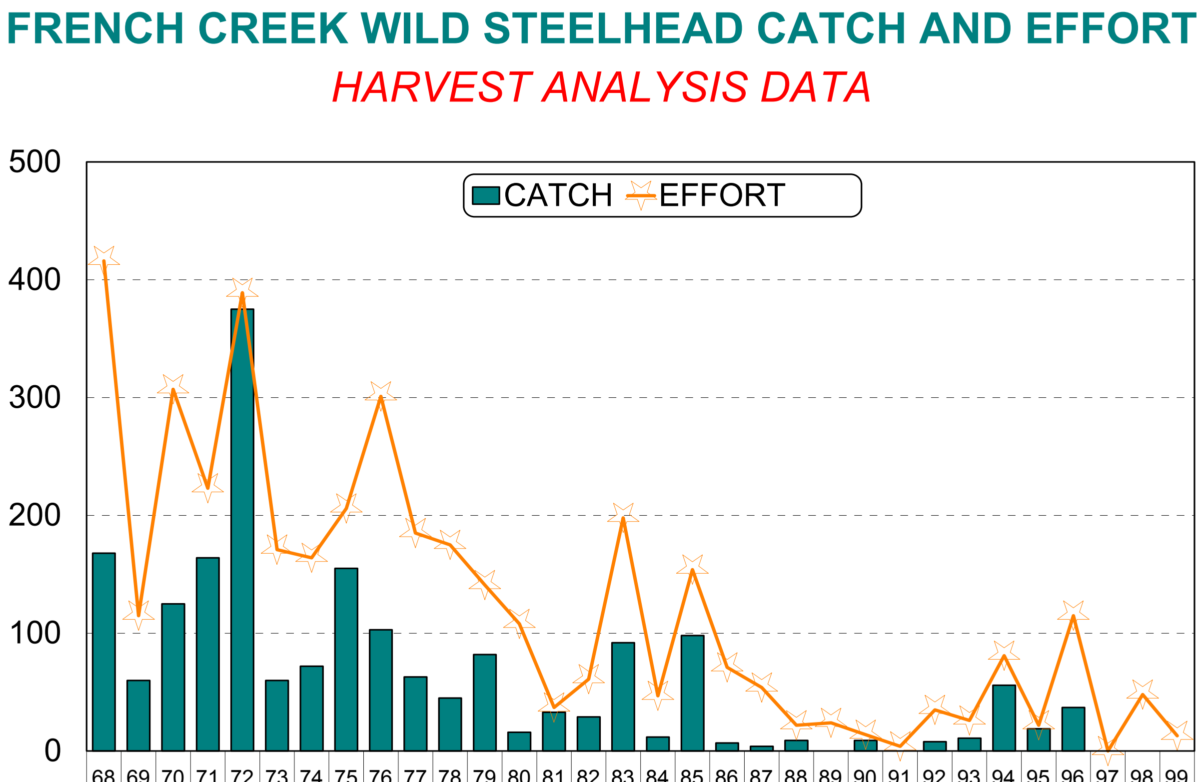
In the late 1980s, DFO conducted downstream trapping of outgoing steelhead, cutthroat and coho smolts from French Creek. That data indicated that French Creek produced more out-migrating fish of each of these species than either Black Creek or the Trent River during the same time (Table 2). During 1986, 2000 steelhead smolts were captured, and in 1987, 2500 were captured. That number of smolts should have produced between 250 and 300 adults based on the ocean survival rate of more than 10% documented in the 1980s (Wightman, 1998). No recent smolt data is available, however, catch information from the steelhead harvest analysis indicates an extreme conservation concern.

Table 2. Downstream trapping data presented by Rory Glennie, 1988.

Out Migration From French Ck., Trent R. and Black Ck.					
Downstream Trapping Data (April to Mid-June)					
Year	***Stream***	***Steelhead Kelts***	***Steelhead Smolts***	***Cutthroat Adults***	***Cutthroat Smolts***
1985	Trent	16	397	0	0
	Black Ck.	21	37	42	65
1986	Trent	20	1274	8	10
	Black Ck.	32	144	75	99
	French	60	2042	150	644
1987	Trent	27	1650	0	23
	Black Ck.	49	147	135	180
	French	75	2500	176	2000

Data collected through the Steelhead Harvest Analysis is presented in Figure 4. This study is comprised of an annual questionnaire sent to steelhead anglers who provide their catch and effort data which the ministry uses to determine fishery trends. In instances where a steelhead population has crashed, the Steelhead Harvest Analysis will show zero catch. When the Steelhead Harvest Analysis demonstrates a zero catch or downward trend for several years, the population is in trouble, and in some severe cases may become extinct. The Steelhead Harvest Analysis shows that steelhead catches have declined steadily since the 1970s in French Creek. Steelhead catches were zero in the last three years that the fishery was open, and the fishery was closed to all steelhead fishing to protect the remnant population starting in 1999 (Fig. 4).

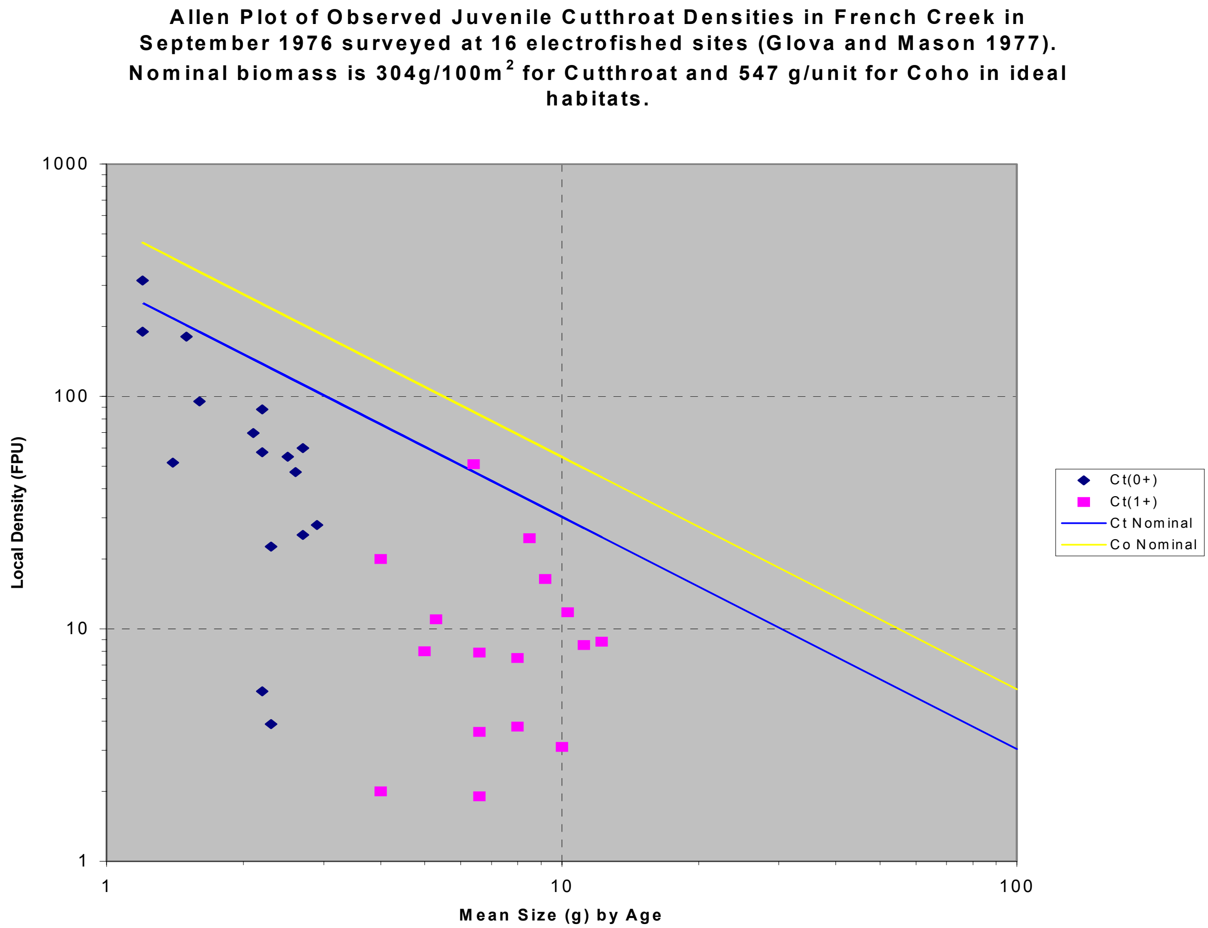
Figure 4. Steelhead Harvest Analysis chart illustrating catch and effort for French Creek



	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
CATCH	168	60	125	164	375	60	72	155	103	63	45	82	16	33	29	92	12	98	7	4	9	0	9	0	8	11	56	19	37	0	0	0
EFFORT	416	115	307	223	389	171	164	206	301	185	175	141	108	37	61	198	47	154	71	54	22	24	14	4	35	26	81	22	115	0	48	13

In 1976, Glova and Mason studied cutthroat populations in French Creek as part of their investigation into competition for food and space between sympatric salmonid populations. Ptolemy (2000) summarized the cutthroat trout sampling data from Glova and Mason’s study and plotted this against predicted populations based on flow and alkalinity (Fig. 5). Ptolemy’s work illustrates that although the habitat was not seeded to 100% capacity, it was still producing considerable numbers of trout juveniles 25 years ago. No recent instream population data is available, however based on current stream characteristics, it is expected that these numbers would be reduced.

