AGRICULTURE WATER DEMAND MODEL

qathet Regional District

June 2020

CANADIAN AGRICULTURAL PARTNERSHIP

qathet REGIONAL DISTRICT

BRITISH COLUMBIA

Canada

AGRICULTURE WATER DEMAND MODEL

Report for qathet Regional District

June 2020

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DISCLAIMER

Table of Contents

List of Figures

List of Tables

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- **Ron Fretwell**
  Program Developer
  RHF Systems Ltd.

- **Denise Neilsen**
  Retired Research Scientist
  Summerland Research and Development Centre
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1. Background

The Agriculture Water Demand Model (AWDM or "Model") was first developed in the Okanagan Watershed. It was initiated in response to rapid population growth, drought conditions from climate change, and the overall increased demand for water. Many of the watersheds in British Columbia (B.C.) are fully allocated already or may be in the next 15 to 20 years. The AWDM helps to understand current agricultural water use and to fulfil the Province's commitment under the "*Living Water Smart – BC Water Plan*" to reserve water for agricultural lands. The Model can be used to establish agricultural water reserves throughout the various watersheds in B.C. by providing current and future agricultural water use data.

Climate change scenarios developed by the University of British Columbia (UBC) and the Summerland Research and Development Centre predict an increase in agricultural water demand due to warmer and longer summers and lower precipitation during summer months in the future.

The Model provides current and future agricultural water demands. It calculates water use on a property-by-property basis, and sums each property to obtain a total water demand for the entire basin or each subbasin. Data on crop type, irrigation system type, soil texture and climate are used to calculate the water demand. Climate data from year 2003 was used to represent the highest water demands in one of the hottest and driest years on record, and year 1997 climate data was used to represent the water demand in a wet year. Lands within the Agriculture Land Reserve (ALR) in qathet Regional District (qRD) are shown in green in Figure 1.

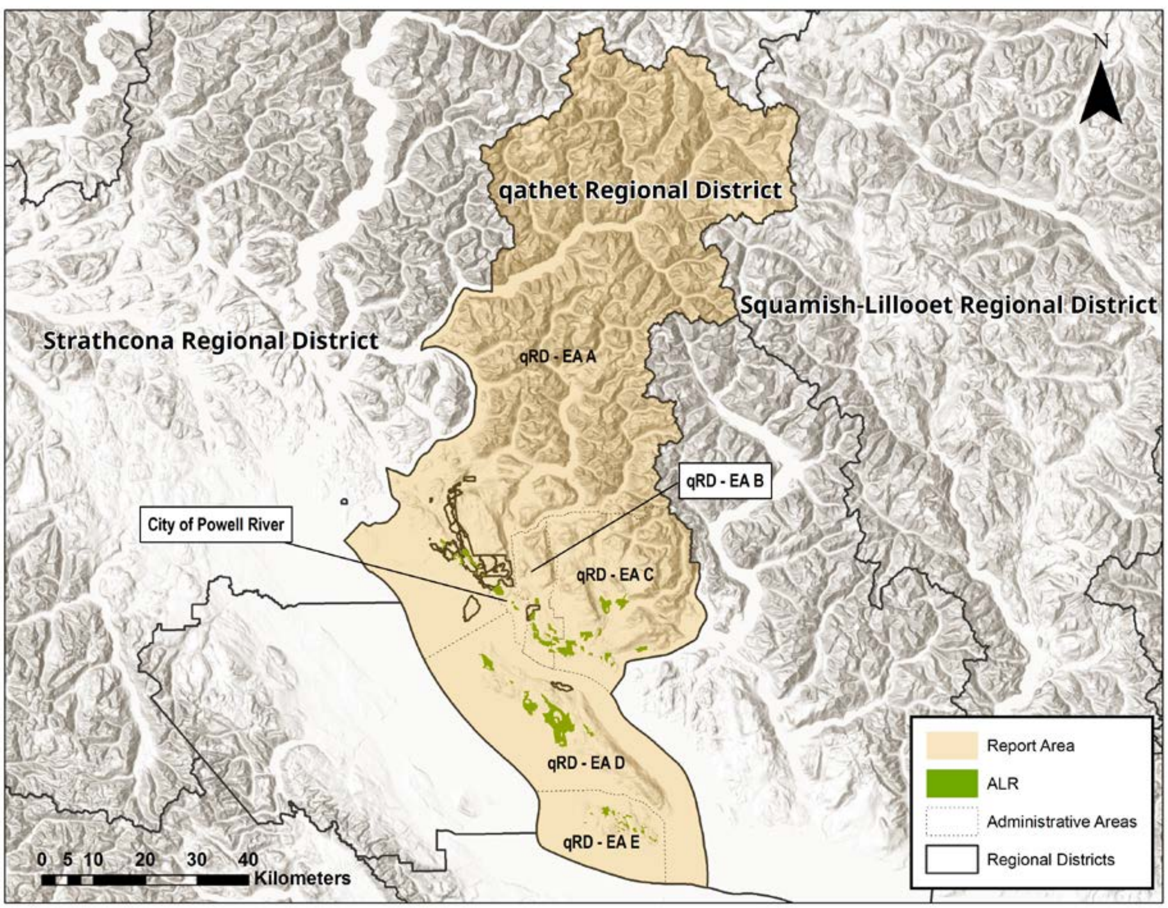

Figure 1 Map of qathet Regional District

2. Methodology

The Model is based on a Geographic Information System (GIS) database that contains data on crop type, irrigation system type, soil texture and climate. An explanation of how the data is compiled for each variable is provided in this section. Figure 2 shows the surveyed area including all properties within the ALR and areas that were zoned for agriculture by the local governments. The survey was conducted by the Ministry of Agriculture (AGRI) staff, and professional contractors and summer students hired by the Ministry of Agriculture.

