PART 2: CHARACTERIZATION AND ASSESSMENT OF WATER USES

2.0 HYDROLOGICAL RESOURCE USE

The hydrologic regimes of watersheds within the Lower Fraser Valley vary as a result of climate, surficial geology and land use. Annual hydrographs closely follows the precipitation cycle - the greatest flows are in November, December and January, when a succession of Pacific storms cross the coast, and minimum flows occur after several dry weeks in July, August and September. Watersheds on the Lower Fraser that support numerous salmon streams are often small to moderate-sized and their 7-day summer low flows range from ten to a few hundred liters/second (Rood 1997).

Summer base flows in the watershed are recharged solely from groundwater sources. These same sources are subject to continual extraction from well and surface water licenses, many of which hit peak demand right at critical low flow periods (Index 1 and 5, Figure 8, Rood & Hamilton 1995). Irrigation extractions are the most significant use in the watershed and are important to the aquatic resource because they occur during minimum stream flows (Rood 1997). The Little Campbell River watershed was identified as being a sensitive stream for fish flows by the Province under the Fish Protection Act in 2000, though it has yet to be designated for flow recovery (Ptolemy 2006). The implications of designation would be that a full recovery plan for fish flows would have to be developed and implemented (MOE 2000).

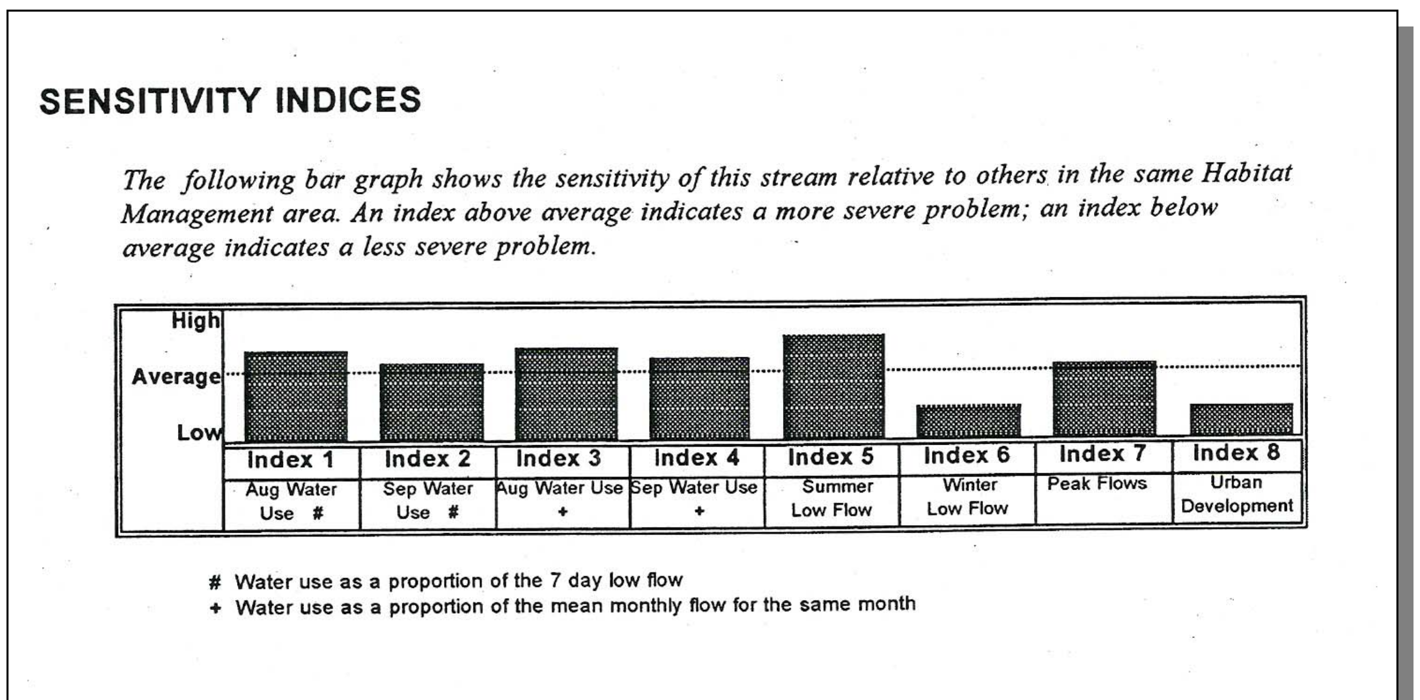

Figure 8. Sensitivity indices for water use on the Little Campbell River watershed (Source: Water Use and Hydrology of Salmon Streams in the Fraser Delta Habitat Management Area, Rood & Hamilton 1995)