Figure 5. French Cutthroat populations summarized from Glova 1976/77. . (Ptolemy, 2000)



<u>Conclusions and Recommendations</u>

Steelhead and sea run cutthroat trout populations in French Creek are severely depressed and may even have been eliminated, but further fish sampling is needed to confirm this. Juvenile population estimates using electroshocking and/or downstream trapping are required to determine the population status of each species. It is suggested that these studies be a priority for any future fish evaluation programs at French Creek. It is also recommend that future investigations include DNA analysis of juvenile fish to determine how many adults are contributing to the population. Snorkel surveys could be employed to augment adult sampling programs.

Ocean productivity combined with instream habitat degradation extended over several decades has affected the carrying capacity, fish production and fisheries. Impacts from freshwater habitat degradation are cumulative and difficult to quantify, however, it is important, at a minimum, to know what factors are limiting fish in these habitats. It is suggested that support be given to further efforts (by stream keepers and DFO) to conduct a detailed fish habitat assessment of

French Creek to identify and, where possible, quantify the amount of fish habitat available and the factors limiting fish production. Currently, habitat data gaps at French Creek include a lack of information regarding substrate composition and sediment inputs, water chemistry and nutrients. Flow and water extraction data is also limited and an attempt should be made to evaluate the contributions of headwater sub-basins to the stream flow, and determine which locations are being affected the most by water extraction.

The detailed fish habitat assessment can form the basis of a comprehensive habitat rehabilitation plan for French Creek, and a land use management plan for the French Creek watershed. The federal and provincial governments are responsible for protecting streams and fish habitat, while local governments are responsible for community development and planning. All levels of government must work together to avoid impacting fish and fish habitat when development is proposed and on-going, and to design and implement rehabilitation projects when habitat has been degraded by past activities. Streamkeeper groups can provide fish and fish habitat assessment data to government agencies which can then use this information to develop plans to guide habitat rehabilitation and watershed land use development and protection initiatives. In the French Creek watershed, the Parksville Streamkeepers are already working to document fish habitat attributes and land use impacts. It is suggested that government (WLAP) continue to support the Parksville Streamkeepers to conduct a detailed watershed assessment. Over time, with governments and land users and streamkeepers working together, it is suggested that a river management plan be developed to protect habitat and plan for recovery. This plan should fit in with existing water management, steelhead recovery and community development plans.

Finally, it is suggested that DFO develop a coho fry-stocking plan for French Creek. Hatchery augmentation can have limited overall success due to its impacts to wild fish production. Specifically, stocking hatchery fish on top of wild fish can reduce the condition and output of wild smolts thereby negating the effect of stocking on the target species, and also impacting the production of non-target species. Glova (1976-77) found that coho dominate trout when these two species share the same habitat. He also found that hydrological conditions of summer low flow in streams offer competitive advantages to salmon over trout. Stocking programs on streams with low summer flow such as French Creek should, therefore, take into account the potential impacts of both stocked salmon on all wild salmonids, and the competitive advantage that stocked and wild coho confer over trout. This is especially important in French Creek where trout populations are already depressed.

The fish-stocking plan should be developed only after evaluation of the current population densities of all species, the availability of habitat, and the flow conditions at various locations in the stream. Furthermore, habitat rehabilitation projects such as flow augmentation and instream engineering encourage habitat segregation between salmon and trout living in the same habitat and may result in better fish production than stocking alone (Parkinson and Slaney, 1975). Therefore, it is suggested that the stocking plan be completed in concert with the fish habitat rehabilitation plan proposed above.

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Wightman C., and B. Ward, and R. Ptolemy, and F.N. Axford, A Recovery Plan East Coast Vancouver Island Steelhead Trout. Minsitry of Environment Lands and Parks, Nanaimo.

APPENDIX 1

PHOTOGRAPHS OF LAND USE ACTIVITIES IN THE FRENCH CREEK WATERSHED

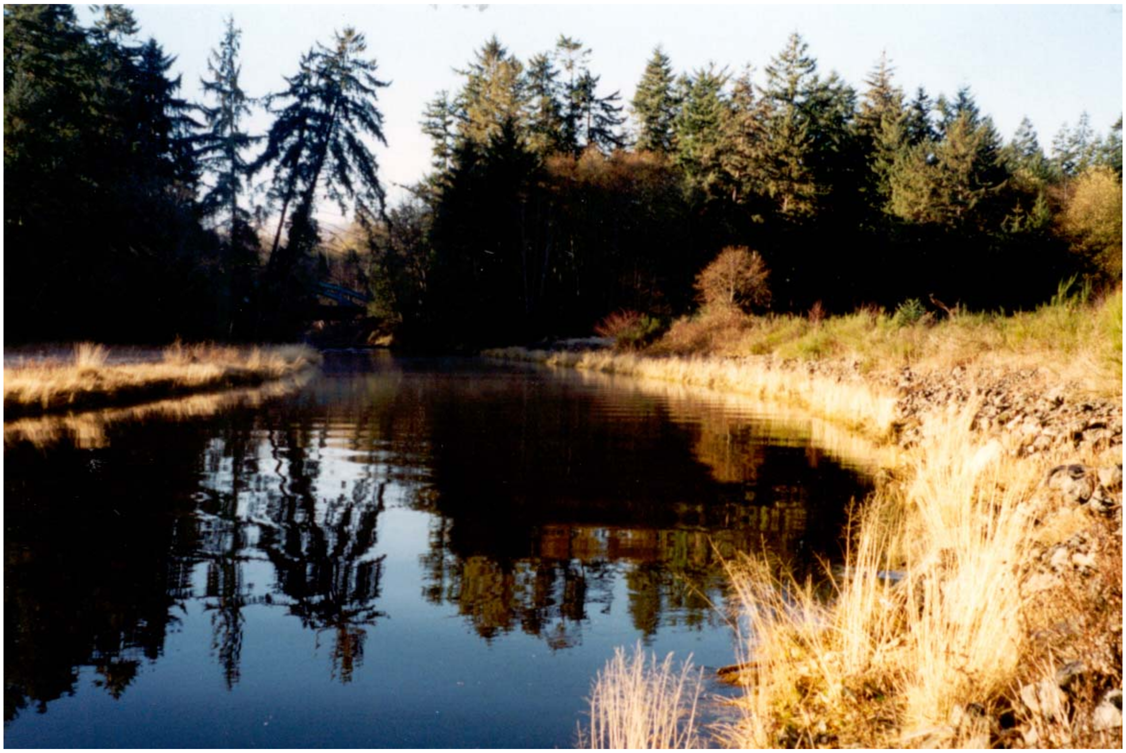


Photo 1.
French Creek Estuary, loss of habitat from channelization and dyking.

Photo 2.
Infilling of estuary for housing development.


Photo 3.
Highway 19A bridge crossing, channel confinement.


Photo 4.
Urban development along stream.

Photo 5.
Armouring along creek, protecting lawn.

Photo 6.
Landslide into stream from private property (1998 and 2000).


Photo 7.
Pumphouse drawing water near stream (one of many along the stream).


Photo 8.
Deposition of fines and organics.


Photo 9.
Cement wall constructed to armour bank.


Photo 10.
Armouring the bank can move or increase erosion downstream.

Photo 11.
Armouring is typically done to protect property (see photo 10). Note proximity of house.

Photo 12.
Removal of riparian cover – recent tree removal.


Photo 13.
Failing banks on private property contribute fine sediments and gravel to French Creek.


Photo 14.
Erosion next to agricultural land.

Photo 15.
Trees fallen in creek due to bank failure.

Photo 16.
Eroded high sand-bank and accumulation of sand in pool below. Note stumpage on top.

Photo 17.
Barrier to fish migration (fishway along left bank, see photo 18).

Photo 18.
Fishway at barrier.

Photo 19.
Log jam upstream of fishway.

Photo 20.
7-meter falls (Pearson falls).

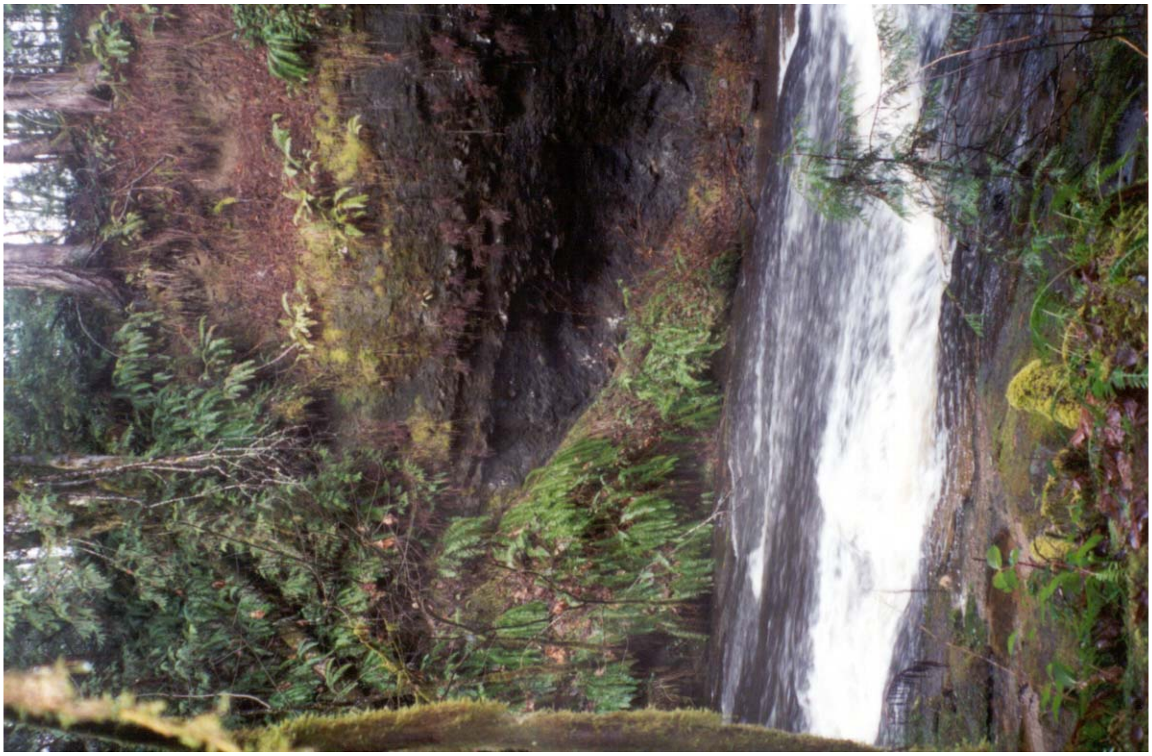


Photo 21.
Barrier to fish migration at low flows, East fork of French Creek.

