AGRICULTURE WATER DEMAND MODEL

Report for Metro Vancouver

June 2013

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DISCLAIMER

The data that is presented in this report provides the best estimates for agriculture water demand that can be generated at this time. While every effort has been made to ensure the accuracy and completeness of the information, the information should not be considered as final. The Government of Canada, the BC Ministry of Agriculture, and the BC Agriculture Council or its directors, agents, employees, or contractors will not be liable for any claims, damages, or losses of any kind whatsoever arising out of the use of, or reliance upon, this information.

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Background

The Agriculture Water Demand Model (AWDM) was developed in the Okanagan Watershed. It was developed 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 (BC) are fully allocated or will be in the next 15 to 20 years. The AWDM helps to understand current agricultural water use and helps 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 BC by providing current and future agricultural water use data.

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

The Model was developed to provide current and future agricultural water demands. The Model 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 sub-basin. Crop, irrigation system type, soil texture and climate data are used to calculate the water demand. Climate data from 2003 was used to present information on one of the hottest and driest years on record, and 1997 data was used to represent a wet year. Lands within the Agriculture Land Reserve (ALR), depicted in green in Figure 1, were included in the project.

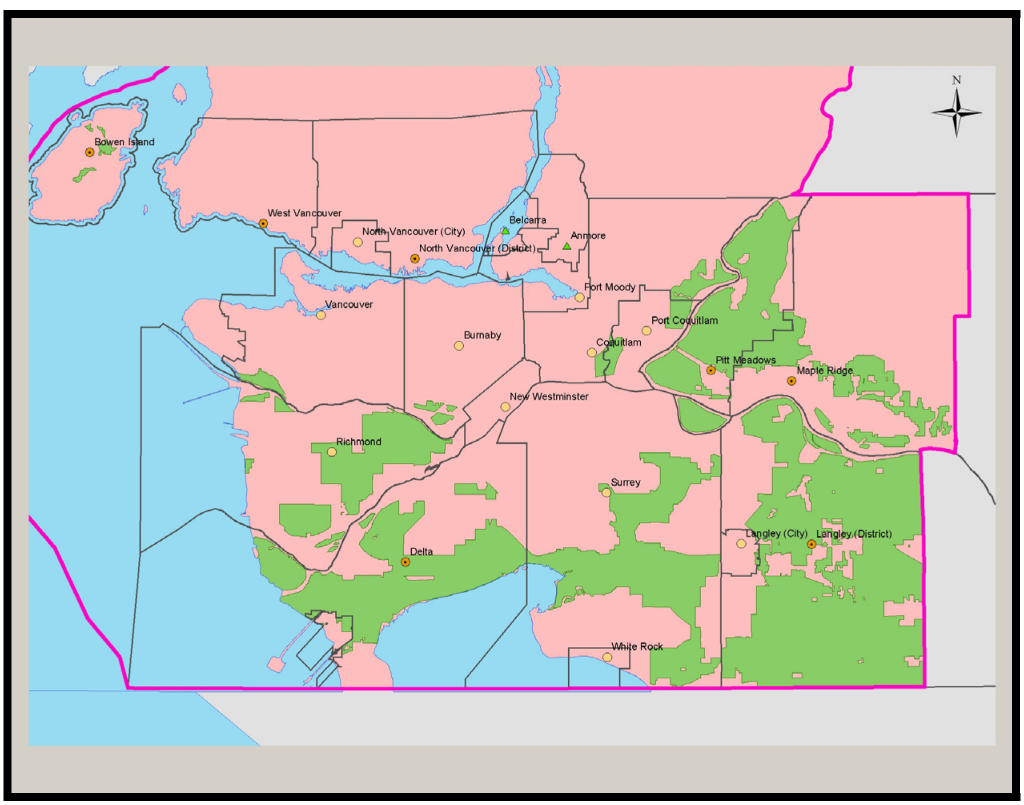

Figure 1 Map of ALR in Metro Vancouver

Methodology

The Model is based on a Geographic Information System (GIS) database that contains information on cropping, irrigation system type, soil texture and climate. An explanation of how the information was compiled for each is given below. The survey area included all properties within the ALR and areas that were zoned for agriculture by the local governments. The inventory was undertaken by Ministry of Agriculture (AGRI) staff, hired professional contractors and summer students.