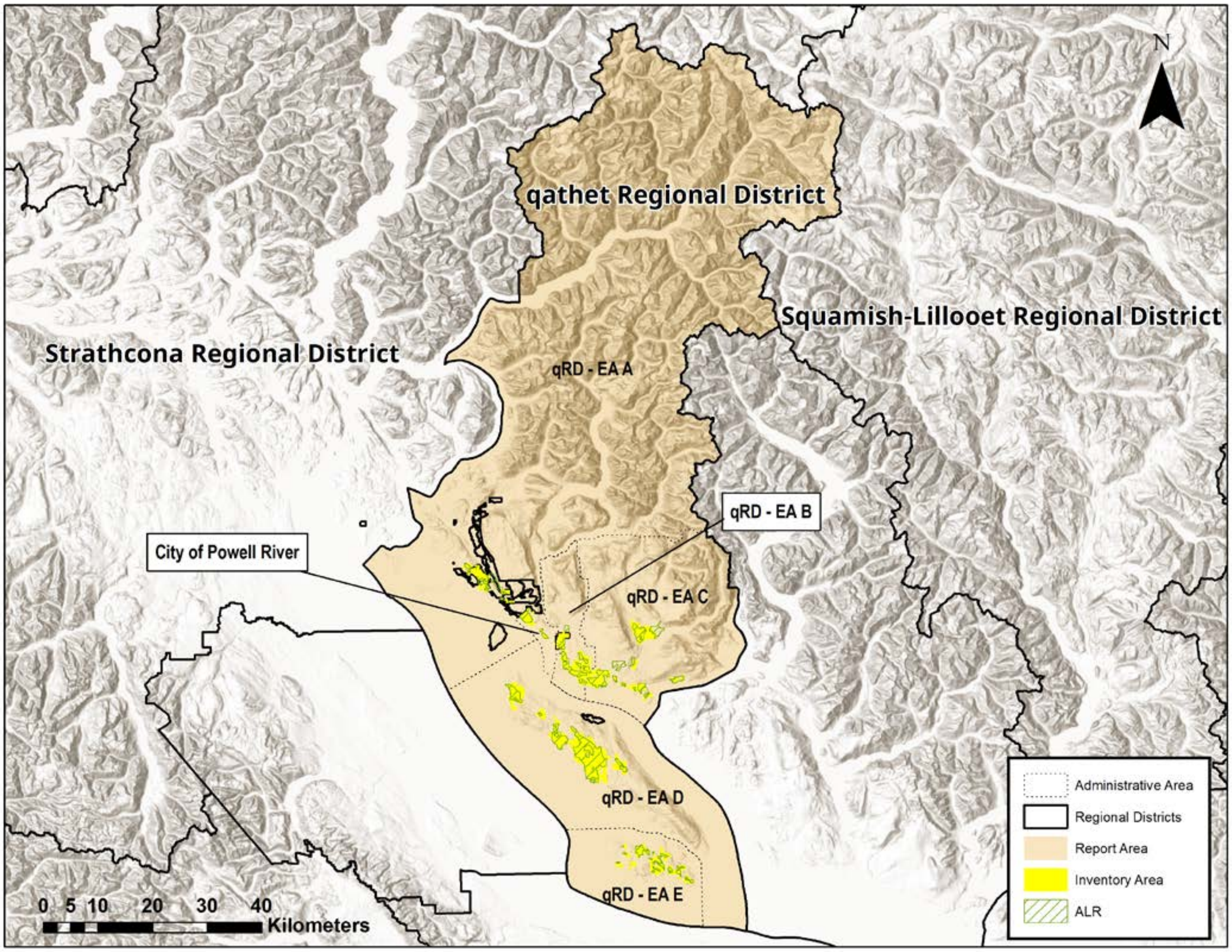

Figure 2 Map of the Surveyed Area

2.1. Cadastre and Polygon

Cadastre data was provided by the Integrated Cadastral Information Society (ICIS). All of the cadastre data was unified into one seamless cover for the entire project area. This process allows the Model to calculate water demand for each parcel and to report out on subbasins, local governments, water purveyors or aquifers by summing the data for those areas. Aerial photographs were used to conduct an initial review of crop type by cadastre. Within each cadastre, permanent physical structures (e.g., farmstead and driveways) were separated from cropping areas by creating new polygons, and excluded from the calculation of water demand. If the difference in crop type could be identified on the aerial photographs, the polygon would be split so each new polygon would contain a unique crop type. This data was entered in the GIS land use database that was used by the field crew to conduct and complete the Agricultural Land Use Inventory (ALUI).

2.2 Agricultural Land Use Inventory (ALUI)

The survey crew uses the land use database created to verify data about each property. Surveys were done in the summer of 2019. The survey crew drove by each property and checked the database for accuracy using visual observation and the aerial photographs on the survey maps. A Professional Agrologist with local knowledge verified what was on the site, and a GIS technician altered the codes in the database as necessary. When the survey was completed for the entire project area, post-survey data quality control was conducted to ensure the additional polygons were accurately entered into the database.

The smallest unit for which water use is calculated are the polygons within each cadastre. A polygon is determined by a change in crop type or irrigation system type within a cadastre. Polygons are designated as blue lines within each cadastre as shown in Figure 3 which provides an enhanced view of a cadastre containing three polygons. Each cadastre has a unique identifier as does each polygon. The polygon identifier is acknowledged by PolygonID. This allows the survey team to call up the cadastre in the database, review the number of polygons within the cadastre and ensure the land use is coded accurately for each polygon.

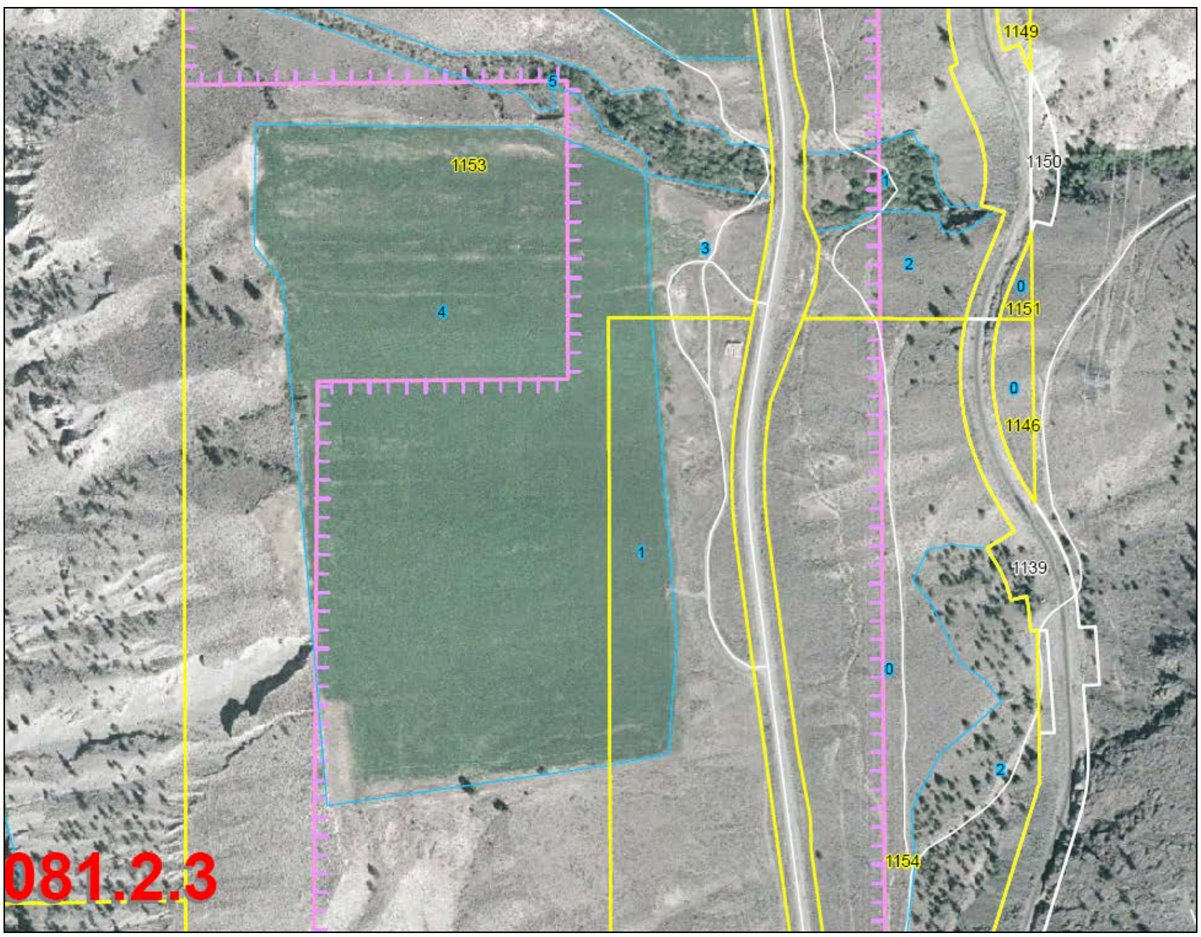

Figure 3 Cadastre with Polygons

2.3 Soil Information

Soil data was obtained digitally from the British Columbia Ministry of Environment. Soil attributes required for this project was the soil texture, the available water storage capacity, and the peak infiltration rate for each texture type.

The intersection of soil boundaries with the cadastre and land use polygons creates additional polygons that the Model uses to calculate water demand. Figure 4 shows how the land use information is divided into additional polygons using the soil boundaries. The Model calculates water demand using every different combination of crop, soil and irrigation system as identified by each polygon.