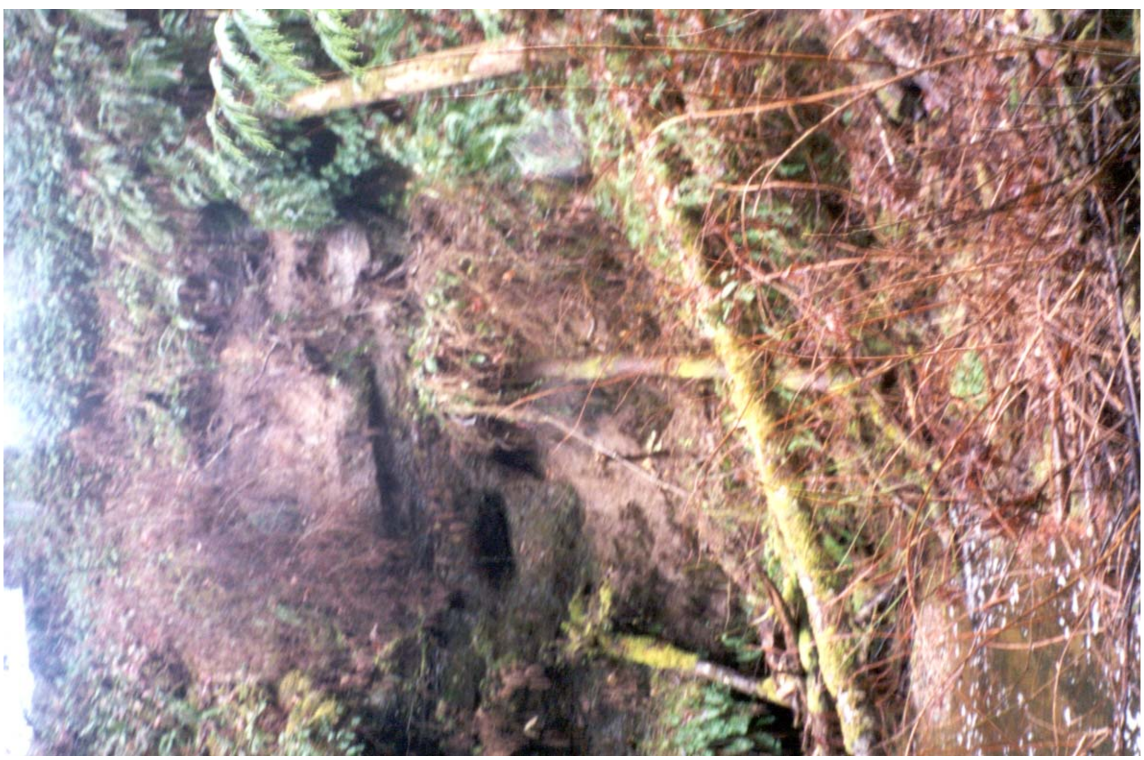


Photo 22.
Bank erosion, West fork of French Creek.

Photo 23.
Eroded bank – pumphouse over well in background, West fork.

Photo 24.
Eroding bank contributing fines and gravel.

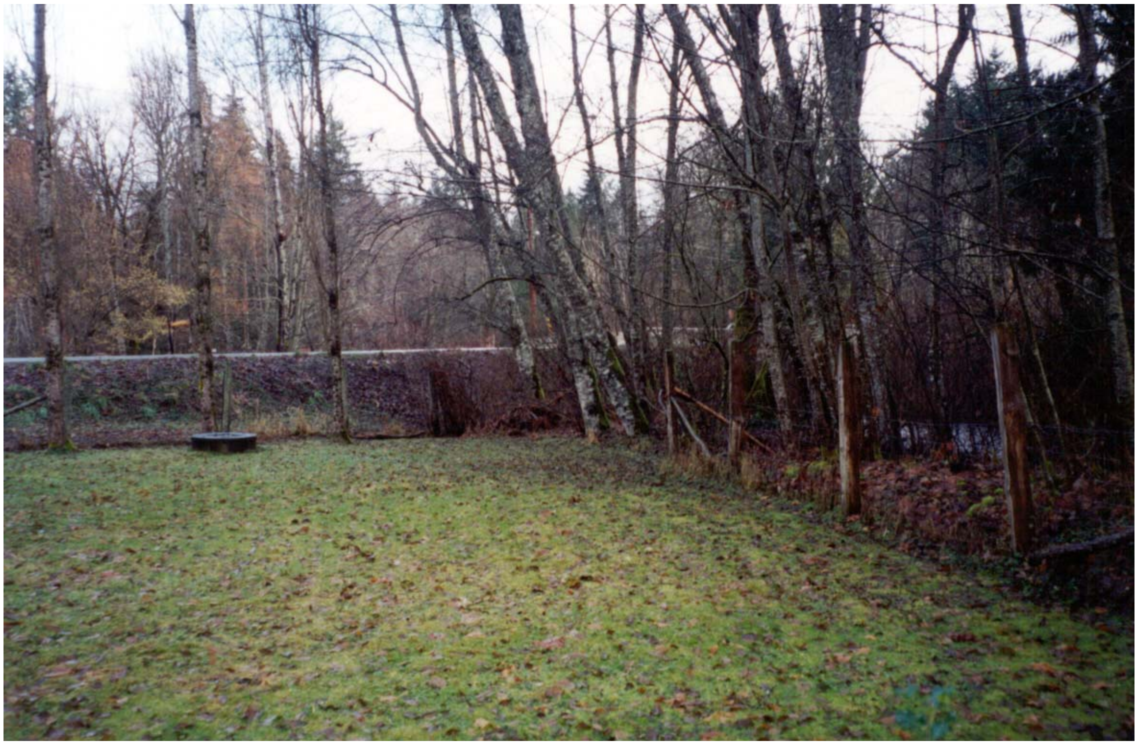


Photo 25.
Streamside well, East fork.


Photo 26.
Tributary stream to West fork of French Creek. Drains wetland immediately adjacent to street.

Photo 27.
Log jam, North fork.

Photo 28.
Gravel deposition, North fork.

Photo 29.
Bank failure along clearing, North fork.

Photo 30.
River confinement and gravel deposition subsequent to bridge crossing on North fork.

Photo 31.
In-stream woody debris, North fork.

Photo 32.
Ditchline draining into tributary of West fork.

Photo 33.
Trenched field drainage contributing to ditch runoff in previous photograph.

Wildlife Impact Statement

Maggie Henigman
Urban Habitat Officer

and

Marlene Caskey, R.P.Bio.,
Ecosystems Officer

Ministry of Water, Land and Air Protection
Vancouver Island
British Columbia

2001

Wildlife in the French Creek Watershed

Overview

The objective of this report is to provide a trend analysis of the species that are understood to have occurred in the watershed prior to human settlement and briefly describe the population status of species that are known to occur here today. This review also provides a discussion of the land use trends and existing habitat availability that influence wildlife species composition and distribution across the watershed. Finally this report provides a short discussion of the measures that could be taken to reverse these trends.

Methods

In order to provide a comprehensive a report, we have conducted a review of the existing "species at risk" data for this watershed, as well as an analysis of the winter 2001 bird count, carried out by the Arrowsmith Field Naturalists. The field naturalists provided total numbers of individuals within each species identified at a number of locations within the French Creek watershed on January 5, 2001. Unfortunately a map of these locations was not available, although we understand that the count was concentrated in the lower portions of the watershed. It was assumed that the species found to be utilizing the watershed would behaviorally prefer natural habitat conditions typical of those found in the Sensitive Ecosystem inventory. For this reason we have correlated this inventory to the *Sensitive Ecosystem Inventory: East Vancouver Island and Gulf Islands 1993-1997 (SEI).*

Physical Setting

French Creek is located on the east-coast of Vancouver Island and flows to the Strait of Georgia from the South Vancouver Island Mountain Ranges. The watershed lies within the Leeward Island Mountains of the Georgia Depression and includes portions of the Coastal Douglas fir (CDFmm) and Very Dry Maritime Coastal Western Hemlock (CWHxm) biogeoclimatic zones of Vancouver Island.

The forests of the watershed lie within the rain-shadow of the island ranges, and typically exhibit warm dry summers and mild wet winters. Growing seasons within these forests are therefore relatively long, although moisture deficits can be a limiting factor to productivity, especially on drier sites. These zones represent the mildest climates in Canada and as a result, the French Creek basin provides prime habitat and growing conditions for many forest based wildlife species and ecosystems.

Hamilton Marsh within the East-Coast CWHxm Biogeoclimatic Zone

Human development over the past 50-100 years has roughly divided the basin into three general areas of “land use”, including the upper watershed as a “working” forest landscape, the middle agricultural belt and the lower urban zone. The Georgia Basin has become very attractive to new settlement, especially along the coastal lowlands of the east coast of Vancouver Island (Ward, 1999). This is resulting in accelerated losses and modifications to critical wildlife habitats and rare ecosystems. Although most wildlife have specific habitat requirements, some are able to adapt to modifications of the landscape. Unfortunately others cannot adapt, and as a result populations and distribution of these species are directly and indirectly impacted.

