4.0 WATER REGION # 2 - LITTLE QUALICUM

4.1 Regional Overview

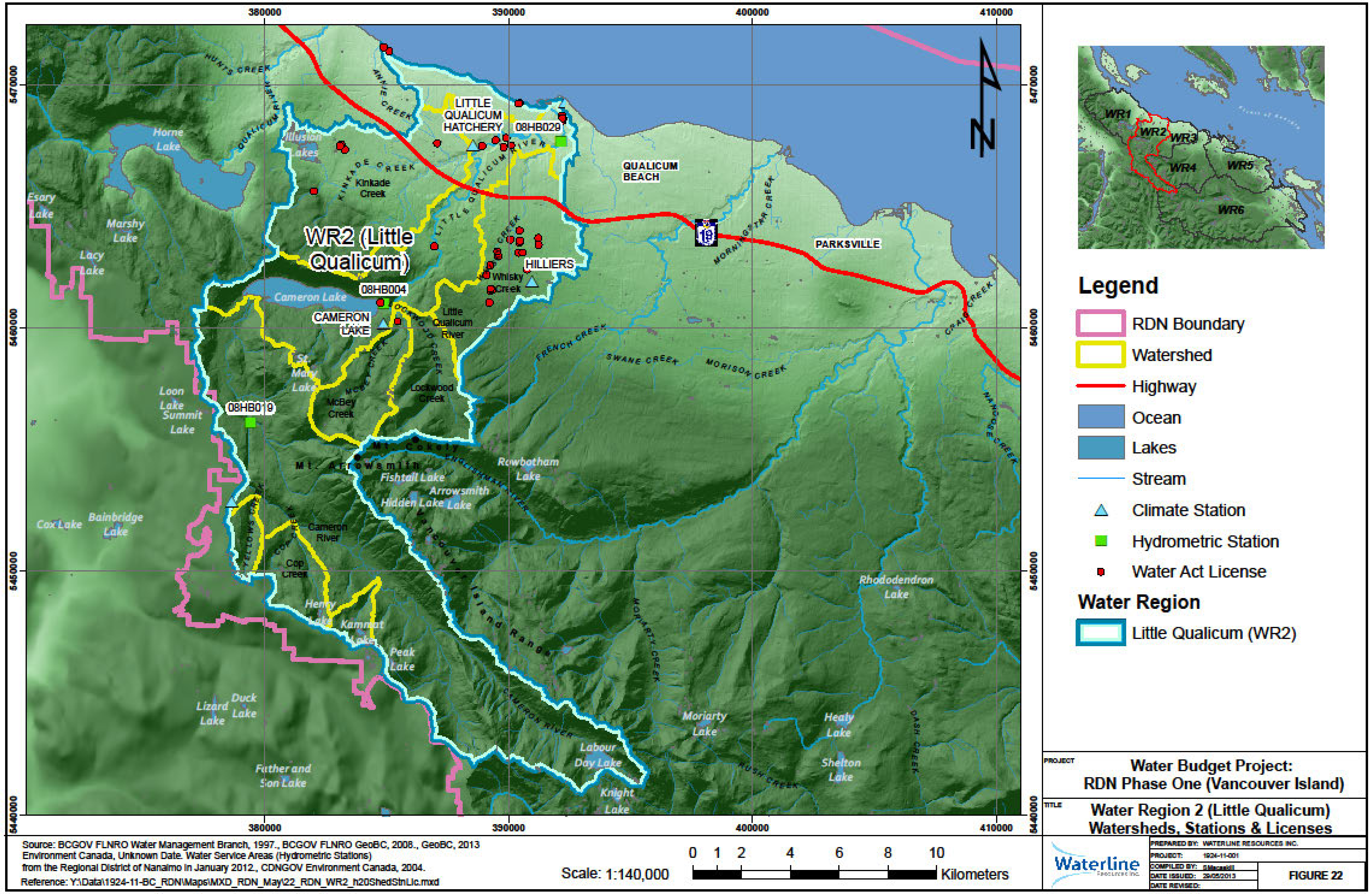
The Little Qualicum water region (WR2 (LQ)) is defined as the area extending from the coast to the headwaters of the Cameron River in the southeast of the water region (Figure 22). It is the fourth largest water region within the RDN covering an area of approximately 259 km^2. The region includes major watersheds as listed in Table 11. The largest watershed is associated with the Little Qualicum River with an estimated drainage area of 251.7 km^2. Cameron Lake is also a major surface water feature within WR2 (LQ). Two hydrometric stations, six climate stations, and approximately 42 surface water diversion points exist within the region (Figure 22 and Table 11).

Table 11: WR2 (LQ) - Watersheds, Wells and Surface Water Licenses

Total Water Region Area	*** 259 km^2**
Major Watersheds	**Drainage Area[1] (km^2)**
Kinkade Creek (tributary to Little Qualicum River)	39.6
Whisky Creek (tributary to Little Qualicum River)	26.8
McBey Creek (tributary to Little Qualicum River)	11.5
Lockwood Creek (tributary to Little Qualicum River)	14.3
Cameron Lake/River (tributary to Little Qualicum River)	111.8
Little Qualicum River (including tributaries)	251.7
Wells and Surface Water Diversion Points	**No.**
# Water Wells listed in MOE DB	387
Surface water diversion licenses	42

Note: Drainage Areas are based on 1:50,000 BC Watershed Atlas. *The total water region area includes area that drains directly into the ocean and is not part of a major watershed. Little Qualicum Watershed Drainage Area is the area to the mouth and includes all tributary areas.

According to the MOE Wells Database (BCGOV ENV Water Protection and Sustainability Branch, 2008) WR2 (LQ) has the 3rd lowest number of water wells (387 wells) of the six water regions in the RDN. The MOE database likely only represents a fraction of the actual wells currently in use. Many well records may not have been entered into the database and some wells may simply not be in use or have been abandoned. As there is no mandatory requirement for submitting well logs or well abandonment records, it is not possible to determine the groundwater demand from private wells with any degree of certainty, nor is it possible to assess the vulnerability that may exist with improperly abandoned or standing water wells.



Source: BCGOV FLNRO Water Management Branch, 1997., BCGOV FLNRO GeoBC, 2008., GeoBC, 2013
Environment Canada, Unknown Date. Water Service Areas (Hydrometric Stations)
from the Regional District of Nanaimo in January 2012., CDNGOV Environment Canada, 2004.
Reference: Y:\Data\1924-11-BC_RDN\Maps\MXD_RDN_May\22_RDN_WR2_h20ShedStnLic.mxd

Figure 22: WR2 (LQ) – Watersheds, Hydrometric/Climate Stations & Licenses

4.2 Surface Water Assessment

4.2.1 Topography and Land Use

The Little Qualicum Water Region (#2) is located in the northern section of the Regional District of Nanaimo, between Big Qualicum and French Creek. Approximately half of the region is within the Nanaimo Lowlands, the other half lies within the Vancouver Island mountain range.

The region lies along the course of the Englishman River which rises up to Mount Arrowsmith (1,819) near the headwaters. Mount Arrowsmith lies within a UNESCO Biosphere Reserve and Mt. Arrowsmith Regional Park. The majority of the watershed lies within privately managed forest lands with the headwaters in Crown Forest Lands. The lower portion of the water region is rural development with agricultural and low density residential development. A small commercial/light industrial area is located near Hilliers within the Whiskey Creek watershed.

The most significant water feature in the region is the Little Qualicum River and Cameron Lake. Most of the mountainous watersheds in the water region drain to the northwest towards Cameron Lake. The Little Qualicum River flows to the north east from Cameron Lake into the Strait of Georgia. Two smaller lakes in the Kinkade Creek watershed, Ilusion Lakes and Spider Lake, do not have outflow and are thought to flow into the Kinkade Creek watershed through groundwater paths. The major watersheds in the region from north to south are shown in Figure 22.

4.2.2 Climate

The climate for the Little Qualicum Water Region is similar to the rest of the RDN with cool wet winters and mild dry summers. The climate varies significantly between the mountainous and low-lying areas of the region. The low-lying area has a typical rainfall record as the other coastal with an average total annual precipitation for the 1971 to 2000 Climate Normal Period of 1098.5 at the Little Qualicum Hatchery (Figure 23). This compares with recorded average total annual precipitation of 1,162.7 mm at the Nanaimo Airport. The mountain regions typically get precipitation as snow during the winter, providing snowmelt in the late spring. A snow course at Mt. Cokely (03B02A) (Figure 22), operated by the River Forecast Centre, has a long period of manual snowpack records between February and May (1980-Present). The average April 1st SWE recorded at Mount Cokley is 864 mm and the maximum recorded SWE is 2,100 mm on April 1st 1999. Climate station locations are shown on Figure 22.

Maps showing the distribution of annual precipitation and average annual temperature over the water region are shown in Figure 24 and Figure 25, respectively. These maps show the influence of the Mount Arrowsmith and Vancouver Island mountains on precipitation and temperatures compared to the warmer, low-lying coastal areas of Little Qualicum. Total precipitation amounts in coastal areas are typically between 1,000 to 1,500 mm per year while up to 5,000 mm of precipitation per year is likely in the mountainous headwaters near Mt. Arrowsmith.