Flow records for the Little Campbell River watershed are sporadic, short-duration and when compared to other nearby watersheds, the summer-fall base flows are deficient (Ptolemy 2006). In a drought year such as 1987 (Figure 9), the low residual flows in the river at WSC Station 08MH123 (above Sam Hill Creek) in the months of June-September are a result of both surface and groundwater use. The residual flows averaged 128 L/s or about 8% mean annual discharge (MAD). In the absence of water diversions or pumping the June-September flows would have been closer to 12% MAD or 202 L/s. For most coldwater salmon streams, 10% Mean Annual Discharge (MAD) is considered a minimum threshold to sustain aquatic life (MOE 1996). With drought events becoming a potential regular condition as a by-product of climate change the Little Campbell River watershed will likely see even greater impacts in the future (Ptolemy 2006).

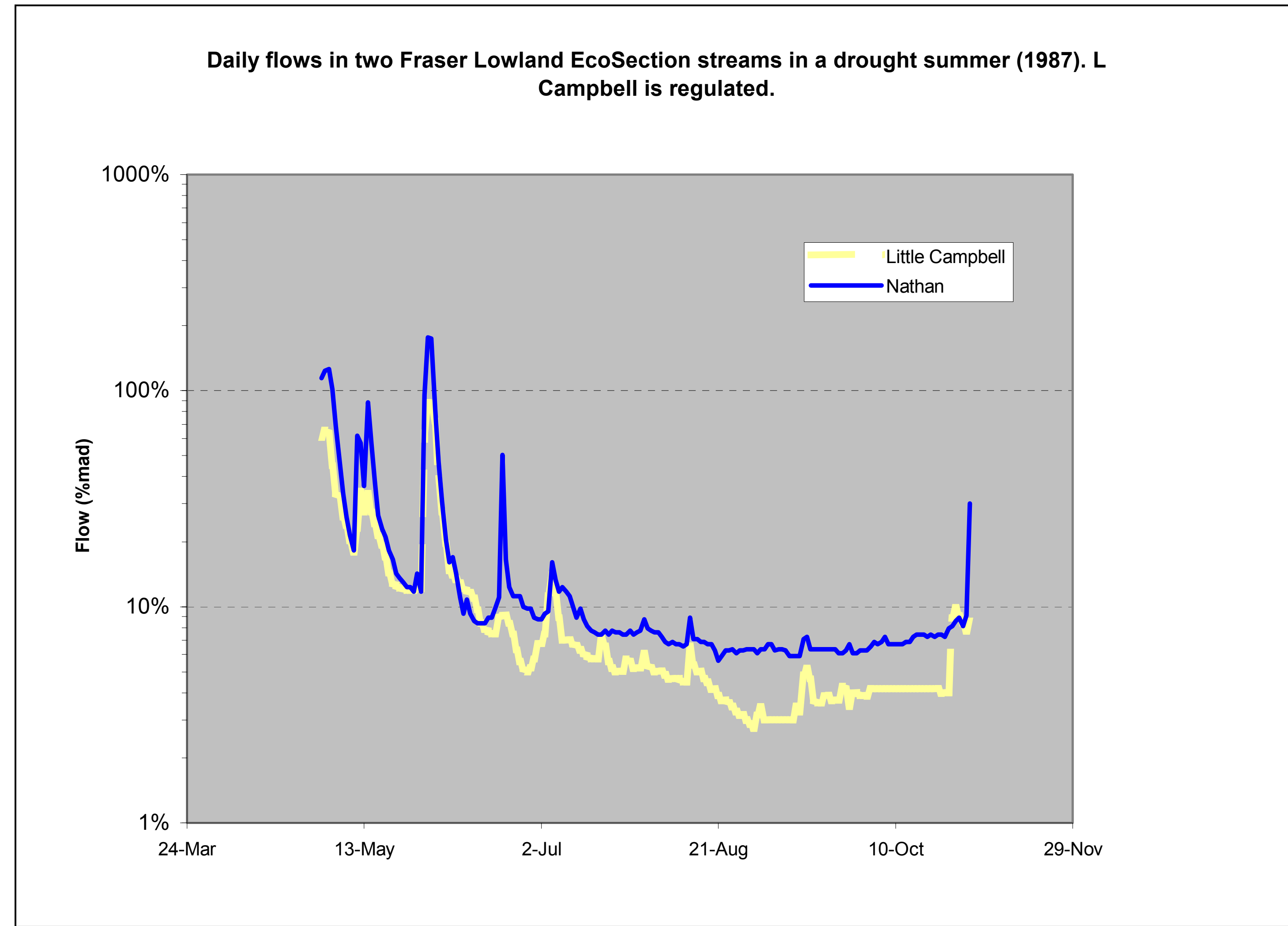

Figure 9. Little Campbell River hydrograph and comparison to a neighbouring smaller system considered less impaired (Nathan Creek) for critical flow periods during a drought year.