Historic Wildlife Occurrence

Prior to the logging of the lower half of the French Creek basin at the turn of the century, the original French Creek ecosystems would have supported a much broader range of wildlife species than that which occurs here today. Species Accounts from the *Rare Birds of British Columbia, prepared by Fraser, Harper, Cannings et al, March 1999* suggest that land use practices such as logging, agriculture and urbanization are chiefly responsible for the landscape alterations that have resulted in many east coast habitats becoming unsuitable for many species that are now considered at risk of extinction. However, the Georgia Basin still supports the highest diversity of bird species in British Columbia; including 90% (249 recorded) of all species known to occur in BC and 60% of all species known to breed here (*The Birds of BC, Volume 1, Campbell, Dawe, McTaggart-Cowan et al).*

We know that prior to logging, the extensive older forests, aquatic and riparian ecosystems within the French Creek basin would have been capable of supporting populations of many species that are not known to occur here today, including:

- Marbled Murrelets (Brachyramphus marmoratus)
- Water Shrew (Sorex palustris brooksi)

- Keen’s Long-eared Myotis (bat) (Myotis keenii)
- Ermine, anguinae subspecies (Mustela erminea anguinae)
- Steelhead trout (Oncorhynchus mykiss)

These species are all now provincially ranked as red or blue species. This means that they are designated or are candidates for legal designation as threatened or endangered under the British Columbia Wildlife Act (*Rare Birds of British Columbia, Fraser, Harper, Cannings et al, March 1999).*

Identified Species at Risk

The Conservation Data Centre in Victoria was contacted to determine what other species at risk may have been identified, in this watershed (see Appendix C). “Species at Risk” is defined as an extirpated, endangered or threatened species or a species of special concern (*The Species At Risk Act – Guide, Environment Canada, 2001).* During a flight of the watershed conducted March 30, 2001 we noted that much of the riparian “habitat” surrounding Dudley and Hamilton Marshes appeared to be intact and we conclude therefore that identified species such as Aeshna tuberculifera (Black-tipped darner) and Glyceria occidentalis (Western mannagrass) may still occur in and/or around these wetlands.

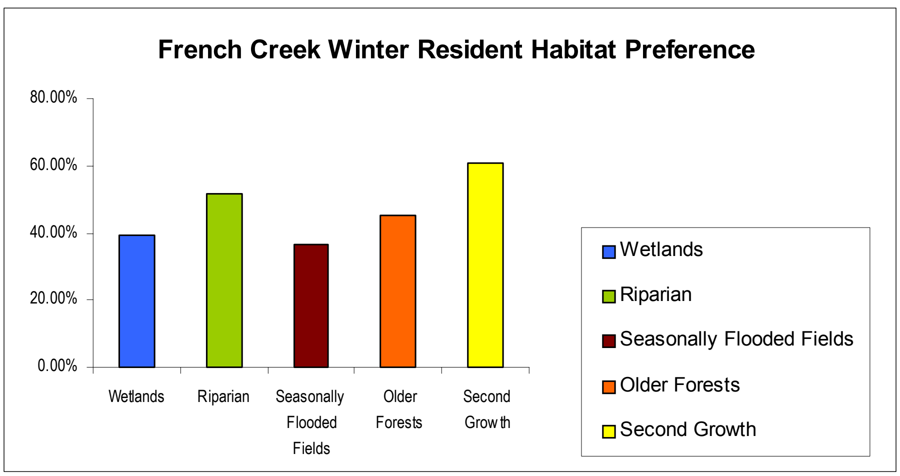
Dudley Marsh – French Creek Watershed

It is possible that remnant nests of Ardea herodias fannini (Great Blue heron) may occur in an area north of Coombs, as described in the CDC report, however it is not believed that this colony has been active for a number of years. As discussed below, viable nesting habitat for large species such as great blue heron in the developing east-coast of Vancouver Island is becoming increasingly rare, due to the development pressure and related nest tree removal within these watersheds.

Current Inventory

Only anecdotal information for bird and mammal presence gathered from local naturalists and regional Fish and Wildlife staff was available upon which to confirm the significance of current resident and migratory wildlife to the ecosystems that were represented there. Due to timing constraints the preparation of this report, we were not able to include migratory bird species that utilize this watershed for breeding purposes during the spring and summer. Natural habitat preferences of the species counts provided by the naturalists was then used to examine the relationship between the resident (winter) populations and the identified Sensitive Ecosystems of the French Creek watershed, as defined by the *SEI* (See also Report #9).

Chart 1: Resident Bird Habitat Preference as a Percentage of Identified SEI Polygons



The field naturalist's data has been included in Appendix A. A comprehensive list of winter resident bird species known to occur in the Parksville – Qualicum Beach area, was prepared by N. Dawe and R. Ostling, and has been attached in Appendix B.

The winter data identified a total of 33 species that have been grouped by lifestyle or preferred habitat, and includes: 11 waterfowl, 1 upland game, 3 raptors, and 18 passerine species. The naturalists data shows a fairly even species distribution between the general aquatic and forest ecosystem types.

Impacts of Land Use on Wildlife Species

Currently, Section 34 of the British Columbia Wildlife Act protects the birds, nests and eggs of prescribed species including, eagle, peregrine falcon, gyrfalcon, osprey, heron, burrowing owl. With respect to French Creek however, due in part to the topography, climate and habitat, only eagle, heron and osprey could be expected to occur in this range.

The federal *Migratory Birds Convention Act* does protect a wide range of migratory species, however the habitat protection provided for in this legislation pertains only to the nests of those species and enforcement can be extremely difficult.

Beyond these protection mechanisms, there is presently no legislation at any government level to protect species at risk, although the Federal Government is working towards enactment of the Species At Risk Act (SARA). This means that currently there is no comprehensive protection for the red and blue listed species that occur in the French Creek watershed. There are however, provisions of the Local Government Act and the Official Community Plan process to apply protection restrictions for environmental features as part of the Development Permit process (see Section #10).

Due to the habitat requirements of these species, in order to carry out life processes, it is believed that once the habitats are removed the numbers of individuals using the watershed can be expected to decrease. Modifications of the landscape and fragmentation of habitat within the watershed will likely continue to alter the population densities and distribution of all wildlife species including birds, both resident and migratory. Urbanization, agriculture and logging activities can all be expected to favor the proliferation of highly adaptable bird species, such as the European starling House sparrow and Northwestern crow. Continued loss of mature forests and even single dominant trees will continue to affect population densities of many raptors and cavity nesting species that are dependent upon the availability of this habitat (*The Birds of British Columbia, Campbell Dawe, McTaggart-Cowan etc al*.)

The gradual loss of mature forests will also mean the decline of birds that are protected under Section 34 of the Wildlife Act. Continued impacts to wetlands, and intertidal marshes, as a result of draining, filling and shoreline protection works, will result in a net loss of waterfowl, shorebird and fish habitat and could result in the eventual extirpation of whole populations within the basin.

While it is clear that protection of the aquatic habitats and older forests is critical to the success of many identified species, some modified habitats such as flooded farm fields and juvenile forests are also important for species dependent on an aquatic environment. Protection of old-field and seasonally flooded fields is a vital link in maintaining many populations of birds, amphibians, small mammals and invertebrates that have lost their natural rearing and breeding habitats.

Other Wildlife and Their Habitats

Observations of other watersheds on the east-coast of Vancouver Island and similar to French Creek, indicate that land-use impacts to wildlife populations is likely very similar to this watershed. No discrete data was available for mammal presence or distribution, however Black tailed deer *(Odocoileus hemionus)* and Roosevelt Elk *(Cervus elaphus roosevelti)* are known to occur in the study area in open forested areas and below 900 m elevation (*Coastal Black tailed Deer Study, BC Ministry of Forests, 1998)*. These forests and adjacent aquatic habitats also support Black bear *(Ursus canadensis)*, River otter *(Lontra canadensis)*, Mink *(Mustela vison),* Beaver (*Castor canadensis*) and at least two species of bat *(Myotis spp.)*.

Recommendations

Residents and local government can assist in reversing the trends noted above through the following measures:

- Protect wildlife habitat through the identification and protection of the Sensitive Ecosystems that support them.
- Protect habitat recruitment for species at risk through the identification and protection of the sensitive ecosystems that support them.
- Adopt development permit areas that can restrict development activities in, and maintain effective buffers for, identified Sensitive Ecosystems as well as the nest trees prescribed under Section 34 of the Wildlife Act.
- Identify and establish greenways corridors; managed for larger species such as bear, deer and elk; especially where human/wildlife conflicts are known to exist or are likely to occur as development continues.
- Encourage landowners to maintain wildlife friendly areas on their property, for nesting and feeding purposes
- Retain snags and older trees with suitable buffers, to minimize human and property hazards and benefit the many species that utilize these trees.

Acknowledgements

We are grateful to the Arrowsmith Field Naturalists for their assistance in collecting the bird data for this report. We also wish to acknowledge regional rare and Endangered Species Biologist and Wildlife and Conservation Officer staff for their support in preparing information concerning species presence and habitat use in the watershed.