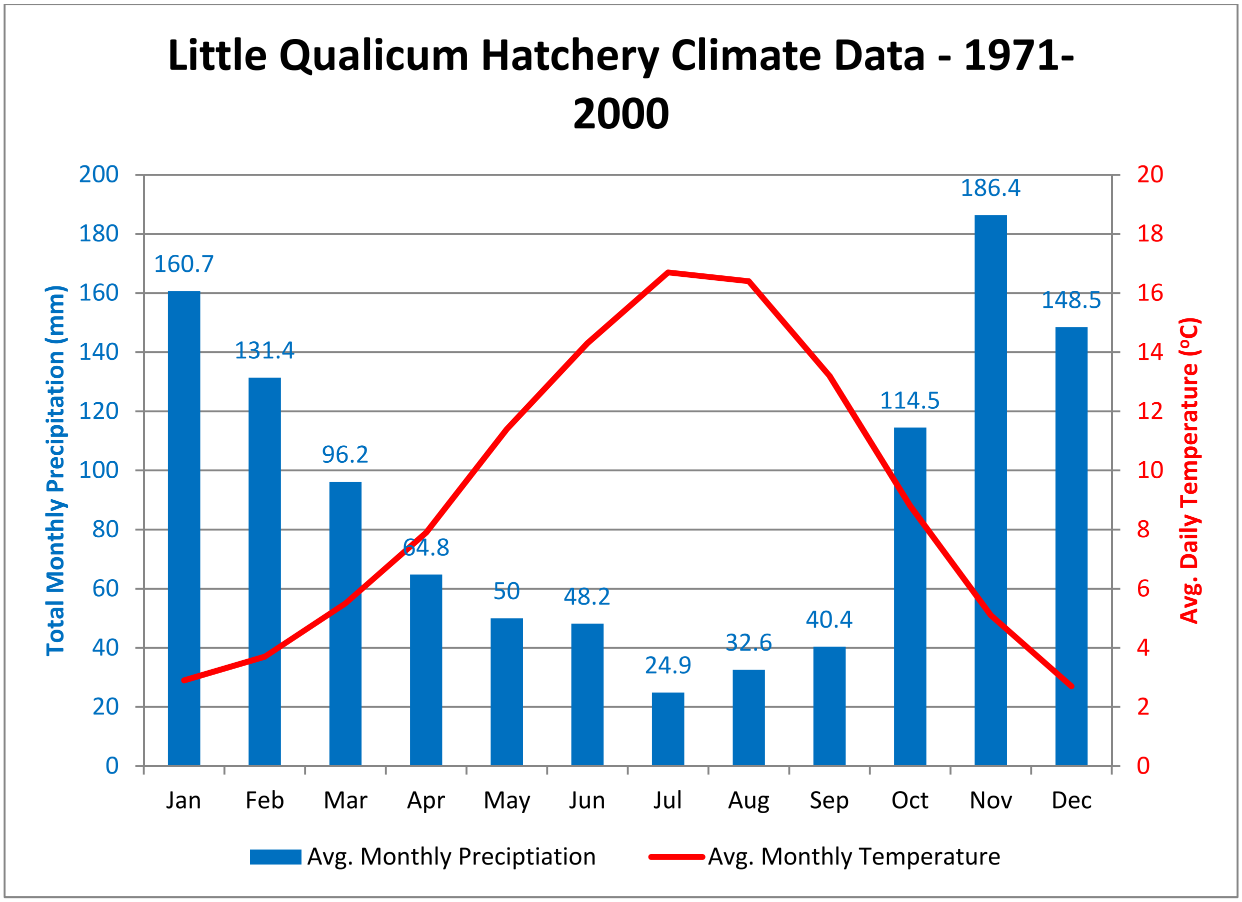
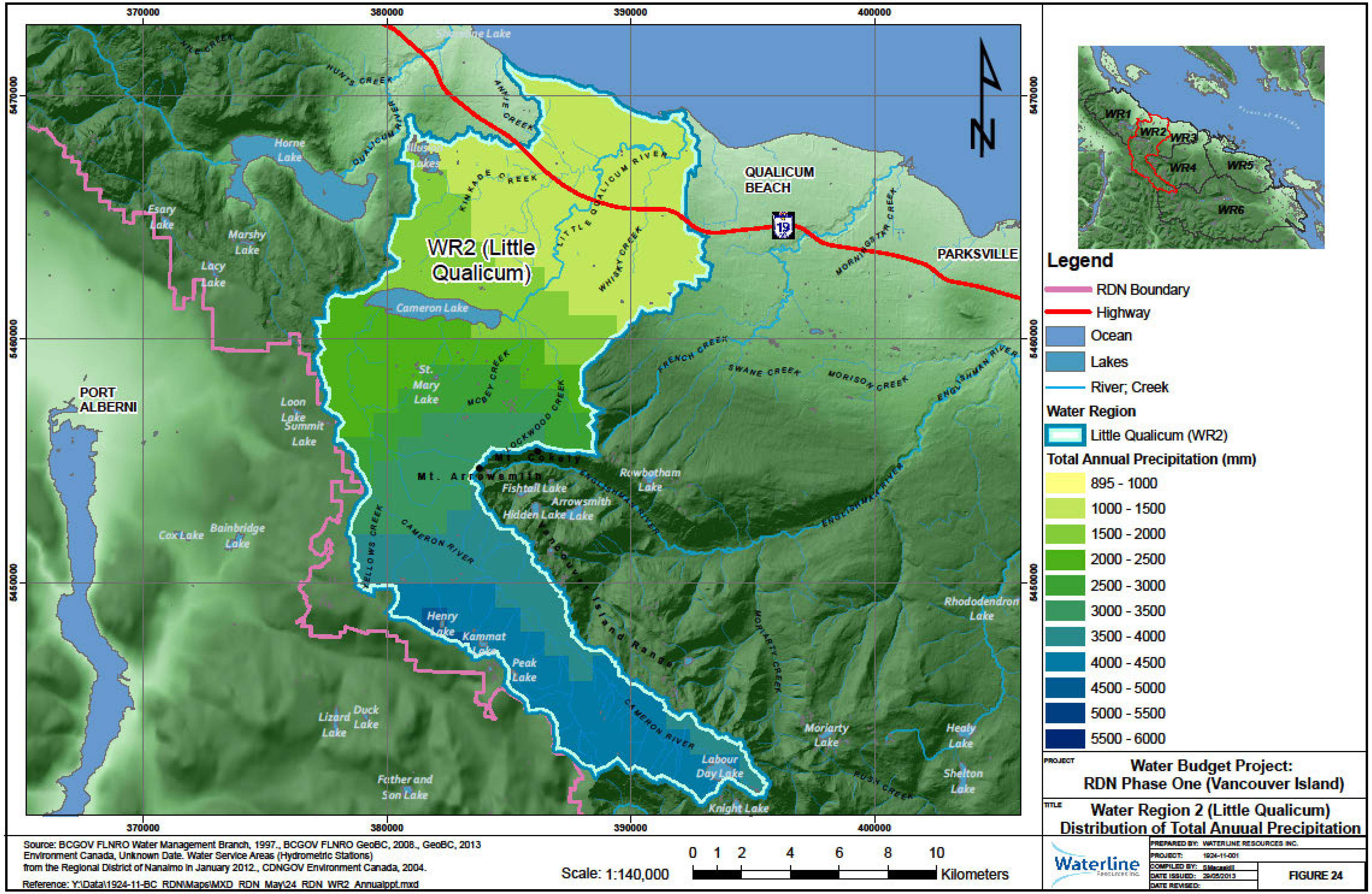


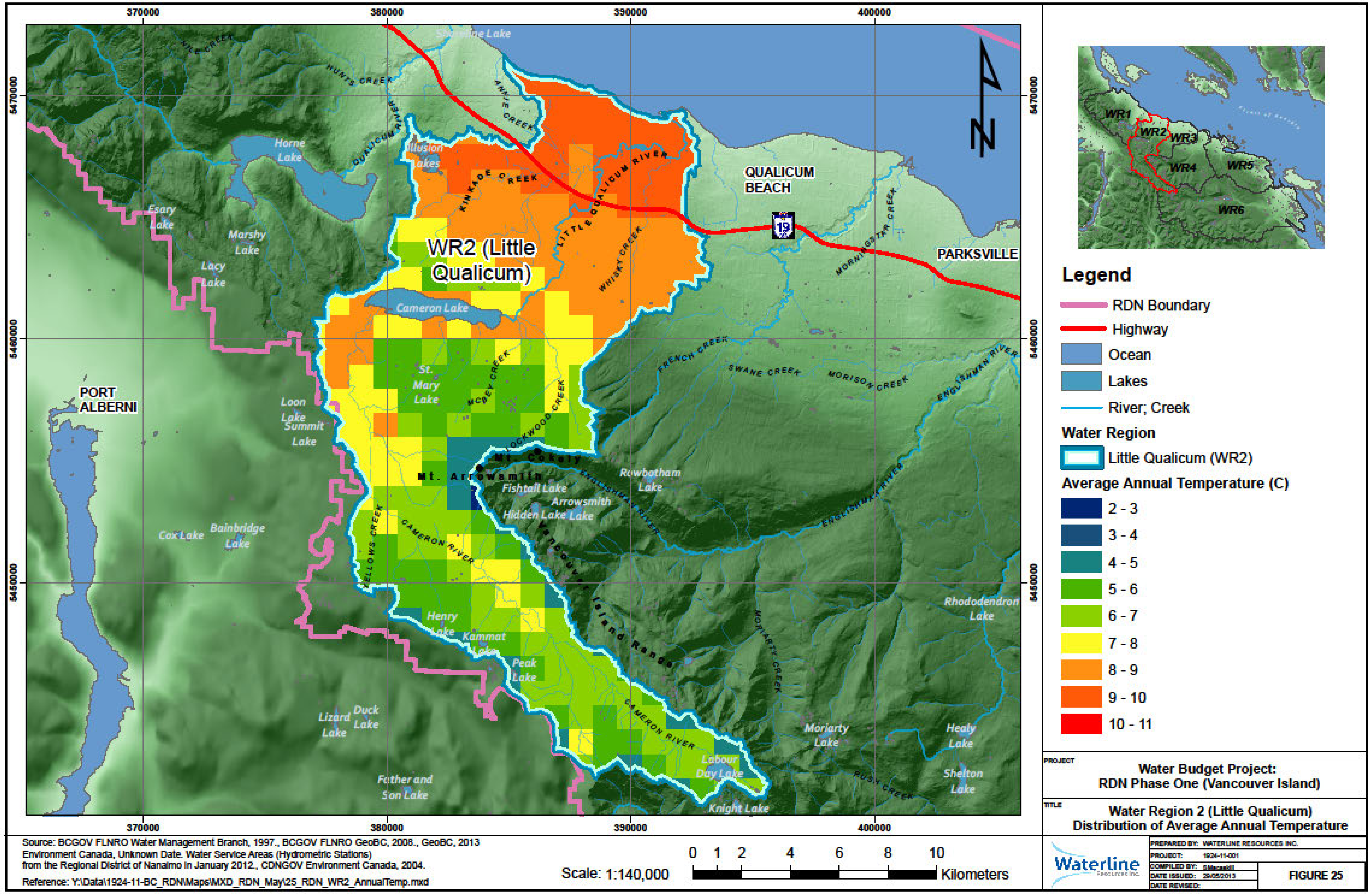
Figure 23: WR2 (LQ) – Little Qualicum Hatchery Monthly Climate (1971-2000 Normal)



Source: BCGOV FLNRO Water Management Branch, 1997., BCGOV FLNRO GeoBC, 2008., GeoBC, 2013
Environment Canada, Unknown Date. Water Service Areas (Hydrometric Stations)
from the Regional District of Nanaimo in January 2012., CDNGOV Environment Canada, 2004.