2.1 Demand & Issues by Water Use Type:

While BC is perceived to have an abundance of water it is often inaccessible. The majority of new licenses are for those systems with existing licenses. Declining water levels related to human activities are mostly a result of intensive local groundwater pumping for industry, agriculture and domestic supplies combined with decreased recharge due to increasing imperviousness in urbanizing areas (Golder & Associates 2003).

The Little Campbell River watershed has a long history of extraction issues. In BC in 1959 it was considered fully subscribed for water use. Then in 1969 this was lifted and further licenses for irrigation and domestic use have since been granted. Data for extraction on the U.S. side was not included as part of this study. In total 86 licenses ranging from domestic to irrigation to conservation (salmon hatchery) compete for water resources (Table 7 and Figure 10). The majority of licenses occur downstream of Campbell Valley Regional Park (Drever and Brown 1999).

Surface waters are not the only hydrological resource being extracted in this watershed - source aquifers are also continually tapped through 1099 wells (Table 8 and Figure 11). Twenty-five percent of the wells are extracted for domestic use; however the majority of wells (73%) do not have a known designated use. These "unknown" use designations most likely refer to private wells, which would typically be used for domestic or irrigation (Graham 2006). However, this knowledge gap presents a significant challenge for those making water management decisions. Withdrawals are not just limited to the mainstem, most major tributaries are subject to extraction as well (Table 9). Appendix 1 and 2 provide a more detailed breakdown of surface water license and well use information in the watershed.

Table 7. Breakdown of surface water licenses (points of diversion) in the Little Campbell River watershed (Source: Water Atlas BC http://srmapps.gov.bc.ca/apps/wrbc/ 2006)

Use Type	Number of Licenses	Total Licensed Volume (Potential total = 3511.05 m^3/day)	% of Total Volume
Irrigation	27	1713.29	48.80%
Frost Protection	1	1182.79	33.69%
Conservation[1]	1	978.74	n/a
Watering	4	213.51	6.08%
Fire Protection	8	122.34	3.48%
Land Improvement	18	109.22	3.11%
Livestock Watering	1	59.42	1.69%
Domestic	19	56.07	1.61%
Nurseries	1	54.07	1.54%
Unknown	6	0.00	0.00

[1] Water is cycled through salmon hatchery system then re-inputted into channel downstream, therefore volume is not included in potential total extraction

Table 8. Breakdown of well use in the Little Campbell River watershed (Source: Water Atlas BC http://srmapps.gov.bc.ca/apps/wrbc/ 2006)

Use Type	Number of Wells	Total Allowed Volume (m^3/day) (Potential total = 94,276.33 m^3/day)	% of Total Volume
Unknown	797	52226.96	55.40%
Domestic	276	36088.46	38.28%
Municipal	8	2943.22	3.12%
Irrigation	3	1418.00	1.50%
Commercial/Industrial	8	1136.41	1.21%
Community Water Supply	3	354.28	0.38%
Other	3	109.01	0.12%
Observation	1	0.00	0.00%

Table 9. Distribution of water use by drainage unit within the Little Campbell River watershed

Little Campbell River Watershed			Surface Water Demand (Number of POD's)		Groundwater Demand (Number of Wells)	
Sub-watershed	**Local & Mainstem watersheds**	*Associated tributaries*	**86 known** Total Licensed Volume **= 26,890.61 m^3/day**		**1099 known[2]**, Potential Total Volume = **94,276.33 m^3/day**	
East Sub-watershed	MS-1	*Kerfoot Creek*	7	7	165	165
Langley Sub-watershed	LW-1	*Unnamed north (214th St.)*	25	0	627	38
	LW-2	*Unnamed south (210th St.)*		1		34
	LW-3	*Jacobson Creek*		1		122
	LW-4	*Highland Creek, Jenkins Creek*		5		55
	MS-2			18		378
Surrey Sub-watershed	LW-5	*East Twin Creek, West Twin Creek*	44	12	229	57
	LW-6	*Sam Hill Creek, Thomson Creek*		5		30
	LW-7	*Kuhn Creek, Theodore Creek*		5		76
	MS-3			22		66
West Sub-watershed	LW-8	*Fergus Creek, Murray Creek*	10	8	76	59
	LW-9	*McNally Creek*		0		7
	MS-4			2		10

[2] Two unidentified wells fall on the border between sub-watersheds and therefore have not been recorded