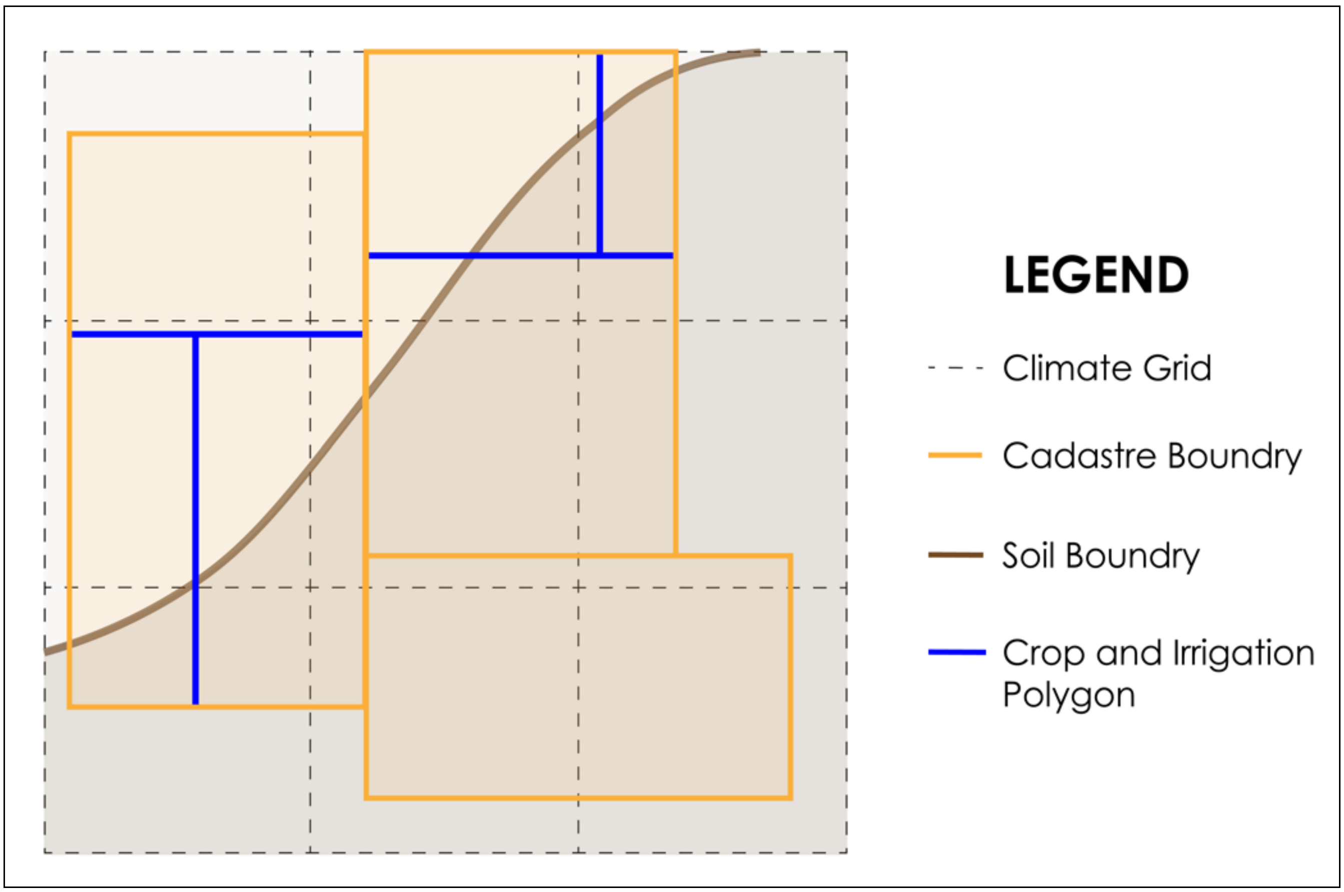

Figure 4 Polygon Attributes

2.4 Climate Information

The agricultural water demand is calculated using climate data, crop type, irrigation system type and soil texture. The climate generally gets cooler and wetter from south to north and as elevation increases. To incorporate the climatic diversity, climate layers were developed for the entire Province on a 500 metre by 500 metre grid. Each grid cell contains daily climate data, minimum and maximum temperature (T_{min} and T_{max}), and precipitation all of which allow the Model to calculate a daily reference evapotranspiration rate (ET_o) value. A range of agro-climatic indices such as growing degree days (GDD), corn heat units (CHU), frost free days and temperature sum (T-sum) can also be calculated for each grid cell based on temperature data. These values are used to determine seeding dates and the length of the growing season in the Model.

The climate dataset has been developed by using data collected from climate stations across the Province from 1961 to 2010. This climate dataset was then interpolated to provide a climate data layer for the entire Province on the 500 metre by 500 metre grid. The climate grid cell that is prominent for a cadastre boundary is assigned to that cadastre. Additional polygons are not generated with the climate grid.

The attributes attached to each climate grid cell include:

- Latitude
- Longitude
- Elevation
- Aspect
- Slope
- Daily Precipitation
- Daily T_{min} and T_{max}

A climate database contains T_{min}, T_{max}, T_{mean} and Precipitation for each day of the year from 1961 until 2010. The parameters that need to be selected, calculated and stored within the Model are evapotranspiration (ET_o), T-sum, effective precipitation (EP), frost free days, first frost date, GDD with base temperatures of 5 ^oC and 10 ^oC, and CHU. These climate and crop parameters are used to determine the growing season length as well as the beginning and end of the growing season in Julian day.

3. Model Calculations

The Model calculates the water demand for each polygon by using crop type, irrigation system type, soil texture and climate data as explained below. Each polygon was assigned an ID number as mentioned previously.

3.1 Crop

The CropID is an attribute of the PolygonID as each polygon contains a single crop. The crop information is collected (as observed during the land use survey) and stored with the PolygonID. CropID provides cropping attributes to the Model for calculating water use for each polygon. CropID along with the climate data is also used to calculate the growing season length and the beginning and end of the growing season. The attributes for CropID include rooting depth, availability coefficient, crop coefficient and a drip factor.

- Rooting depth is the rooting depth for a mature crop in a deep soil.
- An availability coefficient is assigned to each crop. The availability coefficient is used with the IrrigID to determine the soil moisture available to the crop for each PolygonID.
- The crop coefficient adjusts the calculated ET_o for the stages of crop growth during the growing season. Crop coefficient curves have been developed for every crop. The crop coefficient curve allows the Model to calculate water demand with an adjusted daily ET_o value throughout the growing season.
- The drip factor is used in the water use calculation for polygons where drip irrigation systems are used. Since the Model calculates water use by area, the drip factor adjusts the percentage of area irrigated by the drip system for that crop.

3.2 Irrigation

The IrrigID is an attribute of the PolygonID as each polygon has a single irrigation system type operating. The irrigation system type is collected (as observed during the land use survey) and stored with the PolygonID. The land use survey determines if a polygon has an irrigation system operating, what the system type is, and if the system is being used. The IrrigID contains an irrigation efficiency listed as an attribute.

Two of the IrrigID, Overtreedrip and Overtreemicro are polygons that have two systems in place. Two irrigation IDs occur when an overhead irrigation system has been retained to provide crop cooling or frost protection. In this case, the efficiency factors for drip and microsprinkler are used in the Model.

3.3 Soil

The digitized soil database came from the British Columbia Ministry of Environment. In addition, soil data provided by Agriculture and Agri-Food Canada (AAFC) was also used to generate multiple soil layers within each polygon. Each parcel was assigned the most predominant soil polygon, and then for each crop field within that soil polygon, the most predominant texture within the crop's rooting depth was determined and assigned to the crop field.

Note that textures could repeat at different depths. The combined total of the thicknesses determined the most predominant texture. For example, a layer of 20 cm sand, followed by 40 cm clay and then 30 cm of sand would have sand be designated at the predominant soil texture.

The attributes attached to the SoilID is the Available Water Storage Capacity (AWSC) which is calculated using the soil texture and crop rooting depth.

The Maximum Soil Water Deficit (MSWD) is calculated to decide the parameters for the algorithm that is used to determine the Irrigation Requirement (IR). The Soil Moisture Deficit (SMD) at the beginning of the season is calculated using the same terms as the MSWD.

3.4 Climate

The climate data in the Model is used to calculate a daily reference evapotranspiration rate (ET_o) for each climate grid cell. The data that is required to calculate this value are:

- Elevation, metres (m)
- Latitude, degrees (^{o})
- Minimum Temperature, degree Celsius (^oC)
- Maximum Temperature, degree Celsius (^oC)
- Classification as Coastal or Interior
- Classification as Arid or Humid
- Julian Day

Data that is assumed or are constants in this calculation are:

• Wind speed	2 m/s
• Albedo or canopy reflection coefficient,	0.23
• Solar constant, G_{sc}	0.082 $MJ^{-2}min^{-1}$
• Interior and Coastal coefficients, K_{Rs}	0.16 for interior locations 0.19 for coastal locations
• Humid and arid region coefficients, K_o	0 °C for humid/sub-humid climates 2 °C for arid/semi-arid climates

4. Livestock Water Use

Livestock type was observed and recorded during the land use survey as listed in Table 1. Livestock scale was also observed and entered into the database: very small, small, medium, large, very large, and very very large. The Model calculates an estimated livestock water demand using the livestock scale observed. Water use for each animal type is calculated differently depending on requirements. For example, for a dairy milking cow, the water demand for each animal includes, drinking, preparation for milking, pen and barn cleaning, milking system washout, bulk tank washout and milking parlor washing. However, for a dry dairy cow, the demand only includes drinking and pen and barn cleaning.