Reference: Y:\Data\1924-11-BC_RDN\Maps\MXD_RDN_May\24_RDN_WR2_Annualppt.mxd

Figure 24: WR2 (LQ) – Distribution of Total Annual Precipitation



Source: BCGOV FLNRO Water Management Branch, 1997., BCGOV FLNRO GeoBC, 2008., GeoBC, 2013
Environment Canada, Unknown Date. Water Service Areas (Hydrometric Stations)
from the Regional District of Nanaimo in January 2012., CDNGOV Environment Canada, 2004.

Reference: Y:\Data\1924-11-BC_RDN\Maps\MXD_RDN_May\25_RDN_WR2_AnnualTemp.mxd

Figure 25: WR2 (LQ) – Distribution of Average Annual Temperature

4.2.3 Stream Gauging and Monitoring

Two Water Survey of Canada stations are located within the Little Qualicum Water Region. Table 12 lists the names of the hydrometric stations are located in the WR 2 (LQ) and they are shown on Figure 22.

Table 12: WR2 (LQ) – Water Survey of Canada Records

Station Name (WSC Number)	Period of Record	Natural or Regulated	Drainage Area to Gauge (km^2)	Mean Annual Discharge (m^3/s) and Volume (million m^3)	Mean Summer Discharge (m^3/s) and Volume (million m^3)
Little Qualicum River (08HB029)	1960 to 1986	Regulated since 1978	237	11.9 m^3/s 375.7 million m^3	3.1 m^3/s 24.4 million m^3
Little Qualicum at Cameron L. (08HB004)	1913 to 2001	Regulated since 1978	135	8.8 m^3/s 276.6 million m^3	2.4 m^3/s 19.0 million m^3

Note: 1 – Summer Period Jul to Sep (three lowest average months)

In addition to the records outlined above, a lake level gauge has been operated on Cameron Lake since 1978. The records indicate that lake levels fluctuate approximately about 1.0 m on average but have a maximum recorded range of 3.4 m.

Flows in the Little Qualicum River are controlled by a weir at the outlet of Cameron Lake. Hydrographs showing monthly average flows in the river before and after regulation are shown in Figure 26 and Figure 27.

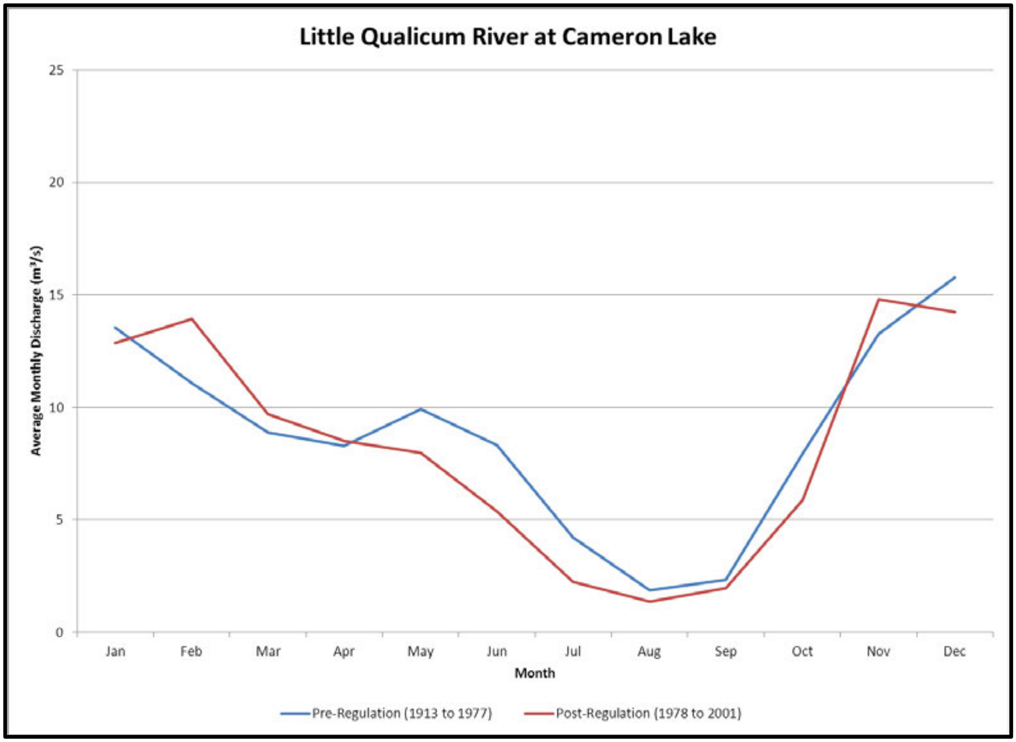


Figure 26: WR2 (LQ) – Little Qualicum River at Cameron Lake

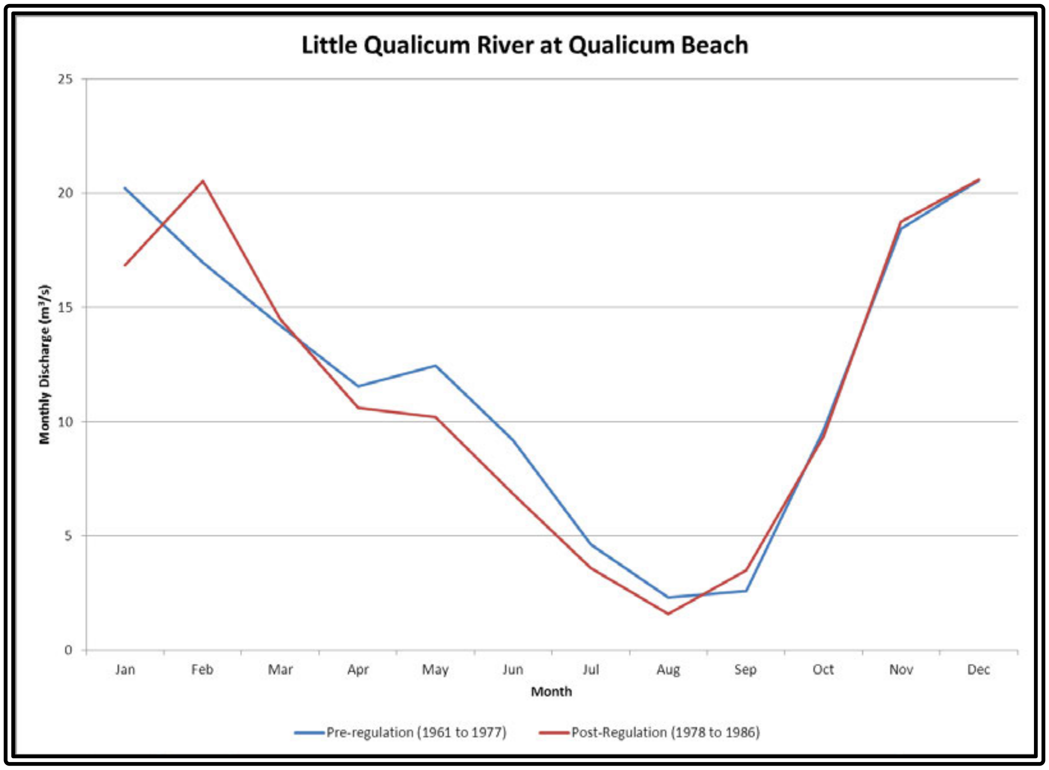


Figure 27: WR2 (LQ) – Little Qualicum River at Qualicum Beach

4.2.4 Hydrology and Surface Water Resources

The hydrological model has provided estimates of average available surface water resources for the major watersheds in the region for the year and the summer (Table 13).

Table 13: WR2 (LQ) – Available Surface Water Resources (Avg. for 1971 to 2000 period)

Watershed	Drainage Area[1] (km^2)	Mean Annual Discharge (m^3/s) and Volume (million m^3)	Mean Summer Discharge (m^3/s) and Volume (million m^3)	Previous Estimate of MAD (m^3/s)
Kinkade Creek	39.6	1.1 m^3/s 35.2 million m^3	0.04 m^3/s 0.3 million m^3	
McBey Creek	11.5	0.9 m^3/s 27.9 million m^3	0.2 m^3/s 1.2 million m^3	
Lockwood Creek	14.3	0.9 m^3/s 29.9 million m^3	0.1 m^3/s 0.8 million m^3	
Whisky Creek	26.8	0.8 m^3/s 24.1 million m^3	Less than 0.1 m^3/s	0.7 m^3/s
Cameron River	111.8	11.5 m^3/s 362.6 million m^3	1.8 m^3/s 14.5 million m^3	
Little Qualicum River	251.7	17.2 m^3/s 543.2 million m^3	2.4 m^3/s 18.9 million m^3	11.8 m^3/s

Note: Drainage Areas are based on 1:50,000 BC Watershed Atlas.

4.2.5 Surface Water Demand

Table 14 summarizes the surface water licences in WR2 (LQ) from the BC Surface Water Licence Database. The locations of the surface water licences for WR2 (LQ) are shown on Figure 22. Not all license locations can be seen at this scale as many are in close proximity and plot over each other.