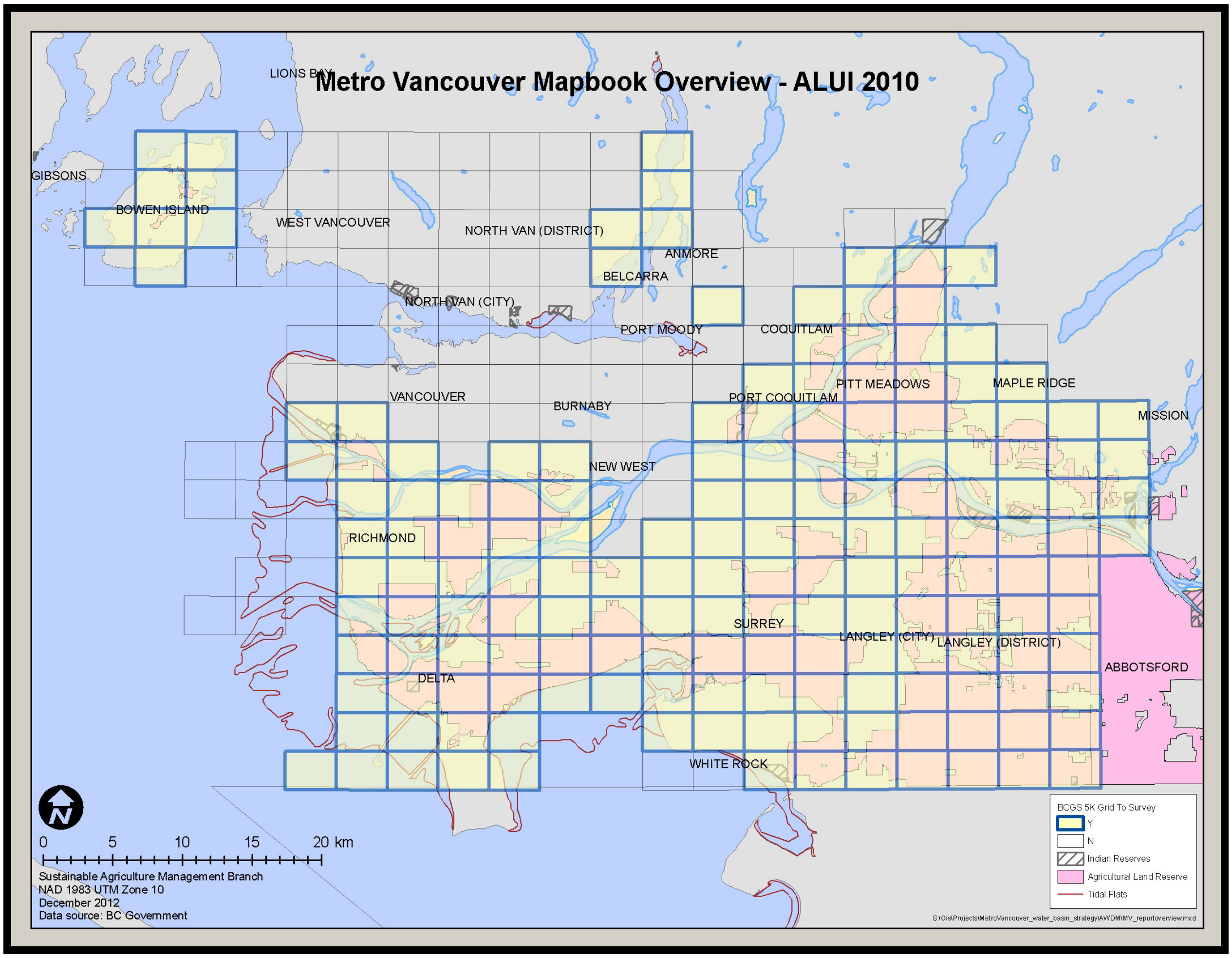

Figure 2 Overlaid Survey Map Sheets, Metro Vancouver

Cadastre

Cadastre information was provided by Metro Vancouver. The entire Metro Vancouver region is covered in one dataset which allows the Model to report out on each sub-basin, local government, water purveyor or groundwater aquifer. A GIS technician used aerial photographs to conduct an initial review of cropping information by cadastre, and divided the cadastre into polygons that separate farmstead and driveways from cropping areas. Different crops were also separated into different polygons if the difference could be identified on the aerial photographs. This data was entered into the database that was used by the field teams to conduct and complete the land use survey.