The water use is estimated on a daily basis per animal even though the facility is not cleaned daily. For example, for a broiler operation, the water use for cleaning a barn is calculated as 4 hours of pressure washing per cycle at a flow rate of 10 gallons per minute (gpm), multiplied by 6 cycles per barn with each barn holding 50,000 birds. On a daily basis, this is quite small with a value of 0.01 Litres per day per bird applied.

For all cases, the daily livestock water demand is applied to the farm location. However, in the case of beef, the livestock spend parts of the year on the range. Since the actual location of the animals cannot be ascertained, the water demand is applied to the home farm location, even though most of the demand will not be from this location. Therefore, the animal water demand on a watershed scale will work well, but not when the demand is segregated into sub-watersheds or groundwater areas.

The estimates used for each livestock are shown in Table 1.

Table 1 Livestock Water Demand (Litres/day)

Animal Type	Drinking	Milking Preparation	Barn Component	Total
Milking Dairy Cow	65	5	15	85
Dry Cow	45		5	50
Swine	12		0.5	12.5
Poultry – Broiler	0.16		0.01	0.17
Poultry – Layer	0.08		0.01	0.09
Turkeys	0.35		0.01	0.36
Goats	8			8
Sheep	8			8
Beef – range, steer, bull, heifer	50			50
Horses	50			50

5. Report Area

The qathet Regional District (qRD) encompasses City of Powell River, and five Electoral Areas (Figure 5).

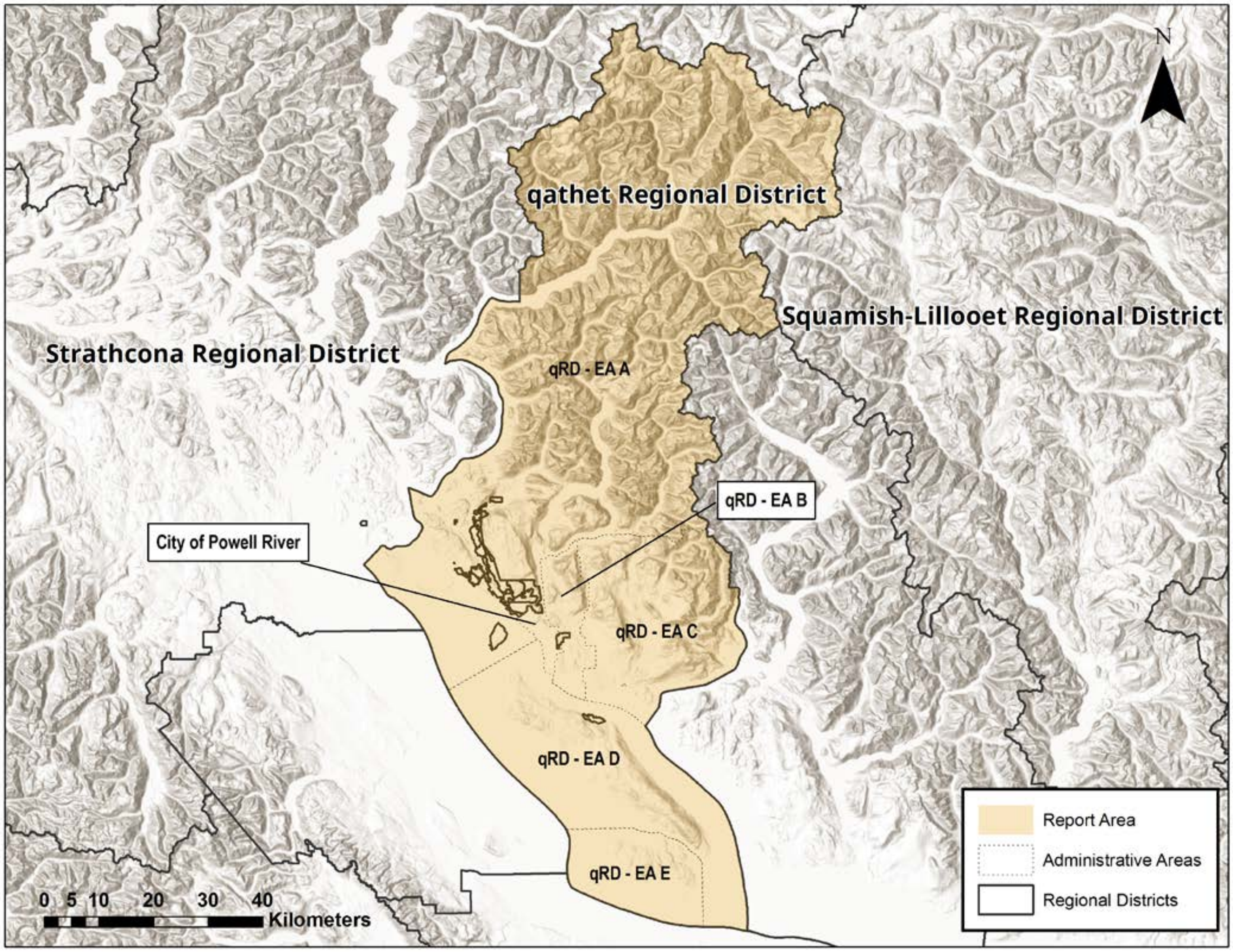

Figure 5 Administrative Areas in qathet Regional District

6. Agricultural Water Demand Results

The Agriculture Water Demand Model (AWDM or “Model”) can generate modelled results using a series of pre-developed scenarios. The Appendix in this report includes summary tables of the modelled results. Climate data from years 1997 and 2003 were chosen as they represent a relatively wet year and dry year respectively. Most results in this report are based on climate data from year 2003 which represents the maximum water demand. Results using climate change scenarios in years 2053, 2056 and 2059 are also presented.

6.1 Annual Crop Water Demand – Tables A and B

The Model offers a selection of three irrigation management factors: good, average and poor. Unless otherwise noted, average management was used in the tables. Appendix Table A provides the annual irrigation water demand based on the crop and irrigation systems observed in the survey year, year 2003 climate data, and average irrigation management. Table B provides the same data for year 1997 climate data.

The total irrigated acreage in qRD is 51.4 hectares (ha), including 11.9 ha of blueberries, and 8.4 ha of forage. In qRD, 4.2 ha is supplied by licensed surface water sources, and 47.2 ha is irrigated with groundwater. Although groundwater licensing is required under the *Water Sustainability Act* (WSA) as of February 29, 2016, no or minimal groundwater licences were issued since then in the project area. Parcels that were observed to have irrigation were assumed to obtain water from aquifers if surface water licences do not exist and that the parcel is not purveyed by the local government.

The total annual irrigation demand was 230,000 m^3 in 2003, and dropped to 118,217 m^3 in 1997. During a wet year like 1997, the demand was only 51% of a hot dry year like 2003.

6.2 Annual Water Demand by Irrigation System – Table C

The irrigation demand can also be summarized by irrigation system type as shown in Table C. The more efficient irrigation system for horticultural crops is drip (including overtreedrip) which irrigates 19.9 ha in the project area, and for forage is low-pressure pivot which are not used in this area. There is also a large portion of the forage irrigated by less efficient sprinkler systems. Sprinkler systems irrigate 28 ha (55%) of the agricultural crops.

6.3 Annual Water Demand by Soil Texture – Table D

The Model calculates water demand on a property by property basis and can summarize the data for each soil texture as shown in Table D. Where soil texture data is missing, the soil texture has been defaulted to sandy loam, i.e., “Sandy Loam (defaulted)”. Soil data has not been completed for this region. This table will be updated once soil data has been developed.

6.4 Annual Water Demand by Subbasin – Table E

The Model calculates water demand on a property by property basis and can summarize the data for each subbasin as shown in Table E.

6.5 Annual Water Demand by Water Purveyor – Table F

The Model calculates water demand on a property by property basis and can summarize the data for each water purveyor as shown in Table F. In qRD, all water licences are held by private landowners based on the information provided by qRD.

6.6 Annual Water Demand by Local Government – Table G

The Model calculates water demand on a property by property basis and can summarize the data for irrigated area within each local government as shown in Table G.

6.7 Annual Water Demand by Electoral Area – Table H

The Model calculates water demand on a property by property basis and can summarize the data for irrigated area within each electoral area as shown in Table H.