Table 14: WR2 (LQ) – Surface Water Demand (m^3)

Type of Demand	Monthly	Annual	Summer (Jul-Sept)
Consumptive Demand			
Agriculture	8,446	101,352	76,010
Domestic	1909	22,912	7,561
Industrial	477	5,728	1,432
Institutional	-	-	-
WaterWorks	41,414	496,967	163,999
Total Consumptive	52,246	626,954	249,002
Non- Consumptive Demand			
Power	-	-	
Conservation	3,439,584	41,275,008	10,318,752
Total Non-Consumptive	3,439,584	41,275,008	10,318,752

Table 15: WR2 (LQ) – Licensed Surface Water Storage (m^3)

Type of Storage	Annual
Storage	1,233
Conservation Storage	4,631,717
Other Storage	215,378
Total Storage	4,848,329

The largest licensed water user in WR2 (LQ) is the Department of Fisheries and Oceans to maintain conservation flows in the Little Qualicum River and to supply the Little Qualicum Fish Hatchery. These flows are supported by storage at Cameron Lake which is controlled by a dam. The total licensed storage on Cameron Lake is 6,280,229 m^3.

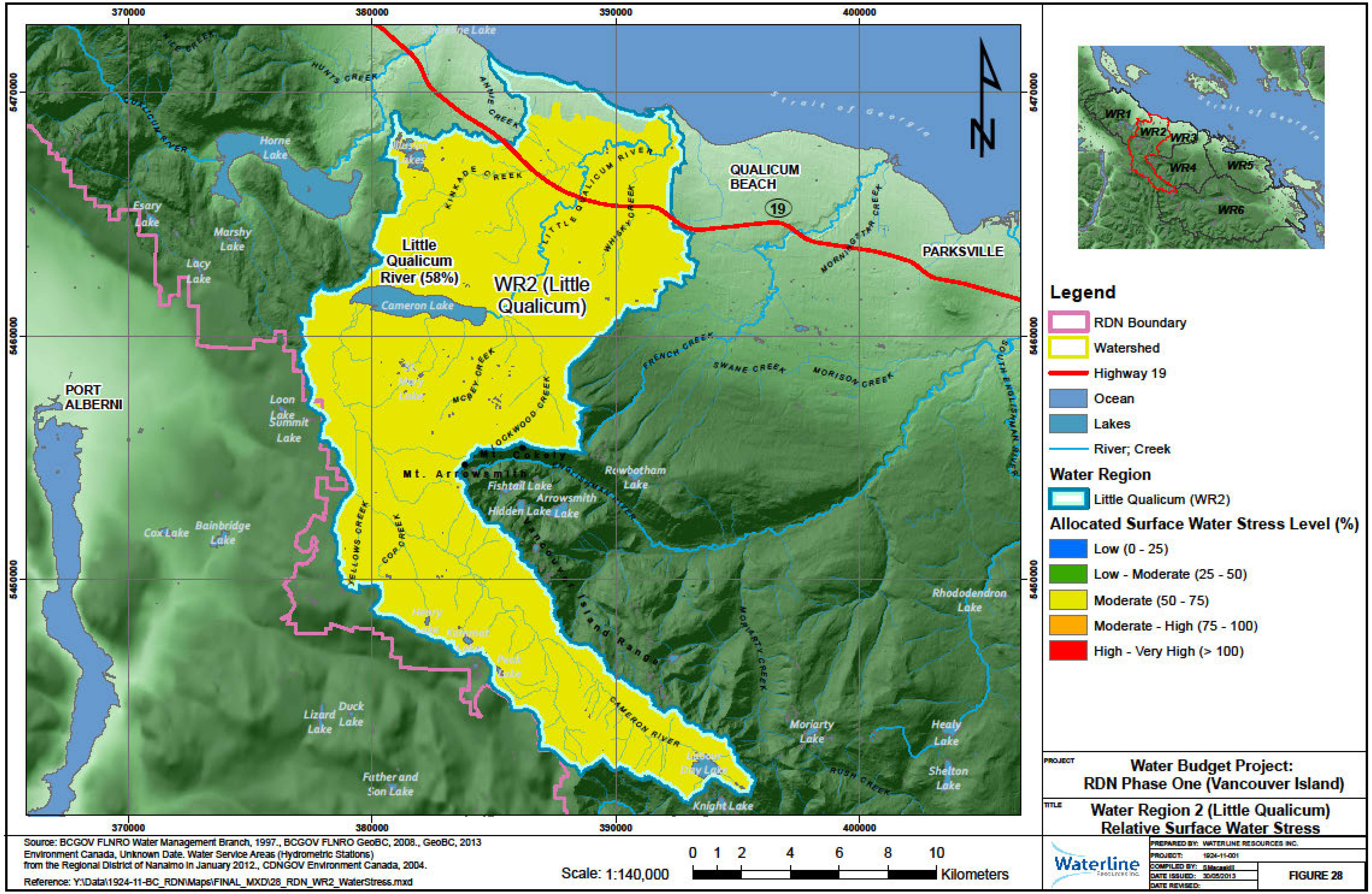
4.2.6 Surface Water Stress Analysis

As outlined in Section 2.5.2, a surface water stress analysis for the Little Qualicum River watershed has been completed. Water budget analysis for other smaller ungauged subwatersheds within WR2 (LQ) should be completed when data is available and as part of a more detailed Tier 1 or Tier 2 water budget assessment (OMNR 2011). The results of the stress analysis for the watersheds in WR2 (LQ) are shown in Table 16. A map showing the relative stress for each watershed is shown in Figure 28.

Table 16: WR2 (LQ) – Surface Water Stress Analysis

Watershed	Average Natural River Flow Supply (million m^3)	Storage (million m^3)	Conservation Flow (10% of MAD) (million m^3)	Licensed Demand (million m^3)	Allocation Stress	Stress Level
Little Qualicum River	18.89	4.85	13.46	0.20	58%	Moderate

Notes: Volumes indicated in the table are average volumes for summer period (Jul to Sep). Average natural river flow is the estimated or recorded unregulated flow in the watershed. Total storage is based on licenced storage volume and assumes all storage is available to support conservation flow and licenced demand for the Jul to Sep period. The 10% of Mean Annual Discharge (MAD) conservation flow is based on current Ministry of Forest, Lands and Natural Resource Operations (MELP 1996) minimum conservation flow policies for the east coast of Vancouver Island. Licenced demand is the total licenced volume for summer based on consumptive water licences. Allocation stress = (Average Natural supply + storage) / (Conservation Flow + Licenced Demand) Surface water stress color codes: : blue=low, green =low to moderate, yellow =moderate, brown =moderate to high, red=high to very high. Values reflect average flow conditions and do not consider drought years.



Source: BCGOV FLNRO Water Management Branch, 1997., BCGOV FLNRO GeoBC, 2008., GeoBC, 2013
Environment Canada, Unknown Date. Water Service Areas (Hydrometric Stations)
from the Regional District of Nanaimo in January 2012., CDNGOV Environment Canada, 2004.

Reference: Y:\Data\1924-11-BC_RDN\Maps\FINAL_MXD\28_RDN_WR2_WaterStress.mxd

PROJECT
Water Budget Project:
RDN Phase One (Vancouver Island)

TITLE
Water Region 2 (Little Qualicum)
Relative Surface Water Stress

PREPARED BY: WATERLINE RESOURCES INC.
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DATE ISSUED: 30/05/2013
DATE REVISED:

FIGURE 28

Figure 28: WR2 (LQ) – Relative Surface Water Stress

4.3 Groundwater Assessment

4.3.1 Existing Groundwater Studies and Data

Given the regional scale of the Phase One Water Budget Assessment, the most important data compiled and geo-referenced by Waterline was the water well information, elevation data, soil and geology maps, land cover, aggregate resource map, mapped aquifers, and water service areas. Other maps were generated using the input data as part of Waterline's work and some samples are provided in Appendix C for illustration purposes (Eg: overburden thickness (Map C7), piezometric contour maps (Maps C8 and C9), air temperature (Map C14), precipitation (Map C15), runoff (Map C16 and C17), evapotranspiration (Map C18), infiltration (Map C19), Water Service Areas (Map C20), and Water Demand Assessment in Non-service areas (Map C21). All of these maps are provided in Appendix C for the entire RDN study area with an explanation of how the map was geo-reference or created by Waterline. These data and layers are now available in the ARC GIS Geodatabase at the RDN Scale, water region scale, watershed scale, on other local scale needed for site specific assessments. These data will be provided to the RDN in electronic format as part of the ARC GIS Geodatabase system which was constructed by Waterline for use by the RDN. These regional datasets form the framework for construction of the conceptual hydrogeologyical model.

Although only some of the data in certain reports may have been incorporated into Waterline's Geodatabase, the primary studies in the region were used in Waterline's water budget assessment to provide local hydrogeological context are provided in Table 17.

Table 17: WR2 (LQ) – Hydrogeology Reference Reports

Author	Year	Study Title
EBA Engineering Consultants Ltd	2003	Drinking Water Protection Plan – Mt. Arrowsmith Watersheds
EBA Engineering Consultants Ltd	2005	Mt. Arrowsmith Final Aquifers Modeling Projects, Parksville Area
Lowen Hydrogeology Consultants	2010	Arrowsmith Water Service Englishman River Water Intake Study Groundwater Management. Discussion Paper 5-1. Existing Groundwater Supply Evaluation and Aquifer Yield Assessment, Prepared by Dennis Lowen, Alan Kohut and Bill Hodge, January 25, 2010.

4.3.2 Description of Aquifers and Water Wells

Four unconsolidated aquifers have been mapped within WR2 (LQ) (Figure 29). Table 18 provides a summary of information on mapped aquifers within WR2 (LQ). Quadra sand and Kame Delta aquifers (662, 661, & 663) have been mapped as moderate productivity, whereas the Salish Aquifer 664 has been mapped as highly productive (BCGOV ENV Water Protection and Sustainability Branch, 2012). The Quadra sand aquifers (662 and 217) are confined with low vulnerability, while the unconfined Salish (664) and Kame Delta (661 and 663) aquifers are described as highly vulnerable. Kame aquifer 661 in the vicinity of Spider Lake appears to be hydraulically connected to the lake and experiences up to 5 m seasonal fluctuations in water level. The GSC drilling program conducted in March 2013 has confirmed that the Kame Delta aquifer (661) is perched and limited in extent (Paradis, Pers. Comm., 2013).