Land Use Survey

The survey maps and database were created by AGRI for the survey crew to enter data about each property. Surveys were done through the summers of 2010 and 2011, with some additional ground truthing done in 2012. The survey crew drove by each property where the team checked the database for accuracy using visual observation and the aerial photographs on the survey maps. A Professional Agrologist verified what was on the site, and a GIS technician altered the codes in the database as necessary (Figure 3). Corrections were handwritten on the maps during. The maps were then brought back to the office to have the hand-drawn lines digitized into the GIS system and have the additional polygons entered into the database.

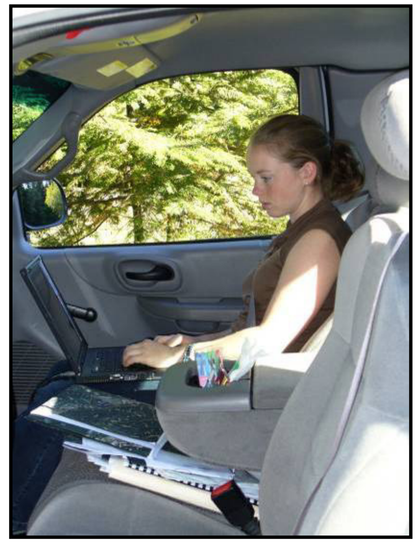

Figure 3 Land Use Survey

Once acquired through the survey, the land use data was brought into the GIS to facilitate analysis and produce maps. Digital data, in the form of a database and GIS shape files (for maps), is available upon request through a data sharing agreement with the Ministry of Agriculture.

Figure 4 provides an example of a map sheet from Langley. The Metro Vancouver region was divided into 250 map sheets. Each map sheet also had a key map to indicate where it was located in the region.