6.8 Improved Irrigation Efficiency and Good Management – Table I

There is an opportunity to reduce water use by converting irrigation systems to a higher efficiency for some crops. For example, drip systems could be used for all fruit crops, vegetable crops and some of the other horticultural crops, but not forage crops. In addition, using better management such as irrigation scheduling techniques will also reduce water use, especially for forage where drip conversion is not possible. Table I provides a scenario of water demand if all sprinkler systems are converted to drip systems for horticultural crops in the project area, as well as converting irrigation systems to low-pressure pivot systems for forage fields over 10 ha, using good irrigation management. In this case, the water demand for 2003 would reduce from 230,000 m^3 to 195,668 m^3 (15% reduction).

6.9 Livestock Water Use – Table J

The Model provides an estimate of water use for livestock. The estimate is based on the number of animals in the project area as determined by the latest census, the drinking water required for each animal per day and the barn or milking parlour wash water. Values used are shown in Table J. For the project area, the amount of livestock water is estimated at 43,954 m^3.

6.10 Crop Water Demand with Climate Change (Year 2050s Climate) for High Demand Years Using Surveyed Crops and Irrigation Systems and Good Management – Table K

The Model also has access to climate change information until the year 2100. While data can be run for each year, three driest years in the 2050s were selected to give a representation of climate change. Figure 6 shows the climate change results which indicate 2053, 2056, and 2059 generate the highest annual ET_o and lowest annual precipitation. Therefore, these three years were used in this report. Table K provides the results of climate change on irrigation demand for the three years selected using crop types and irrigation system types captured in the land use survey. Surveyed crop and irrigation system types were used to show the increase due to climate change alone, with no other changes taking place.

Figure 7 shows all of the climate change scenario runs for the Okanagan using 12 climate change models from year 1960 to 2100. This work was compiled by Denise Neilsen, a retired research scientist at the Agriculture and Agri-Food Canada – Summerland Research and Development Centre. There is a lot of scatter in this figure, but it is obvious that there is a trend of increasing water demand.

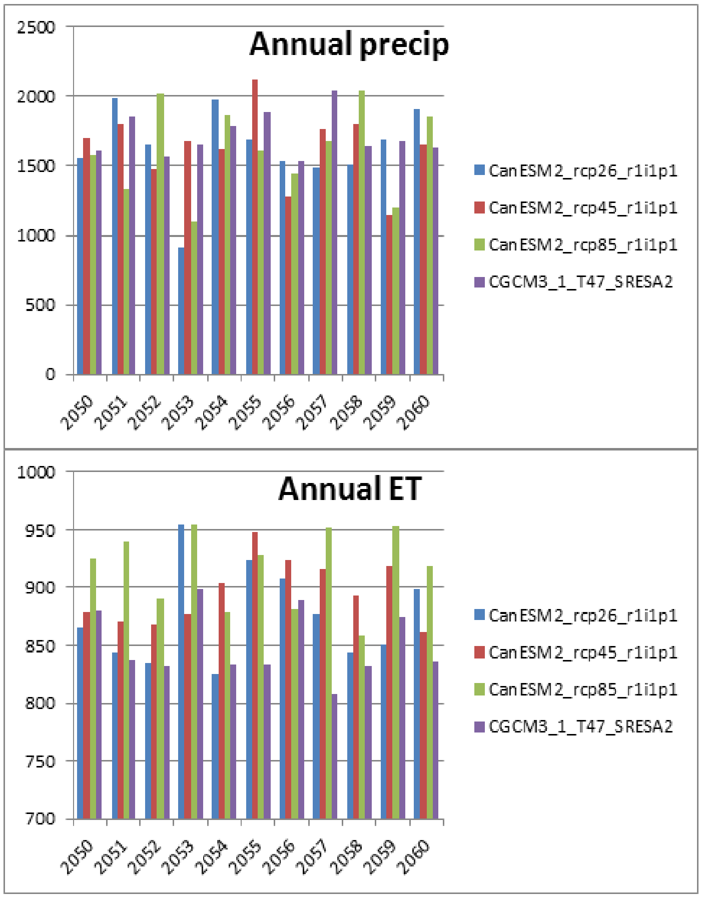

Figure 6 Annual ET and Effective Precipation in Year 2050s

The three climate change models used in this report are access1 rcp85, canESM2 rcp85 and cnrm-cm5 rcp85. Running only three climate change models on three selected future years in the project area is not sufficient to provide a trend like in Figure 7. What the results do show is that in an extreme climate scenario, it is possible to have an annual water demand that is 58% higher than what was experienced in year 2003 based on canESM2 rcp85 climate model in year 2053. More runs of the climate change models will be required to better estimate a climate change trend for the region.

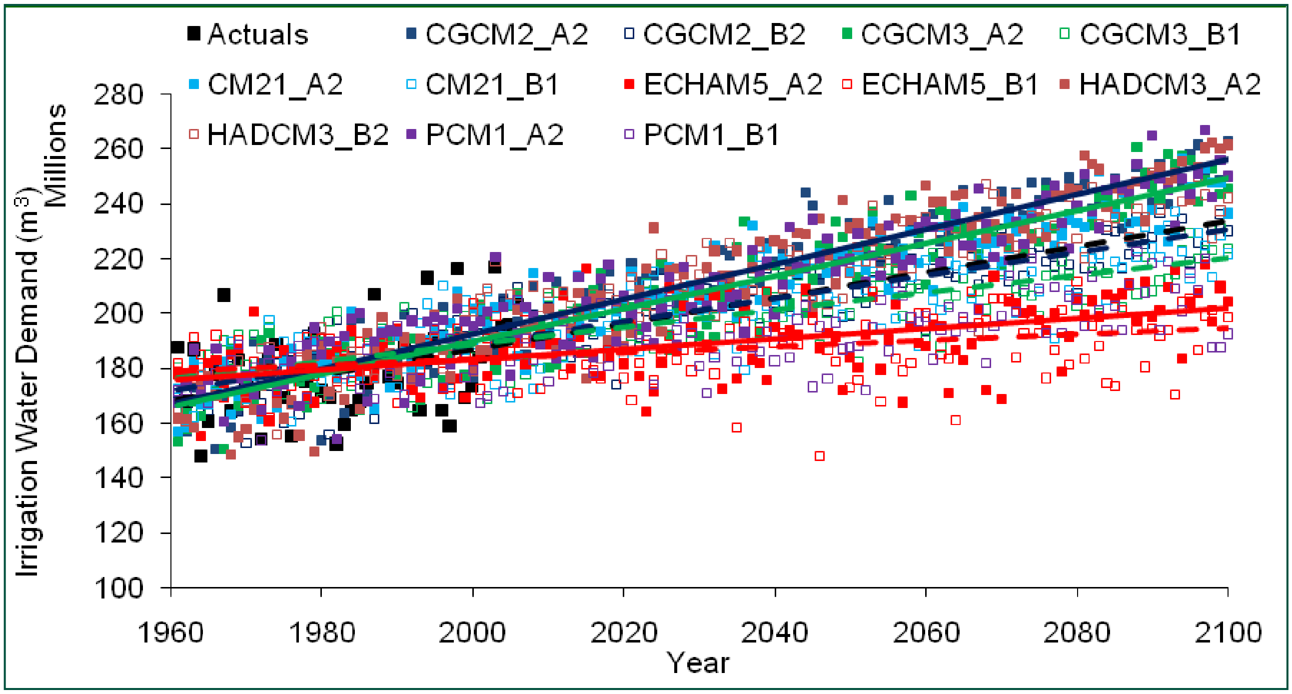

Figure 7 Future Irrigation Demand for All Outdoor Uses in the Okanagan in Response to Observed Climate Data (Actuals) and Future Climate Data Projected from a Range of Global Climate Models

6.11 Water Demand by Crop with Buildout, Year 2003 Climate, and Good Management – Table L

An agricultural irrigated buildout scenario was developed that looked at potential agricultural lands that could be irrigated in the future. The rules used to establish where potential additional agricultural lands were located are as follows:

- within 1,000 m of water supply (lake)
- within 1,000 m of water supply (water course)
- within 1,000 m of water supply (wetland)
- within 1,000 m of high productivity aquifer
- within 1,000 m of water purveyor
- within 125 m elevation from the surface water source to the property
- with Ag Capability class 1-4 only where available
- must be within the ALR
- below 750 m average elevation
- must be private ownership

Permanent physical structure (e.g., farmstead, houses, driveways) are not considered to be available for the buildout scenario. For the areas that are determined to be eligible for future buildout, a crop type and irrigation system type need to be applied. Where a crop already exists in the land use inventory, that crop would remain and an irrigation system type assigned. If no crop exists, then a crop type and an irrigation system type would be assigned as per the criteria below:

- 40% berries – 100% drip
- 30% forage – 50% sprinkler, 50% low-pressure centre pivot
- 30% vegetables – 100% drip

Figure 8 indicates the location of agricultural land that is currently irrigated (blue) and the land that can be potentially irrigated (red). Based on the scenario provided for the project area, the additional agricultural land that could be irrigated is 1,704 ha, which is an increase in irrigated acreage of 3,315%. The water demand for a year like 2003 would then be close to 6 million m^3 assuming efficient irrigation systems and good management.