The majority of supply wells are completed along the coast in unconsolidated Quadra sand and gravel aquifers (Figure 29). As there are no regulatory requirements in BC to submit wells logs to MOE for capture in the Wells Database, the water wells shown on Figure 29 likely represents only a fraction of wells actually drilled.

Table 18: Summary of Mapped Aquifers in WR2 (LQ)

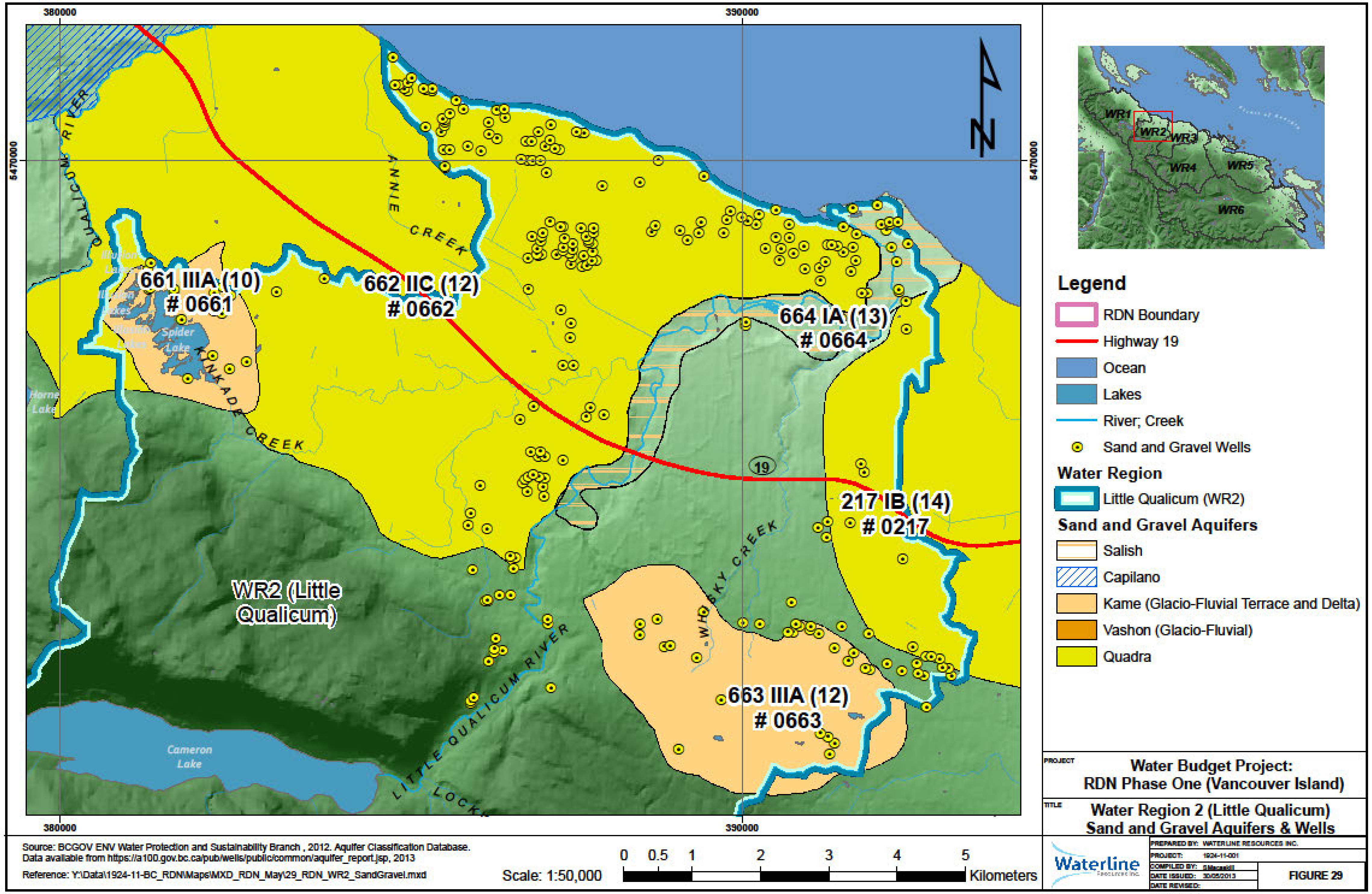
Aquifer Tag No.	Aquifer Name/ Lithology	Location Within Water Region	Potential Groundwater-Surface water or Aquifer to Aquifer Interaction	Developed Aquifer surface Area	Confined, Semi, or unconfined, Aquifer Vulnerability Code	Yield
				(m^2)		(L/M/H)
662	Quadra	Extends from BQ, connected to Kame 661	Ocean, LQ, Aq. 661	2.84E+07	Confined , IIC	M
661	Kame	Along LQ, Springs towards Kinkade Creek	Spider LK, Horne?	9.63E+06	Unconfined, IIIA	M
664	Salish	Lower LQ	Ocean, LQ	4.96E+06	Unconfined, IA	H
663	Kame (Vashon Gf) top of Whiskey Creek	Upper Whisky Creek at border with WR3 (FC)	Whiskey Creek, LQ	9.63E+06	Unconfined, IIIA	M
217	Quadra	Below Kame and Above Haslam 220	LQ and Ocean	6.02E+06	Confined , IB	M

Notes: A/B/C is high/moderate/low vulnerability, I/II/III is heavy/moderate/light use, H/M/L means high/medium/low productivity/yield. All aquifer classification parameters, codes and yield are defined at the following MOE web address http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/aquifers/Aq_Classification/Aq_Class.html#class

4.3.3 Groundwater-Surface Water Interaction - Conceptual Hydrogeological Model

A conceptual hydrogeological model of each aquifer with WR2 (LQ) was developed in order to understand the key elements and linkages between surface water and groundwater systems required to complete the water budget assessment. Although conceptual hydrogeological model developed by Waterline includes numerous cross-sectional views developed within the Waterline Geodatabase, only one 3D view into the subsurface is presented for WR2 (LQ).

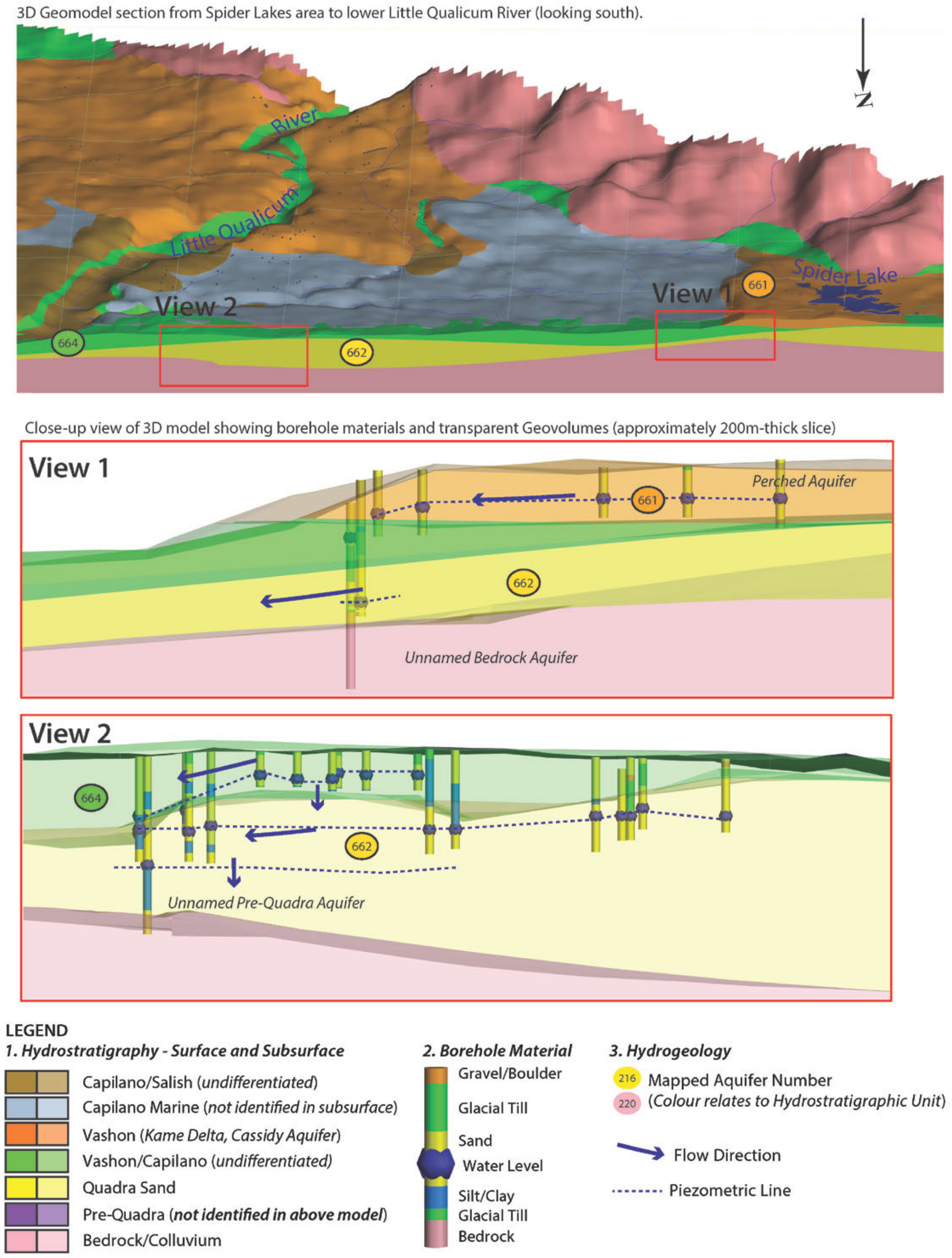
Figure 30 shows a 3D block diagram illustrating the relationship between surface and subsurface geology in WR2 (LQ) where major water supply aquifers have been mapped. The schematic shows two cross-sectional views: one in the Spider Lakes area and one where mapped overburden aquifers intercept the Little Qualicum River.