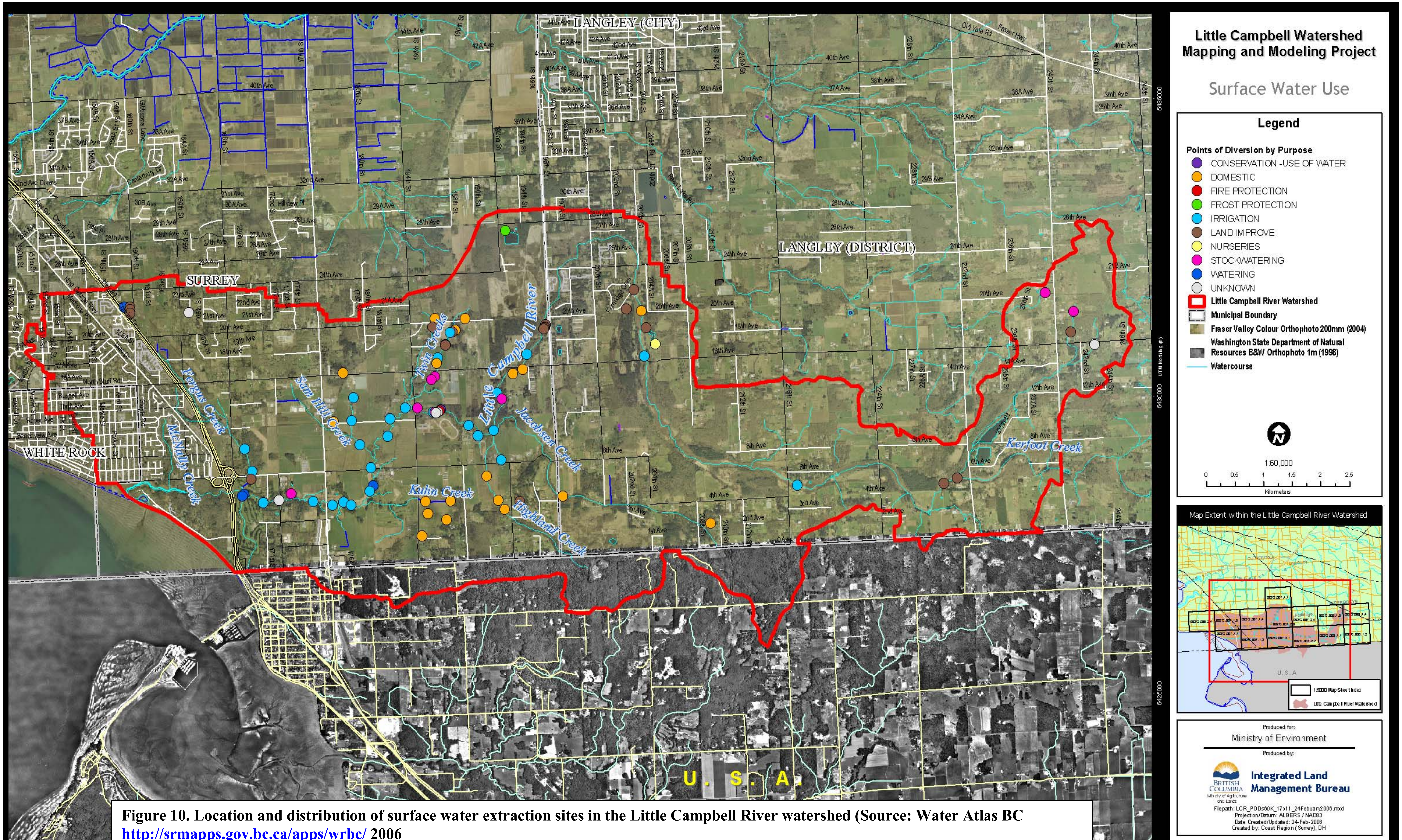

Figure 10. Location and distribution of surface water extraction sites in the Little Campbell River watershed (Source: Water Atlas BC http://srmapps.gov.bc.ca/apps/wrbc/ 2006