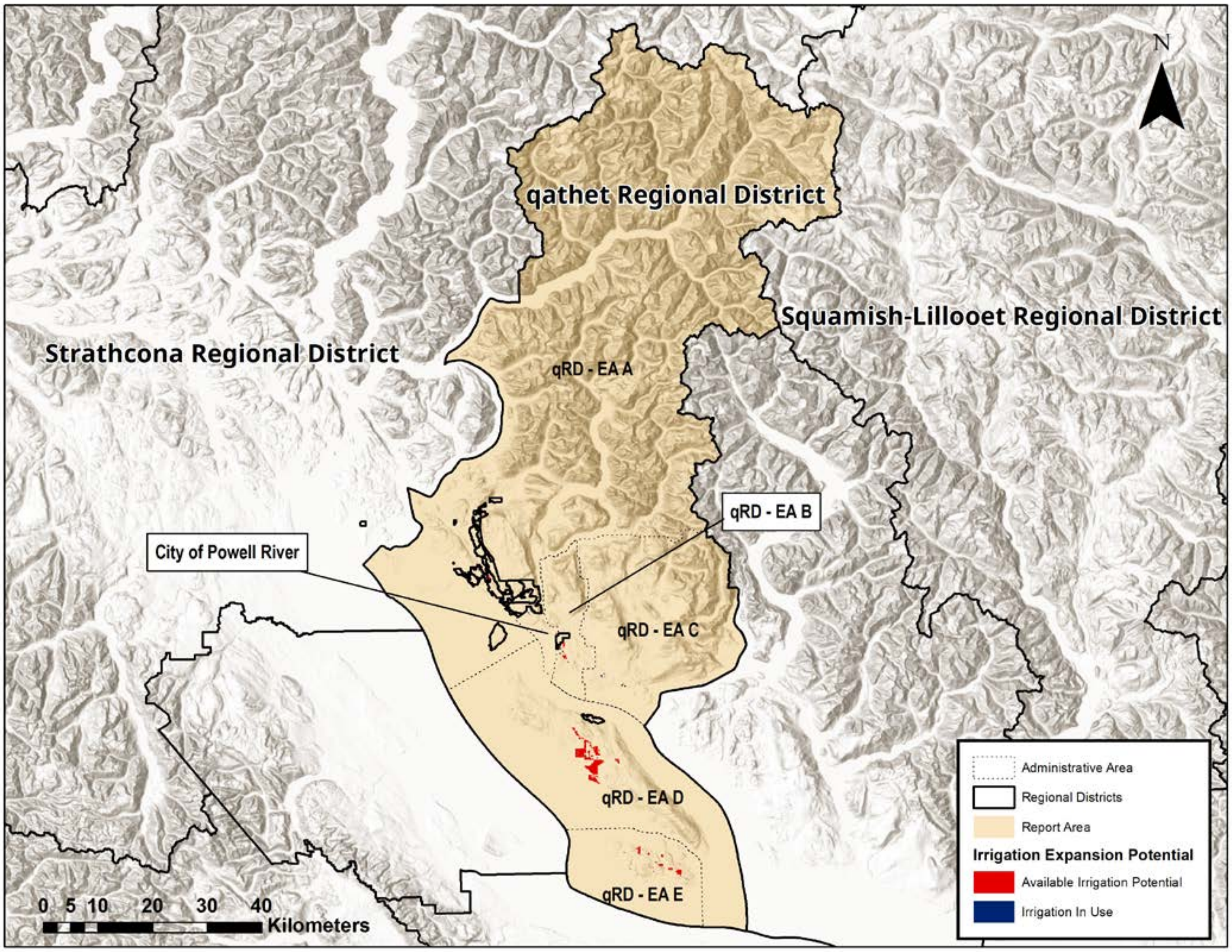

Figure 8 Irrigation Expansion Potential for the Project Area

6.12 Crop Water Demand with Buildout, Climate Change (Year 2050s Climate for High Demand Years), and Good Management – Table M

The same irrigation expansion and cropping scenario used to generate the values in Table K were used to generate the water demand with climate change as shown in Table M. See discussion under Table L section. When climate change is added to the buildout scenario, the water demand increases from 364,534 m^3 to 9.6 million m^3 (a further 2,543% increase) based on climate change model canESM2 rcp85 in Year 2053 using the highest potential scenario.

6.13 Water Demand by Irrigation System with Buildout, Year 2003 Climate, and Good Management – Table N

Table N provides an account of the irrigation systems used by area for the buildout scenario in the previous two examples. Note that pivot irrigation (especially low-pressure type) is expected to be used for forage field over 10 ha in size to be economically feasible.

6.14 Water Demand by Soil Texture with Buildout, Year 2003 Climate, and Good Management – Table O

Table O provides the water demand by soil type for the buildout scenario used in this report. Comparing these values with the result in Table D will provide information on the possible increased water demand by soil type for the projected irrigated areas. Soil data has not been completed for this region. This table will be updated once soil data has been developed.

6.15 Water Demand by Subbasin with Buildout, Year 2003 Climate, and Good Management – Table P

Table P provides the water demand by subbasin for the buildout scenario used in this report. Comparing these values with the result in Table E will provide information on the possible increased water demand in each subbasin for the projected irrigated areas.

6.16 Water Demand by Water Purveyor with Buildout, Year 2003 Climate, and Good Management – Table Q

Table Q provides the water demand by water purveyor for the buildout scenario used in this report. Comparing these values with the result in Table F will provide information on the possible increased water demand by each water purveyor for the projected irrigated areas. Naming convention for water purveyors follows the approved version published by GeoBC.

6.17 Water Demand by Local Government with Buildout, Year 2003 Climate, and Good Management – Table R

Table R provides the water demand by local government for the buildout scenario used in this report. Comparing these values with the result in Table G will provide information on the possible increased water demand in each local government for the projected irrigated areas.

6.18 Water Demand by Electoral Area with Buildout, Year 2003 Climate, and Good Management – Table S

Table S provides the water demand by electoral area for the buildout scenario used in this report. Comparing these values with the result in Table H will provide information on the possible increased water demand in each electoral area for the projected irrigated areas.

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Appendix Tables

Appendix Table A. Water Demand by Crop Using Year 2003 Climate and Average Management

Year: 2003	Water Source									Total		
	Surface Water			Reclaimed Water			Groundwater					
Crop Group	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)
Apple	0	0	0	0	0	0	6.2	38,691	628	6.2	**38,691**	628
Berry	0.3	999	360	0	0	0	1.6	6,494	411	1.9	**7,493**	403
Blueberry	0	0	0	0	0	0	11.9	36,351	306	11.9	**36,351**	306
Forage	0	0	0	0	0	0	8.4	45,474	541	8.4	**45,474**	541
Fruit	0.7	3,743	523	0	0	0	0.6	2,956	499	1.3	**6,700**	512
Grape	1	2,099	202	0	0	0	4.5	6,218	139	5.5	**8,317**	151
Nursery Shrubs/Trees	1.5	9,582	629	0	0	0	0.3	1,432	431	1.9	**11,014**	594
Pasture/Grass	0	0	0	0	0	0	5.1	29,099	571	5.1	**29,099**	571
Vegetable	0.6	3,257	583	0	0	0	7.5	30,631	409	8	**33,888**	422
	4.2	**20,536**	486	0	**0**	0	47.2	**209,464**	444	51.4	**230,000**	448

Appendix Table B. Water Demand by Crop Using Year 1997 Climate and Average Management