Source: BCGOV ENV Water Protection and Sustainability Branch , 2012. Aquifer Classification Database.
Data available from https://a100.gov.bc.ca/pub/wells/public/common/aquifer_report.jsp, 2013

Reference: Y:\Data\1924-11-BC_RDN\Maps\MXD_RDN_May\29_RDN_WR2_SandGravel.mxd

Figure 29: WR2 (LQ) – Sand and Gravel Aquifers and Wells


3D Geomodel section from Spider Lakes area to lower Little Qualicum River (looking south).

Close-up view of 3D model showing borehole materials and transparent Geovolumes (approximately 200m-thick slice)

Figure 30: WR2 (LQ) – Hydrogeological Conceptual Model – Little Qualicum River

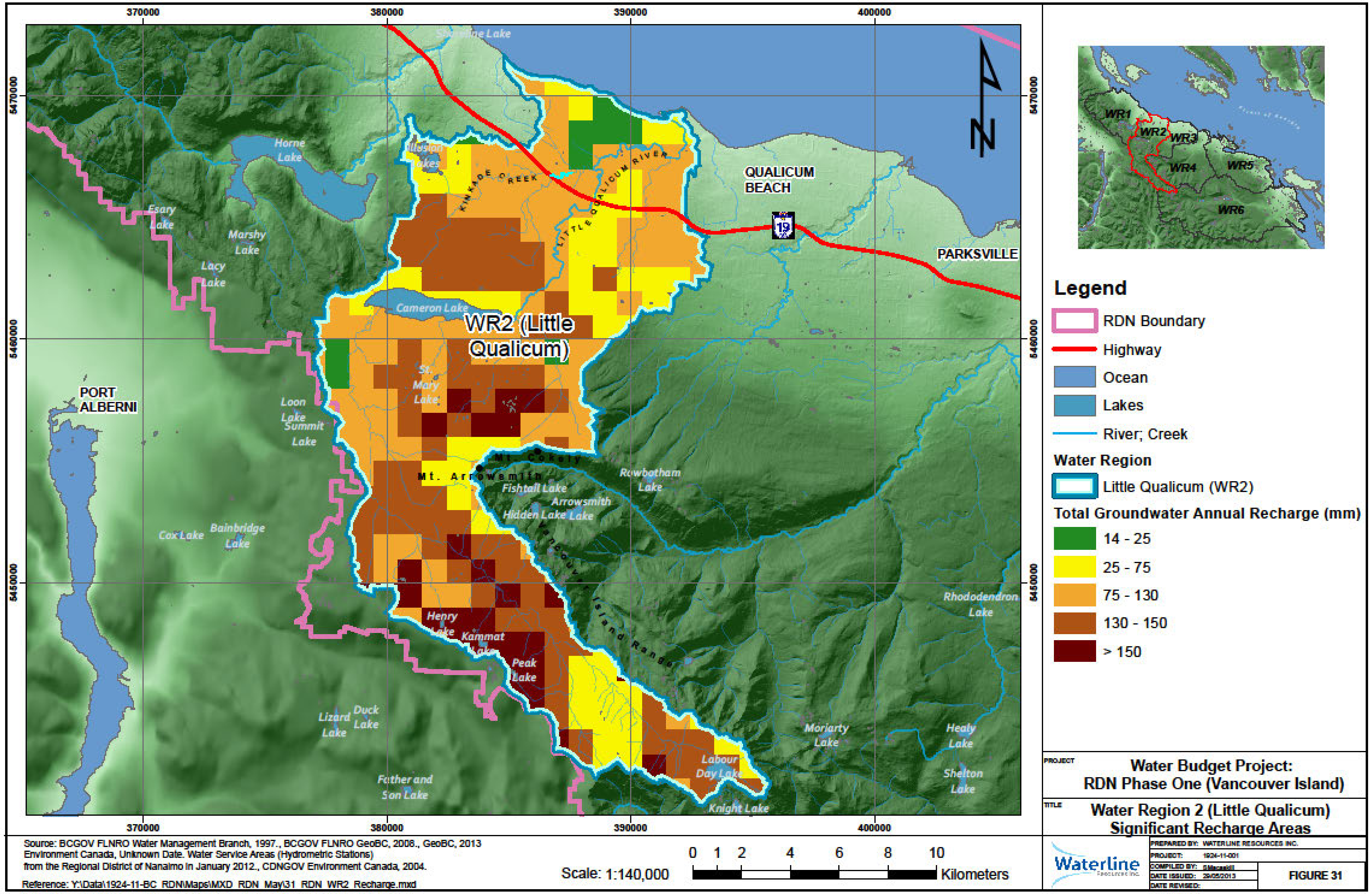
View #1 shows the subsurface view of the unconfined and perched Vashon aquifer (661) which is known to be directly connected to Spider Lake. Water levels in wells completed in the deeper confined Quadra sand aquifer (662) are considerably lower (deeper) than water levels in the overlying Vashon aquifer (661) suggesting disconnected or poorly connected flow systems.

View 2 shows the unconfined Capilano aquifer (664) overlying Quadra Sand Aquifer (662), overlying an unnamed bedrock aquifer (likely 220 found in the adjacent WR3). Water levels in wells completed in the deeper confined Quadra sand aquifer (662) are considerably lower (deeper) than water levels in the overlying Capilano aquifer (664) suggesting poor connection between the two flow systems. A component of groundwater flow in both the shallow and deep aquifers appears to be towards the Little Qualicum River Valley which illustrates the potential interaction with the river.

4.3.4 Significant Recharge Areas

Significant recharge areas within WR2 (LQ) were determined as part of the assessment of infiltration across the region base on topography, mapped textural soil characteristics, land cover (bare land, vegetation, impermeable surfaces), and leaf area index. These areas are important for maintaining recharge to aquifers and base flow to creeks and rivers. The preliminary assessment presented herein is based on the integration of numerous datasets which may be incomplete and therefore will require further field verification. Figure 31 shows significant recharge areas mapped in WR2 (LQ) as part of the water budget project.

Significant recharge areas extend to the upper reaches of WR2 (LQ) and into the upper reaches of Kinkade Creek. Many of the areas indicated are not well developed and others around Kinkade Creek are moderately developed. Spider Lake likely also represents a substantial recharge source for the Kame Delta aquifer (661). Future development planning needs to consider these areas to ensure that recharge continues to be maintained. There is a need to develop protection zones around critical areas contributing recharge to underlying aquifers to ensure the future sustainability of groundwater resources in this region. Better definition of these areas should be completed as the current modelling completed by Waterline and KWL was done on a 1 km square grid.



Source: BCGOV FLNRO Water Management Branch, 1997., BCGOV FLNRO GeoBC, 2008., GeoBC, 2013
Environment Canada, Unknown Date. Water Service Areas (Hydrometric Stations)
from the Regional District of Nanaimo in January 2012., CDNGOV Environment Canada, 2004.

Reference: Y:\Data\1924-11-BC RDN\Maps\MXD RDN May\31 RDN WR2 Recharge.mxd

PROJECT
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Significant Recharge Areas

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FIGURE 31

Figure 31: WR2 (LQ) – Significant Recharge Areas

4.3.5 Groundwater Level Monitoring – BC MOE Observation Well Network

Long-term water level monitoring data provides an indication of an aquifer's response to global, regional, and local environmental changes in climate, groundwater pumping, and the impacts (if any) of other activities related land development. Long-term records also allow for establishing hydraulic linkages between the groundwater and surface water systems.

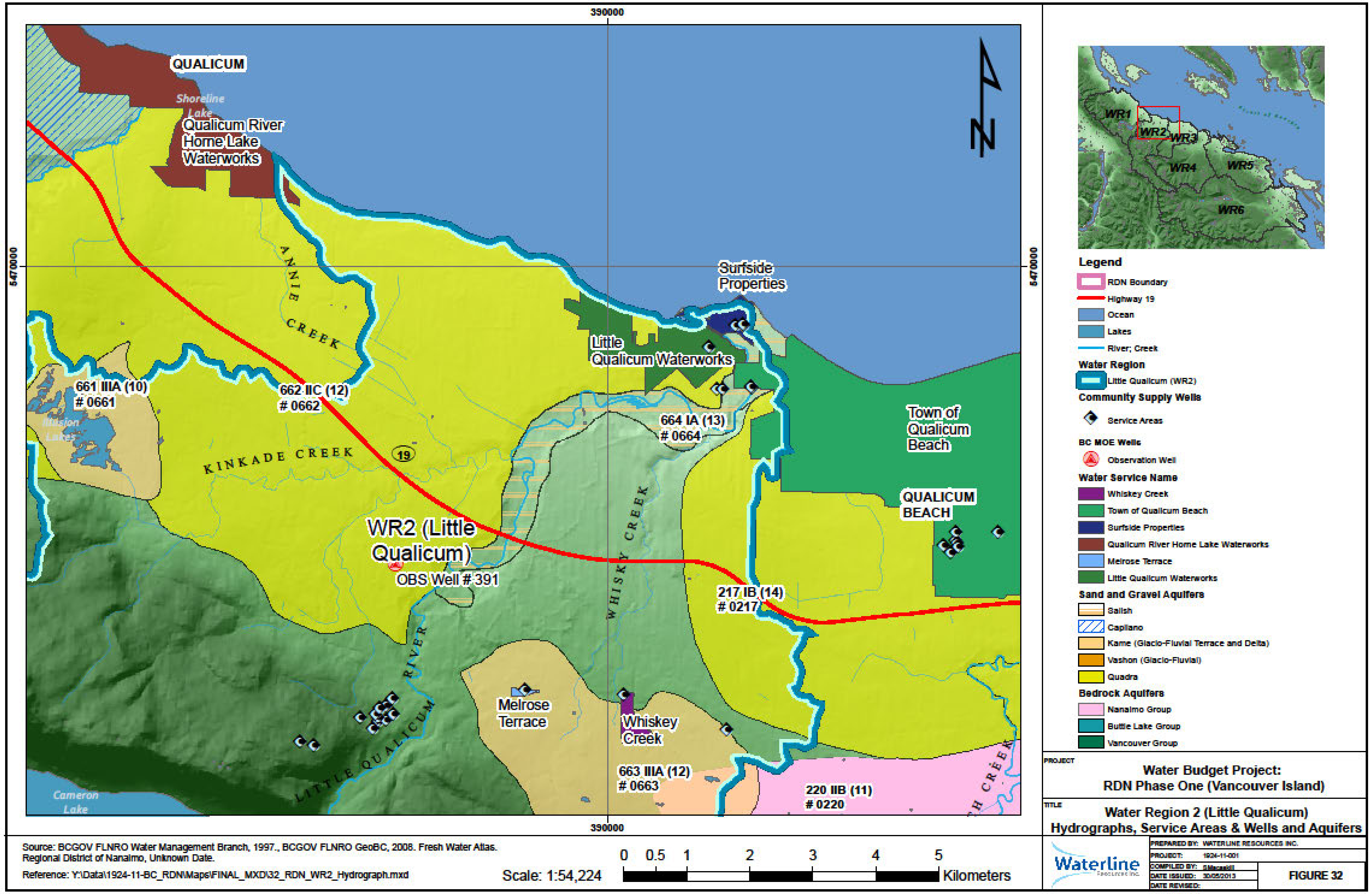
Figure 32 shows the locations of MOE observation wells and long-term water level monitoring records in relation to community water supply wells identified from the MOE Wells Database (E.g.: large municipal users, the RDN, private utilities wells). Although numerous community wells are listed in the database, Waterline understands that not all of these wells shown on Figure 32 are currently active.