Appendix A
Arrowsmith Naturalist Winter Bird Count - 2001
with SEI Assesment

	SPECIES	Count	HABITAT on Vancouver Island	Seasonal Preference	SEI Utilization Code				
					wn	ri	of	sg	fs
Anseriformes	Trumpeter Swan	17	fresh water, bays and estuaries	winter	WN	RI			FS
	Canada Goose	53	fresh water, bays and estuaries	resident	WN	RI			FS
	Mallard	30	fresh water, bays and estuaries	resident	WN				FS
	American Wigeon	41	fresh water, bays and estuaries	winter	WN				FS
	Northern Shoveller	2	fresh water, bays and estuaries	resident/winter	WN				FS
	Bufflehead	15	fresh water, bays and estuaries	isolated breeding	WN	RI			
	Ruddy Duck	2	marshes, bays and estuaries	winter	WN	RI			
	Hooded Merganser	2	wooded ponds, rivers	resident/breeding	WN	RI			
	Ringed necked Duck	7	wooded ponds, rivers	winter	WN	RI			
	Lesser Scaup	2	lakes, bays, estuaries	winter	WN				
Laridae	Gaucous winged Gull	50	coastal	resident	WN				
Phasianidae	Ring necked Pheasant	3	farm fields, marsh edge, brush	resident	WN			SG	FS
Accipitridae	Cooper's Hawk	1	mature forest, woodlands, river groves	breeding/resident			OF	SG	
	Bald Eagle	2	coast, rivers, large lakes	resident		RI	OF	SG	
Strigidae	Great Horned Owl	1	forests, stream sides, open country	resident		RI	OF		FS
Columbidae	Band tailed Pigeon	1	foothills, mountain forest, spreads in winter	resident			OF	SG	
Picidae	Northern Flicker	1	open forest, farms, towns, semi-open country	resident				SG	FS
Corvidae	NW Crow	17	near tidewater, shoreline	resident		RI			FS
	Comon Raven	5	mountain forest, coastal cliffs	resident			OF	SG	
	Steller's Jay	5	conifer forests	resident			OF	SG	
Paridae	Chestnut backed Chickade	38	moist conifer forest	resident			OF	SG	
Certhiidae	Brown Creeper	1	mature woodlands, groves, shade trees	resident			OF	SG	
Troglodytidae	Winter Wren	1	woodland and conifer undergrowth	resident			OF	SG	
Muscicapidae	Golden crowned Kinglet	40	conifers and understory	resident			OF	SG	
	American Robin	10	towns, farmland, forests, in winter Ash groves	resident		RI	OF	SG	FS
Sturnidae	European Starling	39	cities, parks, farms	resident				SG	FS
Emberizidae	Fox Sparrow	2	wooded undergrowth, brush	resident/winter			OF	SG	
	Song Sparrow	2	thickets, marshes, roadsides and gardens	breeding	WN	RI		SG	
	Spotted Towee	9	open woods, undergrowth, brushy edges	resident		RI		SG	
	Dark eyed Junco	108	conifer & mixed woods, roadsides, brush	resident		RI	OF	SG	
Fringillidae	Purple Finch	10	woods, groves, suburbs, feeders	resident		RI		SG	
	House Finch	8	cities,suburbs, farms, canyons	resident/winter		RI			FS
	Pine Siskin	70	conifers, mixed woods, alders, weedy areas	resident		RI	OF	SG	

APPENDIX B

PARKSVILLE – QUALICUM BEACH BIRD CHECKLIST

AS COMPILED BY

NEIL K. DAWE AND ROY OSTLING

1993 EDITION

___Red-throated Loon
___Pacific Loon
___Common Loon
___Yellow-billed Loon - R

___Pied-billed Grebe
___Horned Grebe
___Red-necked Grebe
___Eared Grebe - R
___Western Grebe

___Fork-tailed Storm-Petrel - R
___Leach's Storm-Petrel - R

___Double-crested Cormorant
___Brandt's Cormorant
___Pelagic Cormorant

___American Bittern - R
___Great Blue Heron
___Cattle Egret
___Green-backed Heron

___Tundra Swan - R
___Trumpeter Swan
___Mute Swan - R
___Greater White-fronted Goose
___Snow Goose
___Emperor Goose - R
___Brant
___Canada Goose
___Wood Duck
___Green-winged Teal

___Mallard
___Northern Pintail
___Blue-winged Teal
___Cinnamon Teal
___Northern Shoveler
___Gadwall
___Eurasian Wigeon
___American Wigeon
___Canvasback
___Ring-necked Duck
___Greater Scaup
___Lesser Scaup
___Harlequin Duck
___Oldsquaw
___Black Scoter
___Surf Scoter
___White-winged Scoter
___Common Goldeneye
___Barrow's Goldeneye
___Bufflehead
___Hooded Merganser
___Common Merganser
___Red-breasted Merganser
___Ruddy Duck

___Turkey Vulture

___Osprey
___Bald Eagle
___Northern Harrier
___Sharp-shinned Hawk
___Cooper's Hawk
___Northern Goshawk
___Red-tailed Hawk
___Rough-legged Hawk

___Golden Eagle - R
___American Kestrel
___Merlin
___Peregrine Falcon
___Gyrfalcon - R

___Ring-necked Pheasant
___Blue Grouse
___Ruffed Grouse
___California Quail

___Virginia Rail
___Sora
___American Coot
___Sandhill Crane

___Black-bellied Plover
___Lesser Golden-Plover - R
___Snowy Plover - R
___Semipalmated Plover
___Killdeer

___Black Oystercatcher

___Greater Yellowlegs
___Lesser Yellowlegs
___Solitary Sandpiper
___Wandering Tattler - R
___Spotted Sandpiper
___Whimbrel
___Marbled Godwit - R
___Hudsonian Godwit - R
___Ruddy Turnstone
___Black Turnstone
___Surfbird - R

___Red Knot - R
___Sanderling
___Western Sandpiper
___Least Sandpiper
___Baird's Sandpiper
___Pectoral Sandpiper
___Dunlin
___Short-billed Dowitcher
___Long-billed Dowitcher
___Common Snipe
___Wilson's Phalarope
___Red-necked Phalarope
___Red Phalarope - R

___Parasitic Jaeger - R
___Long-tailed Jaeger - R
___Bonaparte's Gull
___Mew Gull
___Ring-billed Gull
___California Gull
___Herring Gull
___Thayer's Gull
___Western Gull
___Glaucous-winged Gull
___Glaucous Gull
___Black-legged Kittiwake - R
___Caspian Tern
___Common Tern
___Black Tern - R

___Common Murre
___Pigeon Guillemot
___Marbled Murrelet
___Ancient Murrelet - R
___Cassin's Auklet - R

___Rhinoceros Auklet
___Rock Dove
___Band-tailed Pigeon
___Mourning Dove

___Barn Owl

___Western Screech-Owl
___Great Horned Owl
___Snowy Owl
___Northern Pygmy-Owl
___Barred Owl
___Short-eared Owl
___Northern Saw-whet Owl

___Common Nighthawk

___Black Swift
___Vaux's Swift

___Anna's Hummingbird
___Rufous Hummingbird

___Belted Kingfisher

___Red-breasted Sapsucker
___Downy Woodpecker
___Hairy Woodpecker
___Northern Flicker
___Pileated Woodpecker

___Olive-sided Flycatcher
___Western Wood-Pewee
___Willow Flycatcher
___Hammond's Flycatcher
___Pacific-slope Flycatcher

___Say's Phoebe
___Thick-billed Kingbird - A
___Western Kingbird
___Eastern Kingbird

___Horned Lark

___Purple Martin - R
___Tree Swallow
___Violet-green Swallow
___Northern Rough-winged Swallow
___Bank Swallow - R
___Cliff Swallow
___Barn Swallow

___Gray Jay
___Steller's Jay
___Clark's Nutcracker - R
___Black-billed Magpie - R
___Northwestern Crow
___Common Raven

___Chestnut-backed Chickadee

___Bushtit

___Red-breasted Nuthatch

___Brown Creeper

___Bewick's Wren
___House Wren - R
___Winter Wren
___Marsh Wren

___American Dipper

___Golden-crowned Kinglet
___Ruby-crowned Kinglet

___Western Bluebird
___Mountain Bluebird
___Townsend's Solitaire
___Swainson's Thrush
___Hermit Thrush
___American Robin
___Varied Thrush

___Northern Mockingbird - R
___Sage Thrasher - R

___American Pipit

___Cedar Waxwing
___Bohemian Waxwing - R

___Northern Shrike
___Loggerhead Shrike - R

___European Starling
___Crested Myna - A

___Solitary Vireo
___Hutton's Vireo
___Warbling Vireo
___Red-eyed Vireo

___Orange-crowned Warbler
___Nashville Warbler - R
___Yellow Warbler

___Yellow-rumped Warbler
___Chestnut-sided Warbler - R
___Black-throated Gray Warbler
___Townsend's Warbler
___Black-throated Green Warbler - R
___Palm Warbler - R
___MacGillivray's Warbler
___Common Yellowthroat
___Wilson's Warbler
___Western Tanager
___Black-headed Grosbeak
___Rufous-sided Towhee
___American Tree Sparrow - R
___Chipping Sparrow
___Vesper Sparrow - R
___Lark Sparrow - R
___Savannah Sparrow
___Fox Sparrow
___Song Sparrow
___Lincoln's Sparrow
___White-throated Sparrow
___Golden-crowned Sparrow
___White-crowned Sparrow
___Harris' Sparrow - R
___Dark-eyed Junco
___Lapland Longspur
___Snow Bunting
___Red-winged Blackbird
___Western Meadowlark
___Yellow-headed Blackbird - R
___Brewer's Blackbird

___Brown-headed Cowbird
___Northern Oriole - R

___Brambling - A
___Rosy Finch - R
___Pine Grosbeak - R
___Purple Finch
___House Finch
___Red Crossbill
___White-winged Crossbill - R
___Common Redpoll - R
___Pine Siskin

___American Goldfinch
___Evening Grosbeak

___House Sparrow

Legend

R - rare; likely to be seen again in suitable habitat, although infrequently.

A - accidental; so far from its normal range that it is not likely to be seen again.