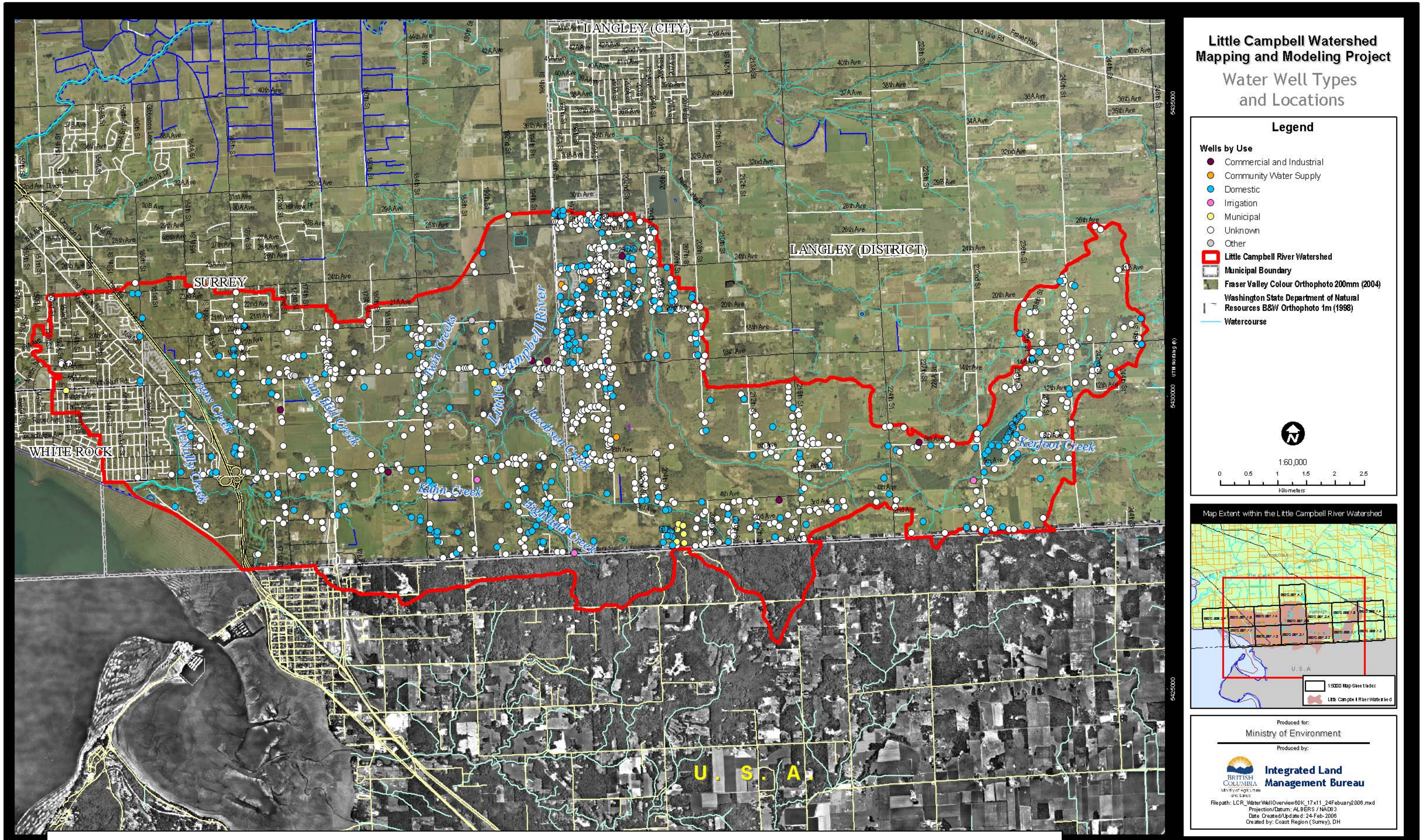

Figure 11. Location and distribution of well extraction sites in the Little Campbell River watershed (Source: Water Atlas BC http://srmapps.gov.bc.ca/apps/wrbc/ 2006

2.1.1 Agricultural Uses:

In the Fraser Valley Region where much of the commercial agriculture cannot thrive without irrigation, water shortages have occurred due to seasonal periods of reduced precipitation and stream flow (Golder & Associates 2003)

In the Little Campbell River watershed, there are 30 known extraction locations for irrigation and they constitute the largest demand of surface water extractions, almost 50% of total volume (1713.29 m^3/day). Along with irrigation, livestock watering is also a component of agriculture extraction and depending on the type and densities of livestock in question, demand can be significant (Table 10). Frost protection represents the second highest form of agricultural water demand; however extraction occurs during winter, when precipitation naturally replenishes channel flow. Both irrigation and livestock watering reach their peak extraction levels during the summer, coinciding with summer low flows. Combined with additional water uses, also corresponding to summer low flows, it is not surprising that the river mainstem has been reported to go down to a trickle or even dry in the lowlands during some years (Riley 2006).