One of the problems encountered by Waterline during the water budget project was that community well owners generally do not cross reference active production wells to respective well logs in the MOE database. Often wells are referred to by local names (E.g.: RDN well # 1, #2, etc…). As water budget calculations require that production wells be assigned to specific aquifers, it is important that cross-referencing with the MOE well logs be done. Well owners are encouraged to report the MOE Well tag number so that accurate water level and groundwater extraction volumes can be allocated to the corresponding MOE well log and mapped aquifer.

Figure 33 and Figure 34 show water level hydrographs for MOE Observation Wells 391 completed in Quadra aquifer 662, and 389 completed in the Salish aquifer 664 near the coast. Water levels in MOE Wells were plotted along with the Qualicum Beach Middle School precipitation record and the PDO trend where appropriate.

The record for MOE well 391 (Figure 33) is about one year and the water level trend follows the precipitation record. The record for MOE Well 389 (Figure 34) is a bit longer and shows that the water level in the aquifer follows precipitation with a 2-5 day delay.

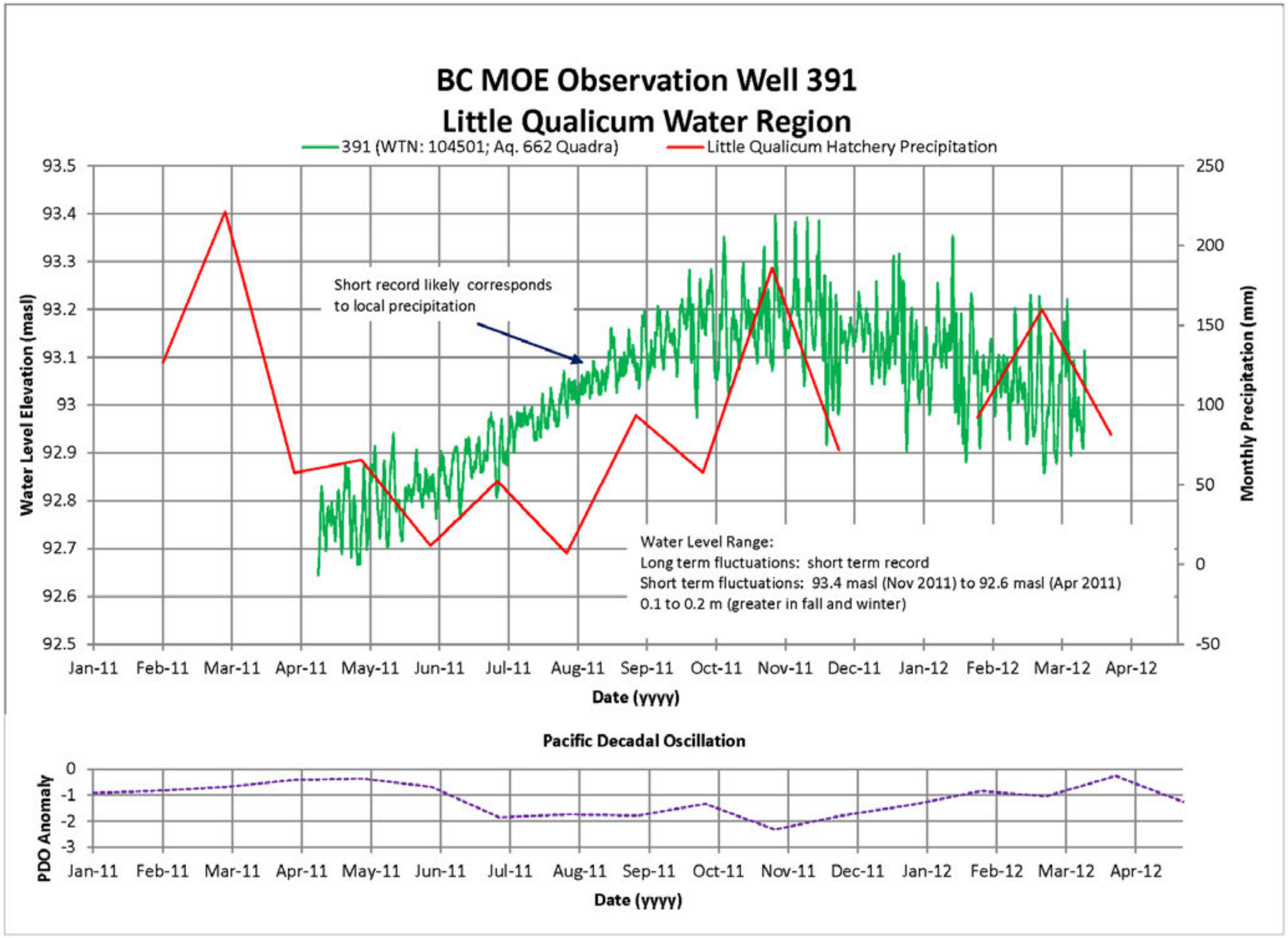
There is some indication that long-term climate variability (PDO graph) related to changes in sea surface temperature in the North Pacific (explained in 2.6.3) may result in a decline in precipitation and corresponding decline in aquifer recharge as the water level hydrograph for MOE well 389 generally follows the PDO trend (Figure 34).



Source: BCGOV FLNRO Water Management Branch, 1997., BCGOV FLNRO GeoBC, 2008. Fresh Water Atlas. Regional District of Nanaimo, Unknown Date.

Reference: Y:\Data\1924-11-BC_RDN\Maps\FINAL_MXD\32_RDN_WR2_Hydrograph.mxd

Figure 32: WR2 (LQ) – MOE Well Hydrographs, Service Areas & Wells, and Aquifers.



BC MOE Observation Well 391
Little Qualicum Water Region

Short record likely corresponds to local precipitation

Water Level Range:
Long term fluctuations: short term record
Short term fluctuations: 93.4 masl (Nov 2011) to 92.6 masl (Apr 2011)
0.1 to 0.2 m (greater in fall and winter)

Pacific Decadal Oscillation

Figure 33: WR2 (LQ) – Water Level Hydrograph BCMOE 391.