Compiled by

Neil K. Dawe and Roy Ostling

Sensitive Ecosystem Inventory Change Analysis

Maggie Henigman
Urban Habitat Officer

and

Marlene Caskey, R.P.Bio.,
Ecosystems Officer

Ministry of Water, Land and Air Protection
Vancouver Island
British Columbia

2001

Sensitive Ecosystem Inventory Change Report

Introduction

The objective of the Sensitive Ecosystem Inventory Change analysis is to determine what modifications have occurred to the Sensitive Ecosystems in the French Creek watershed that were first identified in the original *Sensitive Ecosystem Inventory: East Vancouver Island and Gulf Islands 1993-1997* (SEI)[1]. It also to identifies the land-use activities that appear to influence the rate of modification to these environmentally sensitive lands and provides suggestions for community involvement in order to reverse the trends that have been identified. **As stated in the OCP Review section, for clarity we will refer to the French Creek OCP as the Area "G" OCP.**

Method

To assess the current status of and impacts to the SEI polygons in the French Creek watershed, the Regional GIS staff prepared a set of 1:10 000 scale maps, including the 1999 ortho-photos, the SEI database, TRIM based watercourses as well as the major road locations for orientation purposes. Planning and Assessment Habitat Protection staff then reviewed the polygons within the watershed to determine if the identified "Sensitive Ecosystems" and :Other Important Ecosystems" had been impacted. The original 1:20 000 scale SEI maps were needed to compare and confirm polygon shape and orientation. Analysis included an assessment of those polygons that remained intact, those having been somewhat *Disturbed* and those having been *Severely Disturbed/Degraded*.

Due to our assumption that any disturbance of the SEI ecosystems may affect the ecological integrity of the remaining portion, even if the remainder is apparently untouched, for the purpose of the audit report, we defined "*Modified*" as: the combination of all *Disturbed* and *Severely Disturbed/Degraded* polygons.

Figure 1. Example of A Disturbed Wetland Ecosystem Polygon #-N1400

[1] More information on the SEI is available at: http://srmwww.gov.bc.ca/cdc/sei/

A helicopter reconnaissance flight was conducted on March 30, 2001 as a means of understanding the landscape, hydrology and development impacts in the watershed. This flight also served to confirm the preliminary assessment of suspected impacts to a number of polygons, where the ortho-image was unclear and to assess the scope of damage that we believed to have already occurred.

Data collected in the analysis included a summation of the total number and areas of disturbed or severely degraded polygons by dominant ecosystem type, by land-use and by Regional District electoral area. The total areas represented by each ecosystem type were determined directly from the GIS Oracle Access Tool (GOAT), and were summarized by Pacific Spatial Systems. Disturbed or severely degraded polygons, by ecosystem type, were also calculated as a percentage of the total study area. While it is recognized that the small sample size used in this study does not represent statistically defensible data, it does indicate what impacts have occurred in the watershed, to date.

The review was also compared to a broader SEI audit currently being prepared by Regional Ministry Planning and Assessment staff. The regional audit is being done to assess polygon modifications across the original SEI - Gulf Island and eastern Vancouver Island study area. Results of this audit represented a comparison of roughly 30% of the original 7400 polygons to their current condition. That report indicates an overall modification of **11.2%** of the SEI polygons across the original study area.

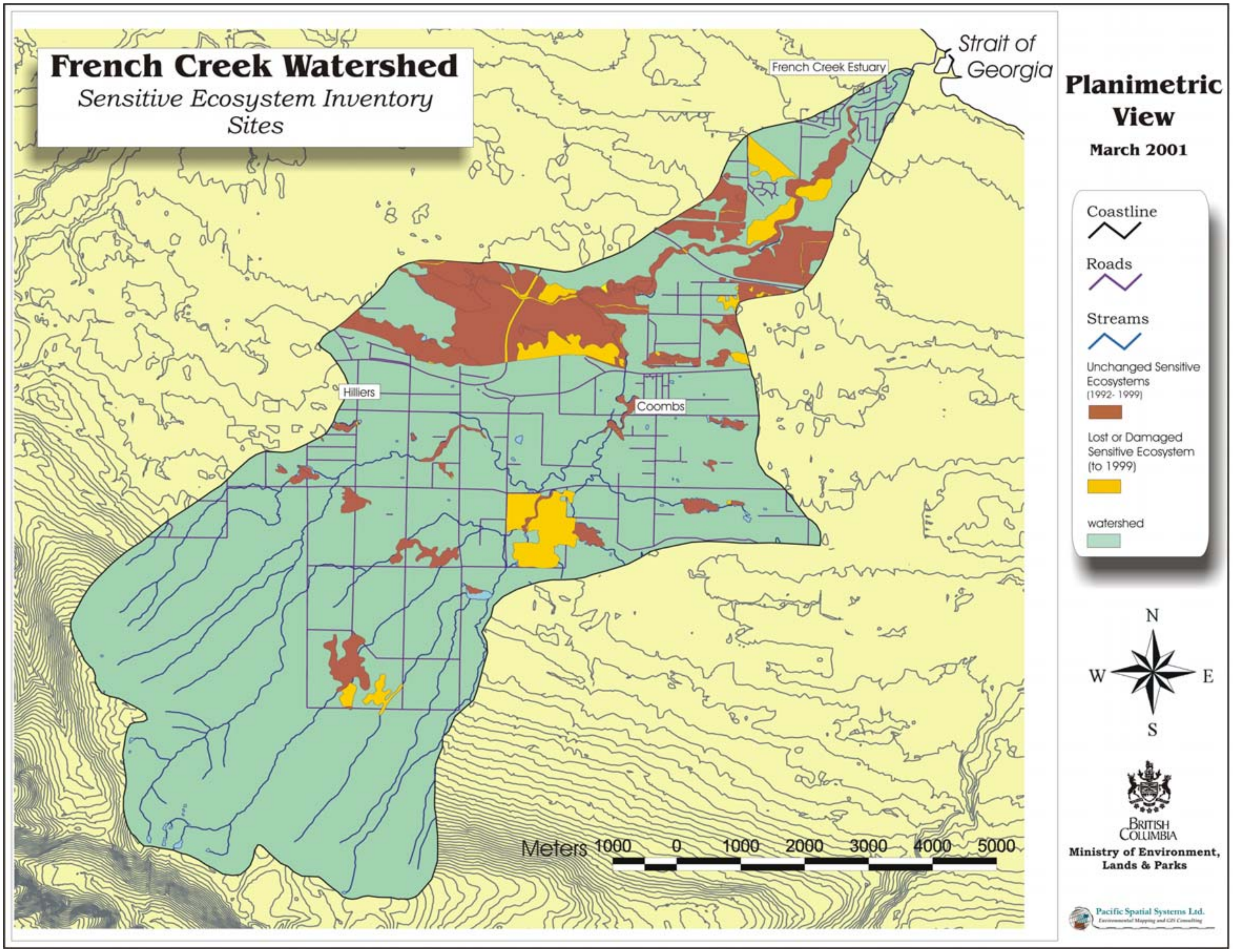
Results

Of the 50 SEI polygons mapped within the French Creek watershed , 8% have been severely degraded/disturbed and another 34% were found to have been disturbed (Figure 2). This results in a total of **42% modified** over the period between when the original air-photos were mapped for the *Sensitive Ecosystem Inventory* and when the 1999 ortho-photos were reviewed for French Creek. A break down of the percentages of modification by ecosystem type for the entire watershed is provided in Table 1.

Table 1: Modified Polygons in French Creek Watershed, by Ecosystem Type

	1997 SEI Polygons		Disturbed		Severely Disturbed/Degraded	
Wetlands	21	42%	4	19%	0	0.0%
Riparian	12	24%	5	41.7%	1	8.3%
Older Forest	4	8%	2	50.0%	1	25.0%
Second Growth	9	18%	5	55.6%	2	22.2%
Seasonally Flooded Fields	4	8%	1	25.0%	0	0.0%
Total	**50**	100%	**17**	**34.0%**	**4**	**8.0%**

The data was also analyzed for the percentage of modified ecosystems that were found within each Electoral Area, as shown in Table 2 (a and b).



French Creek Watershed
Sensitive Ecosystem Inventory Sites
Strait of Georgia
French Creek Estuary
Hilliers
Coombs
Planimetric View
March 2001
Coastline
Roads
Streams
Unchanged Sensitive Ecosystems (1992- 1999)
Lost or Damaged Sensitive Ecosystem (to 1999)
watershed
N
W
E
S
Meters 1000 0 1000 2000 3000 4000 5000
British Columbia
Ministry of Environment, Lands & Parks
Pacific Spatial Systems Ltd.

Table 2a: Analysis of Modified Polygons - Electoral Area “G”

Electoral Area “G”					
		Total	Disturbed	Severely Degraded/Disturbed	%
Sensitive Ecosystem	Wetlands	19	3		15.0%
	Riparian	9	3		33.0%
	Older Forest	3	1	1	66.0%
Other Important Ecosystem	Older Second Growth	6	3	2	83.0%
	Seasonally Flooded Fields	2	1		50.0%
	Total Modified Polygons	**39**	**11**	**3**	**35.9%**

Table 2b: Analysis of Modified Polygons - Electoral Area F

Electoral Area “F”					
		Total	Disturbed	Severely Disturbed/Degraded	%
Sensitive Ecosystem	Wetlands	2	1		50.0%
	Riparian	3	2	1	100%
	Older Forest	1	1		100%
Other Important Ecosystem	Older Second Growth	3	2		66.0%
	Seasonally Flooded Fields	2			0.0%
	Total Modified Polygons	**11**	**6**	**1**	**63.0%**

Land-use impacts within SEI polygons by electoral area were also assessed, using the following land-use categories:

- Forestry – all land identified as FLR or as having a forestry related land use.
- Rural – all ALR lands and land designated for rural subdivision of 2 hectares (5 acres) or greater in size
- Urban – all lands designated for urban subdivision less than 2 hectares in size. This includes commercial designated lands.
- Industrial – all lands designated for industrial uses, excluding forestry

Appendix A, shows the 21 modified polygons broken down by designated land-use.