Table 10. Estimated average daily water consumption for livestock in US gallons/day (Source: MAL 2006)

TYPE OF ANIMAL	DESCRIPTION	US GPD	TYPE OF ANIMAL	DESCRIPTION	US GPD
BEEF			SWINE (with wash water)		
cow with calf *	1,300 lb	12	farrow - finish	--	24 / sow
dry cow/mature cow *	1,300 lb	10	farrow - late wean	50 lb	8 / sow
calf *	250 lb	3	farrow - early wean	15 lb	6.5 / sow
feeder – growing **	400-800 lb	6 - 9	feeder	50 - 250 lb	2 / pig
feeder – finishing **	600-1,200 lb	9 - 12	weaner	15 - 50 lb	0.6 / pig
bull	–	12	POULTRY		
DAIRY			broiler	per 100	4.2
milking * (with wash water)	holstein	36	roaster/pullet	per 100	4.8
dry cow/replacement	holstein	12	layer	per 100	6.5
calf	to 550 lb	3.5	breeder	per 100	8.5
SHEEP AND GOATS			turkey - grower	per 100	15.5
ewe/doe	–	2.5	turkey - heavy	per 100	19
milking ewe/doe	–	3.5	OSTRICH	--	1.2
feeder lamb/kid	–	2	DEER, LLAMA, ALPACA	--	2.5
BISON, HORSE, MULE	–	12	ELK, DONKEY	--	6

* For peak water use on days above 25^0 C multiply gpd by 1.5

** For peak water use on days above 25^0 C multiply gpd by 2

In reviewing the estimated livestock densities (Section 3.2.2.3), the potential amount of water that could end up being taken by livestock is 9,447.80 m^3 per day (Table 11). Not all farms use surface extraction, while undocumented some groundwater wells may also be used as a water supply for livestock.

Table 11. Potential water demand for livestock groups in the Little Campbell River Watershed (based on maximum livestock densities from Table 16, Section 3.2.2.3)

Livestock Type	Estimated Number of Animals	Volume (m^3/day)[3], Total potential extraction = 9,447.80 m^3/day
Llamas/Alpacas	220	2.1
Sheep/Goats	560	5.3
Beef Cattle	901	34.1
Dairy Cattle	450	61.3
Horses	5121	232.6
Poultry	450,000	9,112.4

Extraction for agricultural use can have a significant impact on the very users that depend upon it. As surface water demand exceeds capacity and creates severe draw down conditions, pollutants and contaminants normally diluted can become concentrated or surpass guideline levels. Combined with warm temperatures pathogens such as fecal coliform increase, leading to sources potentially becoming a hazard for livestock (MAL 2006).

Use of contaminated surface water sources for irrigation can also pose a health risk. Fecal coliform is especially an issue where vegetable and berry crops, which are typically eaten raw, are irrigated with water that potentially carries human or livestock wastes (MOE 2006, Payette 2006-In Review). Produce can then become contaminated with pathogens, such as cyclospora or shigella, which can cause gastrointestinal disease in humans. Such pathogens are transmitted through food or water contaminated by human/animal feces. Investigations indicate that outbreaks of food borne illnesses associated with fresh fruits and vegetables have increased in Canada over the last several years (CFIA 2001).

Irrigation demand from groundwater sources can also have affects on soil quality. As water tables drop during low recharge periods leaching of salts, metals and nutrients like nitrates and phosphorus into wells can reach unacceptable concentrations (Golder & Associates 2003). Soils then become unusable for crop production.

[3] converted from USG in Table 21

2.1.2 Domestic Water Uses:

Aquifers and their groundwater resources are the major source of domestic water supply for residents and businesses in south Surrey and the southwest portion of the Township of Langley. The actual impacts of well extraction however are difficult to calculate as there is no recording mechanism to determine exact use rates on a well to well basis. What can be estimated however, is the average amount of water used per day based on the number of domestic wells, and the average use of 1 m^3 per household per day (Environment Canada 2004). The majority of the properties within the watershed is not serviced by GVRD water supply, and therefore we can assume that they contain a well or POD for domestic use on-site.

Similar to concerns over water quality for livestock, contamination of domestic water supplies especially groundwater is beginning to pose increasing risk to health and safety. In May of 2000 seven people died and twenty three hundred people became ill in the town of Walkerton, Ontario because the drinking water became contaminated with pathogenic bacteria. This tragedy cost the government of Ontario $65 million to conduct the inquiry; the loss of life and suffering is estimated at an additional $91 million with costs totaling more than $156 million (Burke 2006). The amended Drinking Water Protection Act and regulations came into force on May 16, 2003, replacing the Safe Drinking Water Regulation under the Health Act. Elevated levels of nitrate in excess of the Canadian Drinking Water Quality Guideline of 10 mg/l, have been found in a significant number of domestic wells in the Langley area (MOE 2001). Elevated nitrate and other organic toxins can have toxic effects on humans, livestock, wildlife and aquatic organisms.

According to the Ministry of Environment, several of Langley's aquifers are now considered vulnerable, insofar as their water levels or levels of contamination may be matters of increasing concern (MOE 2001). In 2001 and 2002, there was a total of 17 Boil Water Advisories issued in the Township of Langley, of which 5 still remained in effect at the end of 2002. Water quality is a particular concern for the large number of residents drawing their water from private wells, most of whom live in rural areas where they may be subject to contamination from on-site sewage disposal systems and/or intensive agriculture.