Year: 1997	Water Source									Total		
	Surface Water			Reclaimed Water			Groundwater					
Crop Group	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)
Apple	0	0	0	0	0	0	6.2	18,665	303	6.2	**18,665**	303
Berry	0.3	405	146	0	0	0	1.6	2,776	176	1.9	**3,180**	171
Blueberry	0	0	0	0	0	0	11.9	16,329	138	11.9	**16,329**	138
Forage	0	0	0	0	0	0	8.4	22,672	270	8.4	**22,672**	270
Fruit	0.7	1,591	222	0	0	0	0.6	1,235	208	1.3	**2,826**	216
Grape	1	440	42	0	0	0	4.5	1,898	42	5.5	**2,337**	42
Nursery Shrubs/Trees	1.5	3,419	225	0	0	0	0.3	552	166	1.9	**3,970**	214
Pasture/Grass	0	0	0	0	0	0	5.1	15,553	305	5.1	**15,553**	305
Vegetable	0.6	1,750	313	0	0	0	7.5	18,557	248	8	**20,307**	253
	4.2	**8,474**	200	0	**0**	0	47.2	**109,743**	233	51.4	**118,217**	230

Appendix Table C. Water Demand by Irrigation System Using Year 2003 Climate and Average Management

Year: 2003	Water Source									Total		
	Surface Water			Reclaimed Water			Groundwater					
Irrigation System	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)
Drip	1.1	2,363	209	0	0	0	18.6	55,105	296	19.8	**57,467**	291
Microsprinkler	0.1	855	755	0	0	0	0.1	906	764	0.2	**1,761**	760
Overtreedrip	0	0	0	0	0	0	0.1	265	377	0.1	**265**	377
Sprinkler	3	17,318	581	0	0	0	16.3	89,300	549	19.2	**106,618**	554
Ssovertree	0	0	0	0	0	0	0.8	3,741	486	0.8	**3,741**	486
Sssprinkler	0	0	0	0	0	0	9	49,511	547	9	**49,511**	547
Subirrig	0	0	0	0	0	0	2.3	10,637	469	2.3	**10,637**	469
	4.2	**20,536**	486	0	**0**	0	47.2	**209,464**	444	51.4	**230,000**	448

Appendix Table D. Water Demand by Soil Using Year 2003 Climate and Average Management

Year: 2003	Water Source									Total		
	Surface Water			Reclaimed Water			Groundwater					
Soil Texture	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)
Cultured Medium	0.1	855	755	0	0	0	1.2	12,118	1,044	1.3	**12,974**	1,018
Sandy Loam (defaulted)	4.1	19,681	478	0	0	0	46	197,346	429	50.1	**217,026**	433
	4.2	**20,536**	486	0	**0**	0	47.2	**209,464**	444	51.4	**230,000**	448

Appendix Table E. Water Demand by Subbasin Using Year 2003 Climate and Average Management

Year: 2003	Water Source									Total		
	Surface Water			Reclaimed Water			Groundwater					
Subbasin	Irrigated Area (ha)	Irrigation Demand (m³)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m³)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m³)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m³)	Avg.Req. (mm)
Jervus Inlet	0	0	0	0	0	0	2.9	14,768	509	2.9	**14,768**	509
Lang Creek	0	0	0	0	0	0	4.7	22,821	488	4.7	**22,821**	488
Mouat Creek	0	0	0	0	0	0	3.1	17,900	571	3.1	**17,900**	571
Myrtle Creek	0.2	736	396	0	0	0	15.6	55,769	357	15.8	**56,504**	358
Parksville	3.9	18,945	482	0	0	0	8.2	53,536	653	12.1	**72,481**	598
Rumbottle Creek	0	0	0	0	0	0	2.6	12,230	480	2.6	**12,230**	480
Sliammon Creek	0	0	0	0	0	0	0.2	803	441	0.2	**803**	441
Toba Inlet	0.1	855	755	0	0	0	9.2	29,394	320	9.3	**30,250**	326
Whittall Creek	0	0	0	0	0	0	0.7	2,243	309	0.7	**2,243**	309
	4.2	**20,536**	486	0	**0**	0	47.2	**209,464**	444	51.4	**230,000**	448

Appendix Table F. Water Demand by Water Purveyor Using Year 2003 Climate and Average Management

Year: 2003	Water Source									Total		
	Surface Water			Reclaimed Water			Groundwater					
Water Purveyor	Irrigated Area (ha)	Irrigation Demand (m³)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m³)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m³)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m³)	Avg.Req. (mm)
Private	4.2	20,536	486	0	0	0	47.2	209,464	444	51.4	**230,000**	448
	4.2	**20,536**	486	0	**0**	0	47.2	**209,464**	444	51.4	**230,000**	448
	4.2	**20,536**	486	0	**0**	0	47.2	**209,464**	444	51.4	**230,000**	448

Appendix Table G. Water Demand by Local Government Using Year 2003 Climate and Average Management

Year: 2003	Water Source									Total		
	Surface Water			Reclaimed Water			Groundwater					
Local Government	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)
City Of Powell River	0	0	0	0	0	0	9.6	30,052	314	9.6	**30,052**	314
qathet Regional District	4.2	20,536	486	0	0	0	37.6	179,412	477	41.8	**199,948**	478
	4.2	**20,536**	486	0	**0**	0	47.2	**209,464**	444	51.4	**230,000**	448

Appendix Table H. Water Demand by Electoral Area Using Year 2003 Climate and Average Management

Year: 2003	Water Source									Total		
	Surface Water			Reclaimed Water			Groundwater					
Electoral Area	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)
Other	0	0	0	0	0	0	9.6	30,052	314	9.6	**30,052**	314
qRD Electoral Area A	0.1	855	755	0	0	0	0.9	5,831	662	1	**6,686**	673
qRD Electoral Area B	0.2	736	396	0	0	0	1.4	6,246	448	1.6	**6,982**	442
qRD Electoral Area C	0	0	0	0	0	0	21.4	83,670	391	21.4	**83,670**	391
qRD Electoral Area D	0	0	0	0	0	0	5.7	30,130	530	5.7	**30,130**	530
qRD Electoral Area E	3.9	18,945	482	0	0	0	8.2	53,536	653	12.1	**72,481**	598
	4.2	**20,536**	486	0	**0**	0	47.2	**209,464**	444	51.4	**230,000**	448

Appendix Table I. Water Demand by Crop Using Improved Irrigation System Efficiency, Year 2003 Climate, and Good Management

Year: 2003	Water Source									Total		
	Surface Water			Reclaimed Water			Groundwater					
Crop Group	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)
Apple	0	0	0	0	0	0	6.2	23,822	387	6.2	**23,822**	387
Berry	0.3	977	352	0	0	0	1.6	6,352	402	1.9	**7,329**	394
Blueberry	0	0	0	0	0	0	11.9	35,463	299	11.9	**35,463**	299
Forage	0	0	0	0	0	0	8.4	43,654	519	8.4	**43,654**	519
Fruit	0.7	2,202	308	0	0	0	0.6	1,746	295	1.3	**3,947**	302
Grape	1	2,051	197	0	0	0	4.5	6,075	136	5.5	**8,126**	147
Nursery Shrubs/Trees	1.5	9,390	617	0	0	0	0.3	1,402	422	1.9	**10,792**	582
Pasture/Grass	0	0	0	0	0	0	5.1	28,169	553	5.1	**28,169**	553
Vegetable	0.6	1,861	333	0	0	0	7.5	19,531	261	8	**21,391**	266
	4.2	**17,335**	410	0	**0**	0	47.2	**178,332**	378	51.4	**195,668**	381

Appendix Table J. Water Demand by Animal Type Using Year 2003 Climate

Year: 2003	Water Demand (m3)
Animal Type	
Beef	9,180
Goats	3,358
Horses	24,364
Poultry - broiler	1,753
Poultry - laying	928
Sheep	4,030
Swine	342
	43,954

Appendix Table K. Crop Water Demand with Climate Change (Year 2050s Climate for High Demand Years) Using Surveyed Crops and Irrigation Systems and Good Management

	Climate Model									Crop Irrigation Total		
	Access1 rcp85			CanESM2 rcp85			cnrm-cm5 rcp85					
Year	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)
2053	51.4	**273,183**	532	51.4	**364,534**	709	51.4	**189,549**	369	51.4	**275,755**	537
2056	51.4	**312,860**	609	51.4	**203,203**	395	51.4	**132,279**	257	51.4	**216,114**	420
2059	51.4	**255,750**	498	51.4	**301,484**	587	51.4	**171,066**	333	51.4	**242,767**	473