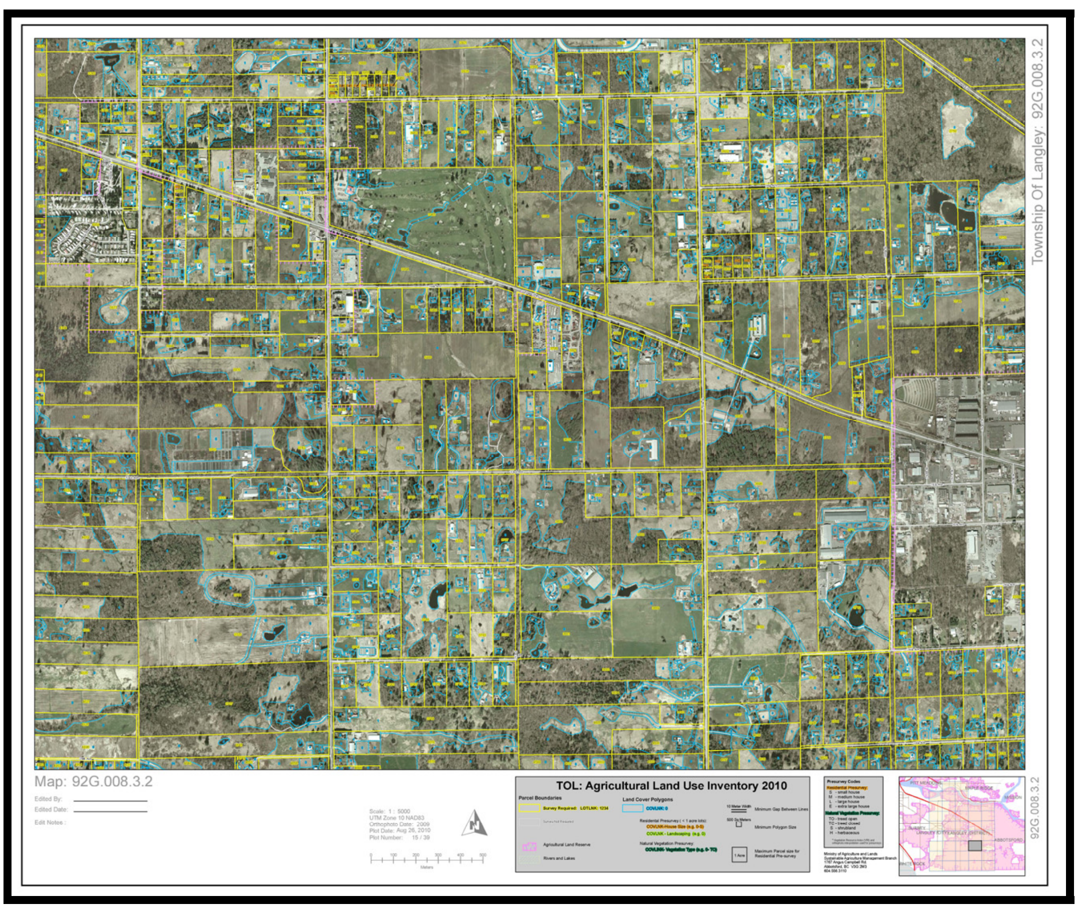

Figure 4 GIS Map Sheet

The smallest unit for which water use is calculated are the polygons within each cadastre. A polygon is determined by a change in land use or irrigation system within a cadastre. Polygons are designated as blue lines within each cadastre as shown in Figures 4 and 5. The dataset for Metro Vancouver encompasses 14,078 land parcels that are in or partially in the ALR. There are a total of 118,731 polygons generated within these land parcels. Figure 5 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.

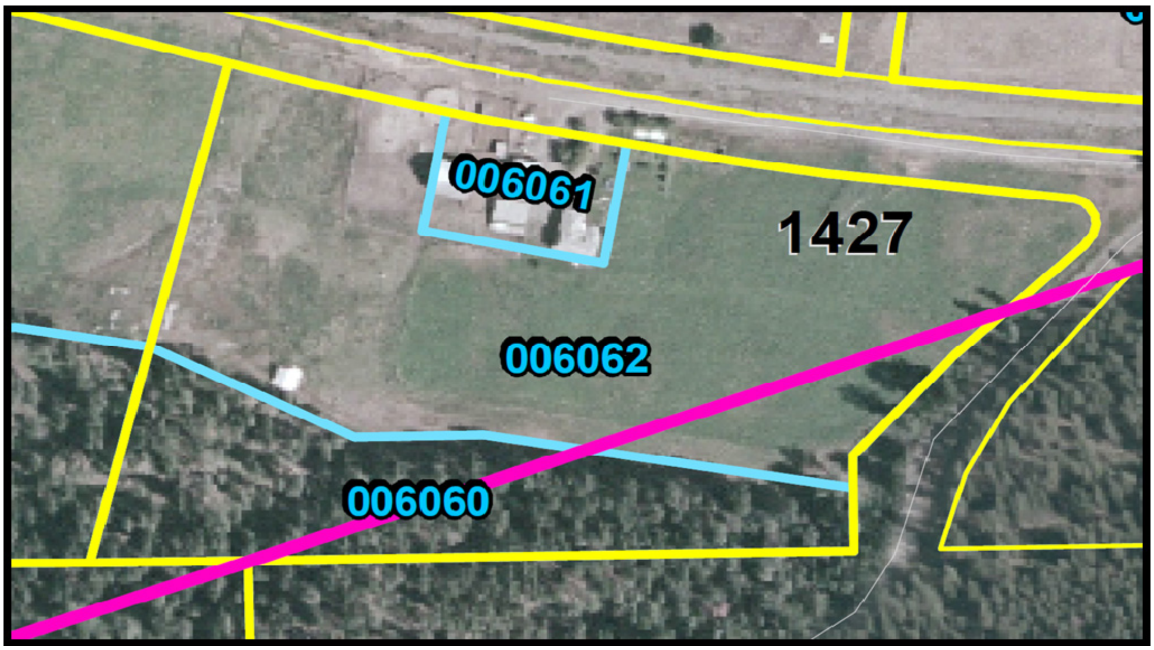

Figure 5 Cadastre with Polygons

Soil Information

Soil information was obtained digitally from the Ministry of Environment's Terrain and Soils Information System. The Computer Assisted Planning and Map Production application (CAPAMP) provided detailed (1:20,000 scale) soil surveys that were conducted in the Lower Mainland, on Southeast Vancouver Island, and in the Okanagan-Similkameen areas during the early 1980s. Products developed include soil survey reports, maps, agriculture capability and other related themes. Soil information required for this project was the soil texture (loam, etc.), 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 6 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.