As a local example in 2004 the GVRD had to shut down its well source for the East Area offices on 16th Avenue in Langley due to potential contamination from a nearby septic field (Harrison 2006). The analysis performed on the parks water samples showed that of a total 53 samples were taken prior to water system upgrades 9 showed total coliform positive samples (17% of all samples) and 1 fecal reported, which is not in compliance with the provincial regulations. The detection of the one E-coli bacteria triggered notification of the system users of fecal contamination in the water supply. A Boil Water Advisory (BWA) was issued in consultation with the Health Authority. As upgrades to the system proceeded, the BWA remained in effect until the new system was in. Upgrades to the water system included a new well, some new waterlines, UV disinfection and chlorination. Following completion of the upgrades, the system performed in total compliance with the standards of the Provincial Drinking Water Protection Act (GVRD 2004).

2.1.3 Fish and Wildlife:

There is increasing urgency to secure water for the long-term benefit of wildlife, particularly in light of the increasing demand for consumptive use of water. Most wildlife species depend upon wetlands, lakes, rivers, and riparian habitats at some point in their life cycles. Degradation of habitat can be a consequence of failing to ensure adequate water for wildlife. Habitat and species loss may be due to changes in water quantity or quality, salinity, flow rates, temperature, seasonal flow patterns, or groundwater levels. These changes may also facilitate the establishment of non-native species (UC Davis 2005).

While a driving factor in this study has been issue surrounding shellfish harvesting and recovery, the watershed supports a considerable population of ecologically sensitive and commercially important fish and wildlife species, including steelhead salmon. As such, it provides an important regional resource for recreational angling as well as naturalist activities (Miller 1979). Over allocation and subsequent lack of water availability during critical life phases can impact fish and wildlife resources through direct mortality. It can also have significant affects on recreational angling that is reliant on fishery resources.

While the watershed is considered very high in respect to fisheries productivity, summer flows are inadequate and well below 20% of mean annual discharge - natural summer 7-day mean low flow is 4% of MAD and domestic irrigation and industry water demand is 70% of MAD resulting in some sections going dry in the summer months (Georgia Basin Steelhead Recovery Plan 2005). Such flow perturbations severely affect the Little Campbell's fishery resources as well as benthic (substrate) organisms that drive fisheries food chains in coastal watersheds. Areas of useable habitat become reduced, fish become stranded and passage to cooler more stable headwater areas is impeded. As well rising temperatures and decreasing oxygen levels create lethal environment for endemic coldwater dependent aquatic life (Drever 1999).

There is a gap in knowledge as to how groundwater extraction and decreased aquifer capacity is affecting stream flows. The watershed and the aquatic life it supports are completely dependent upon groundwater recharge to sustain surface flows during low precipitation periods. If groundwater resources are depleted to the extent of no-flow or anoxic conditions in surface waters, reoccurring fish kills will likely result.

Little information is available on impacts of low flows and degraded water quality to terrestrial wildlife or various ecosystems in the Little Campbell River watershed. Water quality, quantity, and flow timing can all have an effect on habitats other than flowing waters such as wetlands. Wetlands in the Little Campbell River watershed support hundreds of species, including waterfowl and other birds, fish, amphibians, and invertebrates. As well, in some areas within the watershed wetlands are used for processing stormwater or sewage drain water (Sec. 4.1). This water may not only be substandard in its quality, but the quantity can be erratic in volume and timing having direct affects on the fish and wildlife resources that utilize it.

2.1.4 Recreation:

Clean, safe water resources are equally important for recreational use. Whether for sport or relaxation, health or pleasure, maintaining safe recreational waters requires a concerted effort from all stakeholders. In the Little Campbell River watershed and Semiahmoo Bay area several recreational sectors ranging from kayaking to angling are dependent on water quality and water quantity objectives being met. While no detailed statistics are presently available, both the public and businesses are impacted from loss of recreational opportunity as well as loss of revenue when closures or fish kills happen (Zatwarnitski 2006).

Repercussions of degraded watershed health are not just limited to aquatic recreational opportunities. The Little Campbell estuary is part of a significant flyway and winter feeding area for waterbirds (FSBS 2003). Wildlife viewing is a considerable recreational activity in the watershed and bay (M. Cuthbert 2006). As food chains in the watershed become impaired from increased contamination and decreased water availability, wildlife dependent on benthic organisms, shellfish and other food organisms are impacted.

Other uses such as canoeing, kayaking and swimming can also be significantly impacted by NPSP events and fluctuating water volumes, especially where they occur frequently or are of such a duration as to limit activities. The Little Campbell estuary and Semiahmoo Bay afford a valuable local opportunity for kayaking and ecotourism (Zatwarnitski 2006). As well the City of White Rock hosts an annual sailing regatta in the Bay every spring as part of an effort to attract tourists during off-season periods (City of White Rock 2005).