Appendices B & C provide breakdowns of the occurrence by ecosystem type, for all designated land-uses within Areas “F” & “G”.

- Forestry related activities accounted for 52% (15) of all modified polygons; this breaks down to 38% in Area F and 14% in Area “G”.

- 38% of all modified ecosystems occurred within rural development areas, or 29% in Area “F” and 9% in “G”.

- Lands designated for urban use were limited to those within the French Creek Harbour Comprehensive Development Area and surrounding neighborhood residential land use. Only one polygon with an “urban” designation was mapped in Area “G” and this has been designated as modified. This land use is represented by only one polygon (2.0%) of all mapped polygons in the watershed or 5.00% of all modified polygons in the watershed.

- Similarly, there was only one polygon that was designated as “Industrial” in Area “G” (2.00%) and this had been severely disturbed/degraded.

Analysis of the total area (in hectares) represented by SEI polygons in the French Creek watershed revealed that forested habitats, specifically older second growth and older forests represent 95% of the area of SEI polygons within the watershed. However, the aquatic ecosystems (wetlands and seasonally flooded fields) showed the highest percentage, by land area, of impact by human activities in the watershed.

Table 3: Breakdown of Areas (in hectares) by Ecosystem Type

Ecosystem Type	**Total Area Represented**	**% Total Area**	**Areas Not Disturbed**	**Areas Modified**	**% Area Modified**
Wetland (WN)	86.9	2%	23.4	63.6	**73%**
Riparian (RI)	139.9	2%	100.6	39.3	**28%**
Older Forest (OF)	153.4	3%	114.8506	38.6	**25%**
Older Second Growth (SG)	4933.2	92%	4772.0	161.2	**3%**
Seasonally Flooded Fields (FS)	53.1	1%	17.3	35.7	**67%**
Total	**5366.5**	**100%**	**5028.1**	**338.4**	**6%**

Analysis

Analysis of the ongoing change to the audited ecosystems in French Creek indicates that the greatest number of polygons that have been affected lie within Older Forest and Older Second Growth ecosystems. In terms of land-use impacts to ecosystem integrity, forest and rural designated land use would appear to be having a greater impact on these ecosystems than the other land-use designations (See Appendix B & C). By gross area, these two land-uses also represent the dominant activities in the watershed. Polygons with the highest percentage of area disturbance, however, are the identified aquatic areas (Wetlands and Seasonally Flooded Fields).

The losses incurred through many small-scale encroachments on a wide range of polygons is thought to represent a more significant overall impact to the viability of that ecosystem type in the landscape than that of large-scale encroachments on a few polygons. This is, to some extent, due to the effect of habitat fragmentation, where connectivity of the ecosystem has been lost due to landscape alterations.

The OCP review (See Section 10) indicates that the existing bylaws do not provide adequate or complete protection of all streams or protected wildlife species, let alone identified sensitive ecosystems. Our assessment of the mapped data indicates patterns of loss consistent with forest and rural land use activities, ie removal and conversion of the natural ecosystems for agricultural or forest management purposes. Urban impacts are by comparison small and concentrated in the lowest reaches of the watershed. When compared to the concurrent audit of SEI modifications across the southeast Vancouver Island study area, the total percentage of disturbance within the French Creek watershed was significantly higher.

It should be noted that lands affected by Forest Land Reserve and Agricultural Land Reserve status are governed by the Forest Practices Code, Private Land Forest Practices Regulation and Right to Farm Acts. Provisions of these Acts and Regulations take precedence over Regional District bylaws.

Summary

Based on the above research and the findings of our OCP review, we speculate that the high rate of ecosystem loss in the French Creek watershed may be attributed to a combination of the following factors:

- recent adoption of an Official Community Plan in Area F (1999) and consequently only recent local government mechanisms to protect environmental features – no earlier protection.
- a lack of effective protection mechanisms within both current OCP's and supporting bylaws.
- generally high development pressure within the watershed, in particular over the past 10 years.

Except where they occur within existing protected features, such as watercourse Development Permit Areas, SEI polygons are in peril of alteration as a result of logging, land clearing and other land development activities. Consistent with the findings of the wildlife impacts report, continued growth in the French Creek watershed without improved community awareness and adoption of local government protection mechanisms may result in the loss of most of the remaining sensitive ecosystems over the next few decades.

It is expected that rural, forestry and urban related development will continue to play a significant role in the alteration, removal or encroachment of the SEI polygons. Their loss is also expected to contribute to the continued decline of fish and wildlife species. While provisions of the Fish Protection Act may help to slow this trend over the next few years, community support is needed if effective local government bylaws are to be successfully adopted. We recommend the following strategies.

- Residents of French Creek need to take a more stewardship-oriented role to protect their community and the environmental features that are represented there.
- Senior government agencies should continue to work closely with RDN staff to ensure a better cross-agency understanding of environmental features at risk, benefits of protecting them and barriers to adopting proactive approaches.
- Senior and local government need to play a more pro-active role in educating the community about the effects of human settlement on the function and health of their community.

Appendix A: Total Modified Polygons by Land Use Designation

	RU	%	FOR	%	URB	%	IND	%	TOTAL	%
WN	3	14.3%		0.0%	1	4.8%		0.0%	4	19.0%
RI	1	4.8%	4	19.0%		0.0%	1	4.8%	6	28.6%
OF		8.0%	3	14.3%		0.0%		0.0%	3	14.3%
SG	3	14.3%	4	19.0%		0.0%		0.0%	7	33.3%
FS	1	4.8%		0.0%		0.0%		0.0%	1	4.8%
	8		**11**		**1**		**1**		**21**	

Appendix B: Total Modified Polygons by Land Use Designation in Area F

	RU	%	FOR	%	URB	%	IND	%	TOTAL	%
WN	3	21.4%		0.0%		0.0%		0.0%	3	21.4%
RI		0.0%	3	21.4%		0.0%		0.0%	3	21.4%
OF		8.0%	2	14.3%		0.0%		0.0%	2	14.3%
SG	2	14.3%	3	21.4%		0.0%		0.0%	5	35.7%
FS	1	7.1%		0.0%		0.0%		0.0%	1	7.1%
	6		**8**		**0**		**0**		**14**	

Appendix C: Total Modified Polygons by Land Use Designation in Area G

	RU	%	FOR	%	URB	%	IND	%	TOTAL	%
WN		0.0%		0.0%	1	14.3%		0.0%	1	14.3%
RI	1	14.3%	1	14.3%		0.0%	1	14.3%	3	42.9%
OF		8.0%	1	14.3%		0.0%		0.0%	1	14.3%
SG	1	14.3%	1	14.3%		0.0%		0.0%	2	28.6%
FS		0.0%		0.0%		0.0%		0.0%		0.0%
	2		**3**		**1**		**1**		**7**	

Provisions for Environmental Protection in Official Community Plans

Maggie Henigman
Urban Habitat Officer

and

Marlene Caskey, R.P.Bio.,
Ecosystems Officer

Ministry of Water, Land and Air Protection
Vancouver Island
British Columbia

2001

Provisions for Environmental Protection in Official Community Plans

The following report assesses the provisions for environmental protection for the French Creek watershed, through a review of the existing Official Community Plans (OCP), Zoning Bylaws and designated land use for the two electoral areas of represented in this watershed. For the purposes of administering land use decisions the French Creek watershed area is located within the boundaries of the Regional District of Nanaimo encompassing parts of Electoral Area 'G' (French Creek) and Electoral Area 'F' (Errington/Coombs/Whiskey Creek/Hilliers). **Please note that for the sake of clarity in this report, we will refer to the French Creek OCP as Area "G", and the Coombs Errington OCP as Area "F", understanding that this may not entirely reflect the current electoral designations of the RDN. (See Map 1)**

In terms of establishing land use provisions, the ***Local Government Act*** provides the authority for a regional district to adopt an official community plan (OCP) as well as zoning and subdivision bylaws. Section 919.1 of the ***Act*** allows local government to designate development permit areas for the purpose of protecting the natural environment, its ecosystems and biological diversity. For OCPs, the ***Act*** identifies an official community plan as being a general statement of the broad objectives and policies of the local government respecting the form and character of existing and proposed land use and servicing requirements in the geographical area covered by the plan. An OCP is not a regulatory bylaw except where development permit areas have been designated. Where a development permit area has been established for the protection of a watercourse, the corresponding guidelines may include provisions such as retaining natural vegetation in the riparian areas near a stream.

In the case of these electoral areas, each area has an official community plan (OCP) currently in place – for Electoral Area 'G' – the RDN French Creek OCP Bylaw No. 1115, 1998 and for Electoral Area 'F' – the RDN Electoral Area 'F' OCP Bylaw No. 1152, 1999. Both OCPs have watercourse development permit areas designated over French Creek as well as some of its tributaries. Zoning throughout the RDN, with the exception of Area F, is governed by the RDN Land Use and Subdivision Bylaw No 500, 1987.

These plans reflect the locally driven response to the objectives and directions, of the Regional District of Nanaimo, Regional Growth Management Plan, adopted in January 1997, as well as other regional initiatives that have direct implications on the pattern of land use and development in the French Creek Watershed. The Official Community Plans reflect the preferences of the residents and landowners of the French Creek Electoral Areas G and F with respect to regional, provincial, and in some cases, federal planning responsibilities and initiatives, including environmental protection.

In adopting specific policies to meet the stated objectives of the Plan, the Regional District must strike a balance between community support and the interests of the affected agencies through a community consultation and agency referral process. This process ofdevelopment Permit Areasten presents choices and compromises that can have implications for the future health and sustainability and the watershed in which those activities occur. The lack of acceptance by a community for environmentally sound land management strategies within their OCP often means there is no protection for essential watershed features such as clean water or sustainable greenspace.