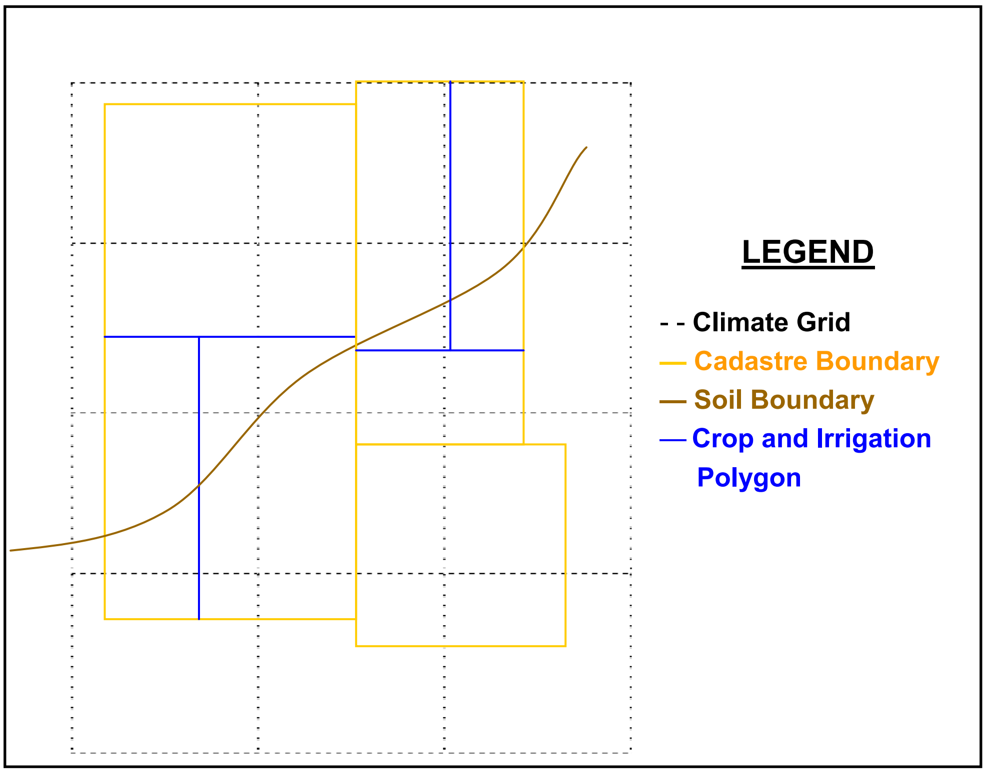

Figure 6 GIS Model Graphic

Climate Information

The agricultural water demand is calculated using climate, crop, irrigation system and soil information data. To incorporate the climatic diversity, climate layers were developed for the entire region on a 500 m x 500 m grid. Each grid cell contains daily climate data, minimum and maximum temperature (T_{min} and T_{max}), and precipitation which allows 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 (Tsum) 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 existing data from climate stations in and around Metro Vancouver from 1961 to 2003. This climate data set was then interpolated to provide a climate data layer for the entire watershed on the 500 m x 500 m grid. A detailed description of the Model can be obtained by contacting the authors.

Some of the existing climate stations that were used to determine the climate coverage are shown in Figure 7. The attributes attached to each climate grid cell include:

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

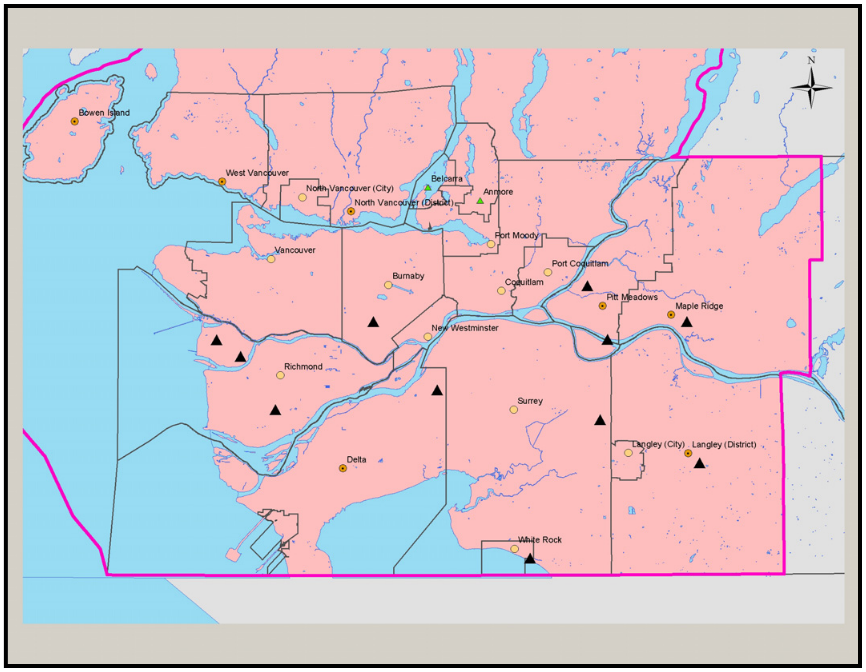

Figure 7 Metro Vancouver Climate Stations

The climate database generated contains T_{min}, T_{max}, T_{mean} and Precipitation for each day of the year from 1961 to 2003. The parameters that need to be selected, calculated and stored within the Model are evapotranspiration (ET_o), Tsum of 1,000 (for the Fraser Valley), effective precipitation (EP), frost free days, GDD with base temperatures of 5 ^oC and 10 ^oC, CHU, and first frost date. 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.

Model Calculations

The Model calculates the water demand for each polygon by using crop, irrigation, soil and climate parameters as explained below. Each polygon has been assigned an ID number as mentioned previously.

It should be noted that in Metro Vancouver, many low-lying areas have high water tables which will reduce the overall irrigation demand. Agricultural water demand results from the Model will therefore be higher than what may actually be used as water tables have not been incorporated in the equation.

Crop

The CropID is an attribute of the PolygonID as each polygon will contain a single crop. The crop information (observed during the land use survey) has been collected and stored with PolygonID as part of the land use survey. CropID will provide cropping attributes to the Model for calculating water use for each polygon. CropID along with the climate data will also be 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.

Irrigation

The IrrigID is an attribute of the PolygonID as each polygon will have a single irrigation system type operating. The irrigation information has been collected and stored (as observed during the land use survey) with the land use data. The land use survey determined if a polygon had an irrigation system operating, what the system type was, and if the system was being used. The IrrigID has an irrigation efficiency listed as an attribute.

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

Soil

The soil layer came from CAPAMP at the 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 at the beginning of the season is calculated using the same terms as the MSWD.

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 (^{o}C)
- Maximum Temperature, degree Celsius (^{o}C)
- 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

Agricultural Water Demand Equation

The Model calculates the Agriculture Water Demand (AWD) for each polygon, as a unique crop, irrigation system, soil and climate data is recorded on a polygon basis. The polygons are then summed to determine the AWD for each cadastre. The cadastre water demand values are then summed to determine AWD for the basin, sub-basin, water purveyor or local government. The following steps provide the process used by the Model to calculate Agricultural Water Demand. Detailed information is available on request.

1. Pre-Season Soil Moisture Content

Prior to the start of each crop's growing season, the soil's stored moisture content is modelled using the soil and crop evaporation and transpiration characteristics and the daily precipitation values. Precipitation increases the soil moisture content and evaporation (modelled using the reference potential evapotranspiration) depletes it. In general, during the pre-season, the soil moisture depth cannot be reduced beyond the maximum evaporation depth; grass crops in wet climates, however, can also remove moisture through crop transpiration.

The process used to model the pre-season soil moisture content is:

1. Determine whether the modelling area is considered to be in a *wet* or *dry* climate (see *Wet/Dry Climate Assessment*), and retrieve the early season evaporation factor in the modelling area
2. For each crop type, determine the start of the growing season (see *Growing Season Boundaries*)
3. For each crop and soil combination, determine the *maximum soil water deficit* (MSWD) and *maximum evaporation factor* (maxEvaporation)
4. Start the initial storedMoisture depth on January 1 at the MSWD level
5. For each day between the beginning of the calendar year and the crop's growing season start, calculate a new storedMoisture from:

    a. the potential evapotranspiration (ET_o)
    b. the early season evaporation factor (earlyEvaporationFactor)
    c. the effective precipitation (EP) = actual precipitation x earlyEvaporationFactor
    d. daily Climate Moisture Deficit (CMD) = ET_o – EP
    e. storedMoisture = previous day's storedMoisture – CMD

A negative daily CMD (precipitation in excess of the day's potential evapotranspiration) adds to the stored moisture level while a positive climate moisture deficit reduces the amount in the stored moisture reservoir. The stored moisture cannot exceed the maximum soil moisture deficit; any precipitation that would take the stored moisture level above the MSWD gets ignored.

For all crops and conditions except for grass in wet climates, the stored moisture content cannot drop below the maximum soil water deficit minus the maximum evaporation depth; without any crop transpiration in play, only a certain amount of water can be removed from the soil through evaporative processes alone. Grass in wet climates does grow and remove moisture from the soil prior to the start of the irrigation season however. In those cases, the stored moisture level can drop beyond the maximum evaporation depth, theoretically to 0.