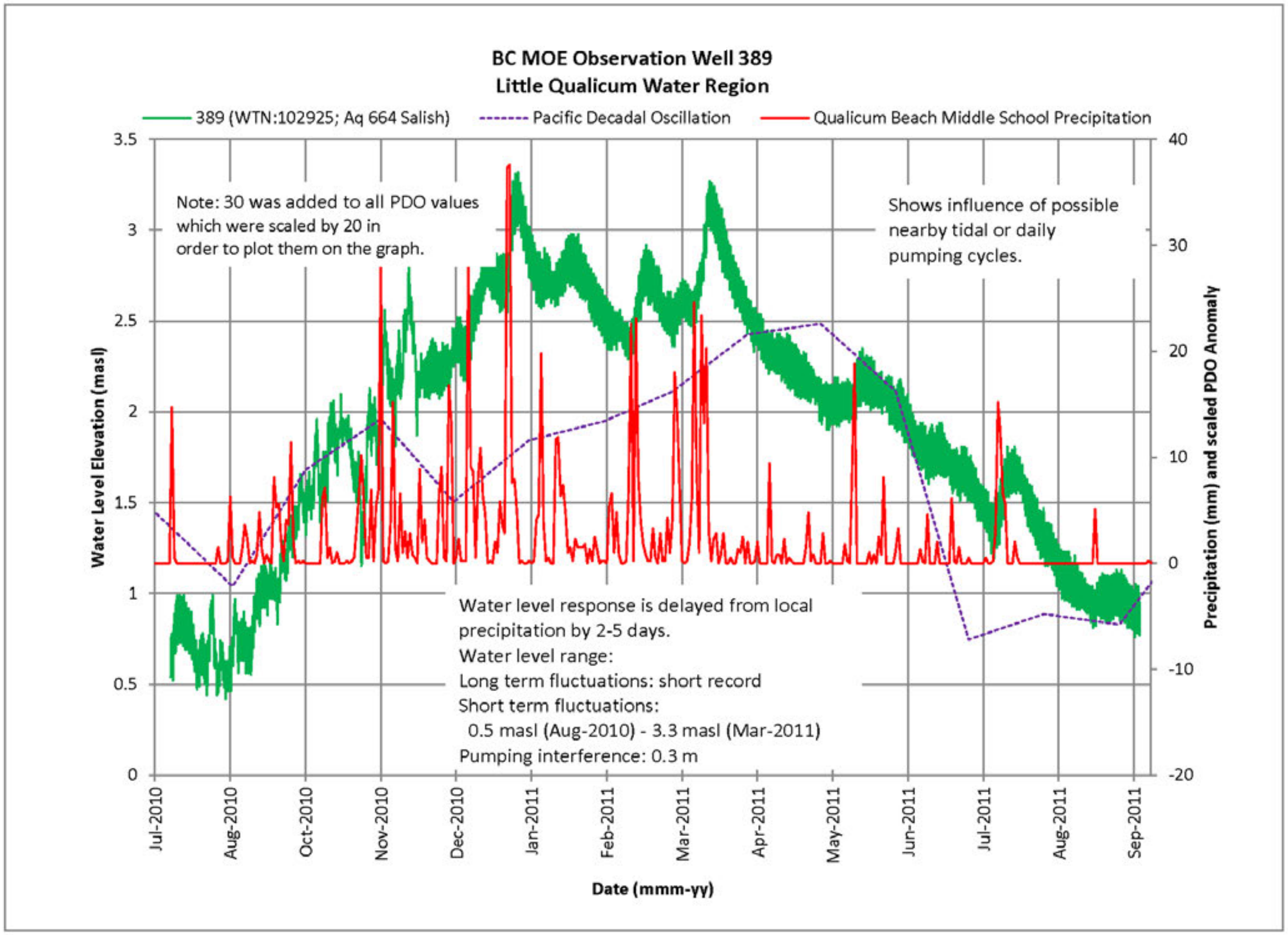


Figure 34: WR2 (LQ) – Water Level Hydrograph BC MOE 389.

4.3.6 Anthropogenic Groundwater Demand

Table 19 summarizes the available groundwater demand data available for WR2 (LQ).

Table 19: WR2 (LQ) – Summary of Anthropogenic Groundwater Demand Analysis

Aquifer Tag No.	Town of Qualicum Beach	RDN Surfside	RDN Melrose System	Whiskey Creek Water System	LQ River Village	Westerly Estates	Other Private Wells (From RDN Water Use Est. based on Zoning compiled on GIS)	Total Ground Water Use Estimate (ANTHout)
	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)
662	NA	NA	NA	NA	NA	NA	1.2E+06	1.22E+06
661	NA	NA	NA	NA	NA	NA	4.1E+04	4.13E+04
664	8.2E+05	1.1E+04	NA	NA	NA	NA	5.7E+05	1.39E+06
663	NA	NA	8.0E+03	8.0E+03	3.44E+04	NA	5.8E+04	1.08E+05
217	NA	NA	NA	NA	NA	?	4.4E+05	4.42E+05

Notes: NA means not applicable, ? Means not known or unavailable, ANTHout means anthropogenic water extraction from aquifer.

The annual water use for serviced areas within the RDN (large municipal users, RDN wells, and private utilities) is typically measured and was provided by the RDN or taken from annual reports for 2010. The groundwater demand estimate for non-service areas was calculated from water use data provided by the RDN for serviced areas, and then applied to non-serviced areas based on civic addresses and zoning classification. The method of assessment is further described in Appendix C (Map C21) and Appendix D.

There may also be groundwater discharging from aquifers that is required for conservation of flow in creeks and rivers based on the physical model developed by Waterline. The total groundwater demand for each aquifer, including conservation flow requirements, was compared against the estimated aquifer recharge to assess the stress on each aquifer. The results are presented in the following section.

4.3.7 Aquifer Water Budgets and Stress Analysis

Table 20 provides a summary of the final water budget calculations for each aquifer mapped within WR2 (LQ). Detailed water budget calculations are provided in Appendix D (Tables D7 and D8). Water budgets for aquifers that extend from one water region to an adjacent water region (E.g.: Aquifer 0662, Figure 29) were completed on the portion of the aquifer which lies within each region. The water budget calculations were also designed to be additive so that a complete water budget of an entire mapped aquifer that extends across a water region boundary can be developed as required.

As indicated above, there are a total of 387 overburden and bedrock wells listed in the MOE data base in WR2 (LQ) which represents the third lowest number of wells in all of the 6 water regions across the RDN on Vancouver Island. It is also recognized that this number may only represent as little as 50% of water wells actually in operation in this region. This generally agrees with the moderate demand for groundwater in WR2 (LQ) in comparison to other regions. Nevertheless, there is a need to better manage groundwater extraction as the population increases in this region.

Based on the water budget estimates for mapped aquifers within WR2 (LQ), overall conditions appear to be mixed, ranging from low to high stress indicated. Some concerns exist in the Spider Lake area (HB Lanarc, 2010) although the water budget assessment indicates only moderate stress. No observation well water level data is available for the Spider Lake area to confirm or refute these concerns.

The stress assessment for Quadra aquifer (662) appears to indicate low stress which agrees with water levels data from MOE well 391 which appears to be trending up. Moderate to high stress is indicated in the sand and gravel aquifers 663 and 217.

More accurate water budget and aquifer stress estimates could only be accomplished using a computer modelling approach. However, the lack of aquifer data would likely render this exercise inconclusive as well. Rigorous testing requirements and complete aquifer test analysis by groundwater practitioners to determine aquifer transmissivity and storativity properties, in addition to long-term groundwater monitoring data in each aquifer would be required to fully assess the actual stress on each aquifer in this region.

Table 20: Summary of Water Budget and Stress Analysis – WR2 (LQ)

Aquifer Tag No.	Aquifer Lithology	Potential Groundwater-Surface water or Aquifer to Aquifer Interaction	MOE Obs Well	Seas. Fluc.	Long Term Fluc. (PDO)	WL Trend (up or down)	Total Est. AQ. Rec. (TRin) (Rp/l + Rmb)	Est. Ann. Disch to Cr. & Down Grad Aquifer (Tc out)	Ground Water Use Estimate (ANTHout)	Total Out [TcOut + ANTH$_{out}$]	Stress Anal. % GW Use of the avail. AQ. Rec.	Relative Stress Assess.
			ID	(m)	(m)	U/D	(m^3/yr)		(m^3/yr)	(m^3/yr)	(%)	Lo, Mod, Hi
662	Quadra	Ocean, LQ	391	2.50	0.80	U	3.2E+07	0.0E+00	1.22E+06	1.22E+06	4	Lo
661	Kame	Spider LK, Horne?	?	?	?	?	1.9E+07	1.2E+07	4.13E+04	1.17E+07	65	Mod
664	Salish	Ocean, LQ	389	3.00	?	D	3.7E+07	0.0E+00	1.39E+06	1.39E+06	4	Lo
663	Kame (Vashon Gf) top of Whiskey Cr.	Whiskey Cr., LQ	?	?	?	?	3.8E+07	2.9E+07	1.08E+05	2.92E+07	81	Mod-Hi
217	Quadra	LQ and Ocean	?	?	?	?	7.2E+06	4.9E+06	4.42E+05	5.32E+06	87	Mod-Hi

Notes: LQ means Little Qualicum, NA means not applicable, AQ means aquifer, Seas. Fluc. means seasonal, fluc. means fluctuation, PDO means Pacific Decadal Oscillation, WL means water level, Est. means estimated, Disch. means discharge, Rec. means recharge ,Cr. Means creek, TRin means total recharge into aquifer, Rp/l means total recharge from precipitation and/or leakage from overlying aquifer, Rmb means total lateral recharge from upgradient aquifer or mountain block, Tc out means total aquifer groundwater discharge to creek, assess. means assessment , Total out means total discharge from aquifer (not including discharge to ocean), ANTH out mean total groundwater Anthropogenic groundwater extraction from aquifer, aquifer stress color codes: blue=low, green =low to moderate, yellow =moderate, brown =moderate to high, red=high to very high.

4.4 Water Management Planning Within WR2 (LQ)

General guidance on water management planning for all water regions is provided in later sections of this document. Specific to WR2 (LQ), the following recommendation are presented for consideration by RDN to improve the state of knowledge in the water region:

- At least one observation well should be installed in each mapped aquifer. Aquifers that currently do not have MOE observation wells include 661, and 663. Waterline understands that MOE/RDN has recently installed an observation well in Aquifer 217 (Lapsevic, Pers. Comm., 2013);
- Well owners should identify the MOE well plate and tag numbers for each of their active water wells. In this manner, water use and monitoring data can be easily cross-referenced with the BC MOE well records. These include the Town of Qualicum Beach wells, RDN Melrose System well, Whiskey Creek Water System wells, Little Qualicum River Village wells, and Westerly Estates wells;
- The significant recharge area map needs to be further updated by further processing of the NRCAN remote sensing data and by field verification;
- Further mapping of the groundwater surface water interactions is also required in the Little Qualicum River to confirm the preliminary assessment. Waterline recommends specialized analysis (E.g.: isotopes[26], noble gases) of groundwater samples in this region to assist in determining groundwater age and origin. Thermal imaging of the river during high and low flow many help to quickly pinpoint areas where more detailed studies may be required;
- Reactivation of WSC surface water gauge on Little Qualicum at Qualicum Beach is recommended;
- River discharge and lake level data collected for Little Qualicum River below Cameron Lake and Cameron Lake levels be obtained at regular intervals from the Department of Fisheries and Oceans and be included in the Regional Water Management database;
- A hydrometric gauge be established on Kinkade Creek to investigate potential influence of groundwater recharge from Illusion Lake and Spider Lake on summer base flows; and
- Lake levels be recorded on Illusion Lake and Spider Lake to investigate any interaction between ground water levels and lake levels; and
- Weekly or Bi-weekly flow measurements during the summer period (June to Sept) be collected as part of the Community Watershed Monitoring Network program for McBey Creek, Lockwood Creek and Whiskey Creek to better understand summer low flows in these smaller watersheds.

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[26] Elements of the same family but with different atomic weights. Technique is used to assess recharge elevation and age of water.