Beach closures are put into effect when coliform levels indicate potential health hazards to both humans and domestic pets. This may occur after heavy rains when overland flow and stormwater flush fecal matter from pets, wildlife, failing septic systems and livestock into the watershed. Local tourism operations are dependent on the opportunities that the Little Campbell and the Bay provide, and more importantly the condition of the watershed. Patrons and the public who come to the Little Campbell and White Rock to explore and enjoy its natural amenities notice algal blooms, pollution events and associated odours. Loss of visual clarity of the waters in the estuary and Bay correspond to lost opportunities and public concerns of safety – all transferring into direct and potential loss of revenue for marine dependent businesses (Zatwarnitski 2006).

2.2 Assessment of Water Use Management - Areas of Concern:

The Little Campbell River watershed was first identified as fully subscribed in 1959. While new licenses were issued in the 1960's, the system has continually been subject to low flow perturbations and is now considered to be over-subscribed (Ptolemy 2006). The highest level of sensitivity to low flows occurs in August, often when the system is most dependent on groundwater recharge to maintain base flows. This time period is also when demand for water for irrigation, domestic use and livestock watering may also be at their peak. (Rood and Hamilton 1997). Regardless of the nature of water demand there is little question that impacts have and will continue to occur. Work commissioned by the Township of Langley (Golder and Associates 2005) has approximated that since 1960 post development impacts to groundwater resources have potentially resulted in a loss of up to 4% of base flows for the Little Campbell River watershed. The study also predicted that a further 5% loss in base flows could potentially be expected if land use transition from rural to urban and associated population growth as outlined in the official community plan continues (Dixon-Warren 2006).

Primary surface water uses in the Little Campbell River watershed revolve around irrigation (highest at 1713.29 m^3/day), frost protection (2^{nd} highest at 1182.79 m^3/day and watering (3^{rd} highest at 213.51 m^3/day). Domestic licenses constitute 22% of surface water rights (at 56.07 m^3/day). With respect to how surface diversions are distributed amongst the various drainage units in the Little Campbell River watershed (Table 9) the Surrey and Langley sub-watersheds carry the greatest burden, with local/mainstem watersheds MS-2, MS-3 and LW-5 having the largest number of POD's.

Groundwater use follows an opposite pattern with combined domestic use topping the list over irrigation. At present municipal water line servicing has been focused in the LW- 8 and 9 drainage units. This corresponds to areas of newer, higher density land use (Baron 2006). Interestingly, while full municipal sanitary servicing is still being considered too costly an upgrade to invest in by many residents (except where subsidies are available, see Section 3.2.1.2 Municipal Sanitary Infrastructure), municipal water improvements are very much supported. This appears tied to increasing instances where individual health risk is at stake from nitrate (and elsewhere arsenic) contamination to drinking water supplies. In the case of sanitary systems and potential fecal coliform impacts to drinking water supplies, it is not being perceived by many residents as an immediate threat and subsequently they are less willing to invest in the necessary infrastructure (Baron 2006).

Surface diversion and groundwater extraction do appear to have a correlation in the Surrey (44 POD's, 229 wells) and Langley (25 POD's and 627 wells) sub-watersheds. This central area of the watershed has the highest number of surface licenses and wells. While there is some variability at the local/mainstem watershed level, MS-2 which overlays the Brookswood aquifer appears to have highest concentration of wells (378) and second highest number of POD's (18). Other areas of the watershed such as LW-3 and MS-1 which overlay several aquifers (Brookswood, South of Hopington and the Boundary aquifer) may also be potential areas of concern as they too have notable concentrations of POD's and wells.

The relationship between water use and availability in the Little Campbell River watershed remains a major knowledge gap. The Township of Langley is the only municipality in the watershed that has undertaken an extensive groundwater protection program, and has attempted to model the actual water balance of demand

and capacity of specific aquifers. What their studies concluded is that the level of error and the lack of information on actual number of wells and extraction rates precluded an ability to identify how much stress is being placed on their aquifers. This has had some positive repercussions however. They may in the future be undertaking a detailed census of groundwater use within their municipal borders and become the first municipality in BC to instate a groundwater management plan (Dixon-Warren 2006). While this study has been able to identify the amount of water potentially extracted from surface and ground sources, the actual timing of extraction and the extent to which users exceed capacity is largely unknown. Adding to this, well use in BC is still presently somewhat unregulated though this hopefully will change as the various phases of the Ground Water Protection Regulation come into force (http://www.env.gov.bc.ca/wat/gws/gws_reg_back/back.html). At present detailed assessments of aquifer capacity at any given time in the watershed continue to remain inconclusive.