Greenhouses and mushroom barns have no stored soil moisture content.

2. In-Season Precipitation

During the growing season, the amount of precipitation considered effective (EP) depends on the overall wetness of the modelling area's climate (see *Wet/Dry Climate Assessment*). In dry climates, the first 5 mm of precipitation is ignored, and the EP is calculated as 75% of the remainder:

$$EP = (Precip - 5) \times 0.75$$

In wet climates, the first 5 mm is included in the EP. The EP is 75% of the actual precipitation:

$$EP = Precip \times 0.75$$

Greenhouses and mushroom barns automatically have an EP value of 0.

3. *Crop Cover Coefficient (K_c)*

As the crops grow, the amount of water they lose due to transpiration changes. Each crop has a pair of polynomial equations that provide the crop coefficient for any day during the crop's growing season. It was found that two curves, one for modelling time periods up to the present and one for extending the modelling into the future, provided a better sequence of crop coefficients than using a single curve for all years (currently 1961 to 2100). The application automatically selects the current or future curve as modelling moves across the c*rop Curve Changeover Year*.

For alfalfa crops, there are different sets of equations corresponding to different cuttings throughout the growing season.

4. *Crop Evapotranspiration (ET_c)*

The evapotranspiration for each crop is calculated as the general ET_o multiplied by the crop coefficient (K_c):

$$ET_c = ET_o \times K_c$$

5. *Climate Moisture Deficit (CMD)*

During the growing season, the daily Climate Moisture Deficit (CMD) is calculated as the crop evapotranspiration (ET_c) less the Effective Precipitation (EP):

$$CMD = ET_c - EP$$

During each crop's growing season, a stored moisture reservoir methodology is used that is similar to the soil moisture content calculation in the pre-season. On a daily basis, the stored moisture level is used towards satisfying the climate moisture deficit to produce an *adjusted Climate Moisture Deficit* (CMD_a):

$$CMD_a = CMD - storedMoisture$$

If the storedMoisture level exceeds the day's CMD, then the CMD_a is 0 and the stored moisture level is reduced by the CMD amount. If the CMD is greater than the stored moisture, then all of the stored moisture is used (storedMoisture is set to 0) and the adjusted CMD creates an irrigation requirement.

The upper limit for the storedMoisture level during the growing season is the maximum soil water deficit (MSWD) setting.

6. *Crop Water Requirement (CWR)*

The Crop Water Requirement is calculated as the adjusted Climate Moisture Deficit (CMD_a) multiplied by the soil water factor (swFactor) and any stress factor (used primarily for grass crops):

$$CWR = CMD_a \times swFactor \times stressFactor$$

7. *Irrigation Requirement (IR)*

The Irrigation Requirement is the Crop Water Requirement (CWR) after taking into account the irrigation efficiency (I_e) and, for drip systems, the drip factor (D_f):

$$IR = CWR \times \frac{D_f}{I_e}$$

For irrigation systems other than drip, the drip factor is 1.

8. *Irrigation Water Demand (IWD_{perc} and IWD)*

The portion of the Irrigation Water Demand lost to deep percolation is the Irrigation Requirement (IR) multiplied by the percolation factor (soilPercFactor):

$$IWD_{perc} = IR \times soilPercFactor$$

The final Irrigation Water Demand (IWD) is then the Irrigation Requirement (IR) plus the loss to percolation (IWD_{perc}):

$$IWD = IR + IWD_{perc}$$

9. *Frost Protection*

For some crops (e.g. cranberries), an application of water is often used under certain climatic conditions to provide protection against frost damage. For cranberries, the rule is: when the temperature drops to 0 ^oC or below between March 16 and May 20 or between October 1 and November 15, a frost event will be calculated. The calculated value is an application of 2.5 mm per hour for 10 hours. In addition, 60% of the water is recirculated and reused, accounting for evaporation and seepage losses.

This amounts to a modelled water demand of 10 mm over the cranberry crop's area for each day that a frost event occurs between the specified dates.

10. *Annual Soil Moisture Deficit*

Prior to each crop's growing season, the Model calculates the soil's moisture content by starting it at full (maximum soil water deficit level) on January 1, and adjusting it daily according to precipitation and evaporation. During the growing season, simple evaporation is replaced by the crop's evapotranspiration as it progresses through its growth stages. At the completion of each crop's growing season, an annual soil moisture deficit (SMD) is calculated as the difference between the soil moisture content at that point and the maximum soil water deficit (MSWD):

$$SMD = MSWD - storedMoisture$$

In dry/cold climates, this amount represents water that the farmer would add to the soil in order to prevent it from freezing. Wet climates are assumed to have sufficient precipitation and warm enough temperatures to avoid the risk of freezing without this extra application of water; the SMD demand is therefore recorded only for dry areas.