In addition to official community plans, the ***Act*** provides for the adoption of zoning and subdivision bylaws. Zoning and subdivision regulations are currently in place in Electoral Area 'G' while a zoning and subdivision bylaw is currently under consideration in Electoral Area 'F'. These types of bylaws establish regulations for land uses including permitted uses, minimum setbacks, maximum height of buildings, and minimum parcels sizes.

For watercourses in the French Creek Electoral Area, minimum setbacks requirements under the zoning provisions are established. These setback regulations apply to buildings and structures only and do not apply to the removal of vegetation or disturbance of soil.

French Creek Electoral Area (Area "G")

The French Creek Area OCP was developed through a public consultation process initiated in 1996 and was adopted in 1998. Prior to adoption of the plan as a bylaw, the OCP was formally referred to various provincial agencies, including the Ministry of Environment, Lands & Parks and Federal Department of Fisheries and Oceans.

The public consultation process identified several key community values that were brought forward in the plan. Environmental protection was identified as one of those values and included the following broad objectives.

- *Protect* and *conserve* the natural environment.
- *Encourage* and *support* community stewardship of the natural environment through community and individual initiative and public education.
- *Support* the coordination and harmonization of efforts among the public, stakeholders, and all levels of government in the protection of the natural environment

The Watercourse Protection Development Permit Areas (DPA) #11 in Area "G" currently includes only French Creek its floodplain and the foreshore. The creek DPA extends 30 metres from the natural boundary (NB) but does not include any other streams or tributaries located outside the area that was designated on Map 11 of the OCP (see Map 1 attached). This DP also applies to alteration of land along the foreshore, providing protection to 15 metres upland of the natural Boundary. The OCP addresses flood protection on French Creek, through the general guidelines for DPA #10 - Sensitive Lands, to protect development from hazardous conditions. Development on slopes greater than 30% is also guided by DPA #10.

Although the nests of several species, including heron and bald eagles are protected by Provincial statute, protection of the nest trees and a suitable buffer is currently only possible under provisions of the *Local Government Act*. There is currently no DPA establishing minimum buffers to protect wildlife nest trees in Area "G". Without suitable buffers these birds and their nests are subject to disturbance and under certain conditions survival of the chicks and the entire clutch may be in jeopardy. In extreme cases, the birds may even abandon the nest and chicks. Buffers are also necessary in the event that ground disturbance has occurred within the trees falling radius, in order to protect the rooting stability of the tree and ultimately to prevent property damage.

Currently, the only legal mechanism for protecting sensitive ecosystems, as defined by the *East Vancouver Island and Gulf Islands, Sensitive Ecosystem Inventory* (SEI), is through the adoption of local bylaws that are supported by the Official Community Plan. The Area “G” OCP provides no protection for these environmentally sensitive features other than to apply a blanket 15 metre DPA to help protect the foreshore and estuarine areas. Other than for flood protection, there is no clear strategy for coping with the loss of shoreline and estuarine habitats at the mouth of French Creek. As shown in our analysis of the Changes to Sensitive Ecosystems in French Creek, ecosystems in this watershed have been significantly impacted (42%) since the inventory was published in 1997. A lack of OCP protection means that there is currently no protection for the following ecosystem types, including the plant and wildlife species they support:

- Wetlands or Riparian zones that are not currently included in the existing watercourse protection DPA. Loss of these sensitive aquatic habitats through draining, filling or vegetation modifications is expected to result in the decline and extirpation of many plant, bird and invertebrate populations.
- Older Forests, such as the last extensive forest identified in DL 138 and 116 south of the BC Hydro Right of Way. Loss of these older forests is expected to result in the decline and possible extirpation of many mammal, songbird and invertebrate species in the watershed.

Secondary ecosystems including Seasonally Flooded Fields and Older Second Growth Forests are also expected to experience fish and wildlife distribution changes and declines, as the landscape is converted to settlement oriented land-uses.

Although the *Local Government Act* does provide for protection of these rapidly declining ecosystems, the SEI had only been published a year before the Area “G” OCP was adopted so protection for them is not represented in this document. Without strong community support to value these features however, it is expected that these ecosystems will continue to decline as the watershed develops.

This OCP currently provides no protection of groundwater, either for human consumption or fish habitat protection needs.

Area F - Coombs and Errington Electoral Area

The Area “F” OCP was adopted in 1999, following a lengthy community consultation process. This process included a more pro-active role by referral agencies and the community than had occurred during previous OCP processes consistent with the amendments to the Local Government Act that were adopted in 2000. However, as in the case of the Area “G” OCP, balancing the community's interests with environmental features at risk can be a difficult task for a local government.

The Area “F” OCP currently includes the following Objectives:
- Protect the natural environment.
- Encourage and support community stewardship of environmentally sensitive areas.
- Promote soil conservation.
- Manage development to minimize the potential for personal injury or loss of property.

The RDN Zoning Bylaw 500 currently does not apply in this Electoral Area, although a zoning bylaw is currently being drafted and there has been extensive community consultation. Zoning Bylaws divide a Regional District Electoral Area into zones of designated land-use and establish regulations for each zone. The absence of such a bylaw in Area “F” means that the RDN cannot prevent the growth of incompatible land-uses on adjacent properties, nor can they ensure that development of those land-uses will consider adequate protection of environmentally sensitive features. An example of this is the inability of the RDN to apply development restrictions to commercial or industrial based industries that lie in close proximity to watercourses that are not otherwise protected under the existing Watercourse Protection Bylaw. In addition, a lack of zoning directly compromises the RDN’s ability to control the number of dwellings or other structures that are constructed on a property, including the additional wastes and alteration to stormwater regimes.

Potential Land-Use Conflict

Our review showed that the plan does not take full advantage of all the environmental protection tools that are now available to regional governments through the *Local Government Act*. Watercourse protection DPA’s in Area “F” for French Creek, Little Qualicum and Englishman Rivers include a 30 metre wide DPA that is measured from the Natural Boundary or, where there is a break in slope, 30 metres from the top of bank. Due to the potential extension of this vegetated setback to the top of bank, this DPA may be said to provide somewhat better protection for the banks of the specified streams than does the Area “G” OCP.

The Watercourse DPA also includes a 15-metre setback for those streams with previously identified fish habitat as identified on OCP Map #3. However, this DPA does nothing to protect many other permanently wetted or ephemeral streams and wetlands in this area where fish surveys have not yet been completed and that directly or indirectly support fish habitat.

There is currently no provision in this OCP for development on hazardous slopes. This can have devastating consequences for sensitive areas affected by development or vegetation disturbance occurring on lands outside the exclusive watercourse protection

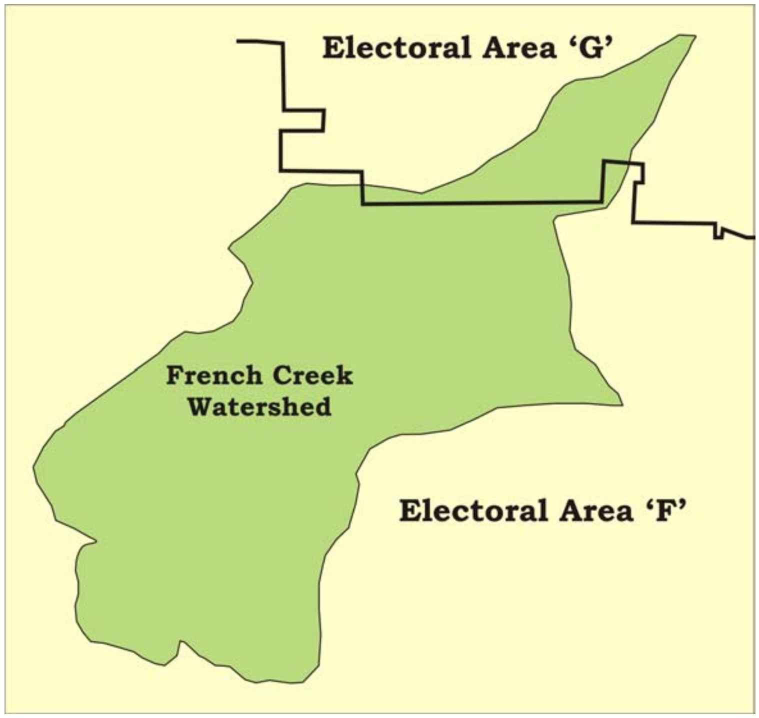
DPA (>30m from NB) but that lie within the steeper banks of the river and above a wide floodplain.

There is currently no provision for protection of sensitive ecosystems as defined by the *East Vancouver Island and Gulf Islands, Sensitive Ecosystem Inventory*. As noted in Area “G”, there is therefore no protection for these specified plant communities or the wildlife species they represent.

There are currently no specific measures identified to protect groundwater supplies, however the OCP does note the importance of preventing contamination of groundwater and supports stormwater management strategies through the use of constructed wetlands.

Summary and Recommendations

Despite significant effort on the part of the Regional District Staff and the local OCP committees however, neither of the bylaws we reviewed for this report appear to have taken full advantage of the provisions of the *Local Government Act* with respect to protection of environmental features. Watercourse protection in these two OCP’s has been dealt with in manner that addresses only the most significant watercourses and ignores the importance of the tributaries and natural storage areas that support the viability and biota of those systems. Other subjects such as ecosystem protection, as well as stormwater and groundwater management strategies, are generally lacking in both documents. It is recommended that future amendments to these documents utilize a watershed-based approach that will include provisions for all aspects of healthy sustainable communities including the environmental features that support them.



Map 1. Electoral areas in French Creek.