Appendix Table L. Water Demand by Crop with Buildout, Year 2003 Climate, and Good Management

Year: 2003	Water Source									Total		
	Surface Water			Reclaimed Water			Groundwater					
Crop Group	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)
Apple	0	0	0	0	0	0	6.2	37,842	614	6.2	**37,842**	614
Berry	448.2	997,569	223	0	0	0	1.6	6,352	402	449.8	**1,003,921**	223
Blueberry	0	0	0	0	0	0	11.9	35,463	299	11.9	**35,463**	299
Forage	452.7	2,446,092	540	0	0	0	8.4	43,654	519	461.2	**2,489,746**	540
Fruit	0.7	3,661	511	0	0	0	0.6	2,878	486	1.3	**6,539**	500
Grape	1	2,051	197	0	0	0	4.5	6,075	136	5.5	**8,126**	147
Nursery Shrubs/Trees	1.5	9,390	617	0	0	0	0.3	1,402	422	1.9	**10,792**	582
Pasture/Grass	0.0	0	0	0	0	0	5.1	28,169	553	5.1	**28,169**	553
Vegetable	803.6	2,145,895	267	0	0	0	7.5	29,981	401	811.1	**2,175,876**	268
	1,708.0	**5,605,513**	328	0	**0**	0	47.2	**203,935**	432	1,755.2	**5,809,448**	331

Appendix Table M. Crop Water Demand with Buildout, Climate Change (Year 2050s Climate for High Demand Years), and Good Management

	Climate Model									Crop Irrigation Total		
	Access1 rcp85			CanESM2 rcp85			cnrm-cm5 rcp85					
Year	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)
2053	1,755.2	**6,575,472**	375	1,755.2	**9,635,240**	549	1,755.2	**4,701,398**	268	1755.2	**6,970,703**	397
2056	1,755.2	**7,768,341**	443	1,755.2	**5,247,735**	299	1,755.2	**3,320,956**	189	1755.2	**5,445,677**	310
2059	1,755.2	**6,490,896**	370	1,755.2	**7,852,854**	447	1,755.2	**4,354,897**	248	1755.2	**6,232,882**	355

Appendix Table N. Water Demand by Irrigation System with Buildout, Year 2003 Climate, and Good Management

Year: 2003	Water Source									Total		
	Surface Water			Reclaimed Water			Groundwater					
Irrigation System	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)
Drip	1,252.2	3,141,604	251	0	0	0	18.6	54,124	291	1,270.8	**3,195,728**	251
Microsprinkler	0.1	855	755	0	0	0	0.1	906	764	0.2	**1,761**	760
Overtreedrip	0	0	0	0	0	0	0.1	265	377	0.1	**265**	377
PivotLP	349.7	1,860,580	532	0	0	0	0	0	0	349.7	**1,860,580**	532
Sprinkler	106	602,473	568	0	0	0	16.3	87,373	537	122.3	**689,847**	564
Ssovertree	0	0	0	0	0	0	0.8	3,579	465	0.8	**3,579**	465
Sssprinkler	0	0	0	0	0	0	9	47,289	523	9	**47,289**	523
Subirrig	0	0	0	0	0	0	2.3	10,400	459	2.3	**10,400**	459
	1,708.0	**5,605,513**	328	0	**0**	0	47.2	**203,935**	432	1,755.2	**5,809,448**	331

Appendix Table O. Water Demand by Soil with Buildout, Year 2003 Climate, and Good Management

Year: 2003	Water Source									Total		
	Surface Water			Reclaimed Water			Groundwater					
Soil Texture	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)
Cultured Medium	0.1	855	755	0	0	0	1.2	12,118	1,044	1.3	**12,974**	1,018
Sandy Loam (defaulted)	1,707.9	5,604,657	328	0	0	0	46	191,817	417	1,753.9	**5,796,474**	330
	1,708.0	**5,605,513**	328	0	**0**	0	47.2	**203,935**	432	1,755.2	**5,809,448**	331

Appendix Table P. Water Demand by Subbasin with Buildout, Year 2003 Climate, and Good Management

Year: 2003	Water Source									Total		
	Surface Water			Reclaimed Water			Groundwater					
Subbasin	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)
Other	0.0	51	679	0	0	0	0	0	0	0.0	**51**	679
Freda Creek	2	4,822	242	0	0	0	0	0	0	2	**4,822**	242
Jervis Inlet	0	0	0	0	0	0	2.9	14,140	487	2.9	**14,140**	487
Lang Creek	0	0	0	0	0	0	4.7	21,943	469	4.7	**21,943**	469
Lois River	0.1	319	242	0	0	0	0	0	0	0.1	**319**	242
Mouat Creek	564.8	2,052,103	363	0	0	0	3.1	17,086	545	568	**2,069,189**	364
Myrtle Creek	85.1	214,957	253	0	0	0	15.6	54,590	350	100.7	**269,547**	268
Parksville	248.8	894,667	360	0	0	0	8.2	52,407	639	257	**947,074**	368
Rumbottle Creek	783.2	2,307,638	295	0	0	0	2.6	11,969	469	785.8	**2,319,607**	295
Sliammon Creek	0	0	0	0	0	0	0.2	786	431	0.2	**786**	431
Toba Inlet	23.9	130,955	548	0	0	0	9.2	28,818	314	33.1	**159,773**	483
Whittall Creek	0	0	0	0	0	0	0.7	2,196	303	0.7	**2,196**	303
	1,708.0	**5,605,513**	328	0	**0**	0	47.2	**203,935**	432	1,755.2	**5,809,448**	331

Appendix Table Q. Water Demand by Water Purveyor with Buildout, Year 2003 Climate, and Good Management

Year: 2003	Water Source									Total		
	Surface Water			Reclaimed Water			Groundwater					
Water Purveyor	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)
Tla'amin First Nation	23.8	130,100	547	0	0	0	0	0	0	23.8	**130,100**	547
	23.8	**130,100**	547	0	**0**	0	0	**0**	0	23.8	**130,100**	547
Private	1,684.2	5,475,413	325	0	0	0	47.2	203,935	432	1,731.4	**5,679,348**	328
	1,684.2	**5,475,413**	325	0	**0**	0	47.2	**203,935**	432	1,731.4	**5,679,348**	328
	1,708.0	**5,605,513**	328	0	**0**	0	47.2	**203,935**	432	1,755.2	**5,809,448**	331

Appendix Table R. Water Demand by Local Government with Buildout, Year 2003 Climate, and Good Management

Year: 2003	Water Source									Total		
	Surface Water			Reclaimed Water			Groundwater					
Local Government	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)
City Of Powell River	5.7	21,293	371	0	0	0	9.6	29,410	307	15.3	**50,703**	331
qathet Regional District	1,678.5	5,454,119	325	0	0	0	37.6	174,525	464	1,716.1	**5,628,644**	328
Tla'amin First Nation	23.8	130,100	547	0	0	0	0	0	0	23.8	**130,100**	547
	1,708.0	**5,605,513**	328	0	**0**	0	47.2	**203,935**	432	1,755.2	**5,809,448**	331

Appendix Table S. Water Demand by Electoral Area with Buildout, Year 2003 Climate, and Good Management

Year: 2003	Water Source									Total		
	Surface Water			Reclaimed Water			Groundwater					
Electoral Area	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg.Req. (mm)
Other	29.5	151,393	513	0	0	0	9.6	29,410	307	39.1	**180,803**	462
qRD Electoral Area A	0.1	855	755	0	0	0	0.9	5,766	655	1	**6,622**	666
qRD Electoral Area B	79.4	193,664	244	0	0	0	1.4	6,140	440	80.8	**199,804**	247
qRD Electoral Area C	2.1	5,140	242	0	0	0	21.4	81,157	379	23.5	**86,297**	367
qRD Electoral Area D	1,348.0	4,359,741	323	0	0	0	5.7	29,055	511	1,353.7	**4,388,796**	324
qRD Electoral Area E	248.8	894,719	360	0	0	0	8.2	52,407	639	257	**947,126**	368
	1,708.0	**5,605,513**	328	0	**0**	0	47.2	**203,935**	432	1,755.2	**5,809,448**	331