There is no fixed date associated with irrigation to compensate for the annual soil moisture deficit. The farmer may choose to do it any time after the end of the growing season and before the freeze up. In the Model's summary reports, the water demand associated with the annual soil moisture deficit shows as occurring at time 0 (week 0, month 0, etc.) simply to differentiate it from other demands that do have a date of occurrence during the crop's growing season.

Greenhouses and mushroom barns do not have an annual soil moisture deficit.

11. Flood Harvesting

Cranberry crops are generally harvested using flood techniques. The Model calculates the flood harvesting demand as 250 mm of depth for 10% of the cranberry farmed area. For modelling purposes, it is assumed that 250 mm of water gets applied to the total cranberry crop area, 10% at a time. The water is reused for subsequent portions, but by the time the entire crop is harvested, all of the water is assumed to have been used and either depleted through losses or released from the farm.

The water demand is therefore calculated as a fixed 25 mm over the entire cranberry crop area. The harvesting generally takes place between mid-October and mid-November where the Model treats it as occurring on the fixed date of November 16.

Livestock Water Use

The Model calculates an estimated livestock water demand using agricultural census data and an estimate of the water use per animal. Water use for each animal type is calculated a bit 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 10 gpm flow rate, 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 demand is applied to the farm location. However, in the case of beef, the livestock spend quite a bit 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 fine 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

Definition and Calculation of Individual Terms used in the Irrigation Water Demand Equation

Growing Season Boundaries

There are three sets of considerations used in calculating the start and end of the irrigation season for each crop:

- temperature-based growing season derivations, generally using Temperature Sum (Tsum) or Growing Degree Day (GDD) accumulations
- the growing season overrides table
- the irrigation season overrides table

These form an order of precedence with later considerations potentially overriding the dates established for the previous rules. For example, the temperature-based rules might yield a growing season start date of day 90 for a given crop in a mild year. To avoid unrealistic irrigation starts, the season overrides table might enforce a minimum start day of 100 for that crop; at that point, the season start would be set to day 100. At the same time, a Water Purveyor might not turn on the water supply until day 105; specifying that as the minimum start day in the irrigation season overrides table would prevent any irrigation water demands until day 105.

This section describes the rules used to establish growing season boundaries based on the internal calculations of the Model. The GDD and Tsum Day calculations are described in separate sections. The *standard end of season* specified for several crops is the earlier of the end date of Growing Degree Day with base temperature of 5 ^{o}C (GDD_5) or the first frost.

1. ***Corn (silage corn)***
   - uses the corn_start date for the season start
   - season end: earlier of the killing frost or the day that the CHU2700 (2700 Corn Heat Units) threshold is reached

2. ***Sweetcorn, Potato, Tomato, Pepper, Strawberry, Vegetable, Pea***
   - corn_start date for the season start
   - corn start plus 110 days for the season end

3. ***Cereal***
   - GDD_5 start for the season start
   - GDD_5 start plus 130 days for the season end

4. ***AppleHD, AppleMD, AppleLD, Asparagus, Berry, Blueberry, Ginseng, Nuts, Raspberry, Sourcherry, Treefruit, Vineberry***
   - season start: (0.8447 x tsum600_day) + 18.877
   - standard end of season

5. ***Pumpkin***
   - corn_start date
   - standard end of season

6. ***Apricot***
   - season start: (0.9153 x tsum400_day) + 5.5809
   - standard end of season

7. ***CherryHD, CherryMD, CherryLD***
   - season start: (0.7992 x tsum450_day) + 24.878
   - standard end of season

8. ***Grape, Kiwi***
   - season start: (0.7992 x tsum450_day) + 24.878
   - standard end of season

9. ***Peach, Nectarine***
   - season start: (0.8438 x tsum450_day) + 19.68
   - standard end of season

10. ***Plum***
    - season start: (0.7982 x tsum500_day) + 25.417
    - standard end of season

11. ***Pear***
    - season start: (0.8249 x tsum600_day) + 17.14
    - standard end of season

12. ***Golf, TurfFarm***
    - season start: later of the GDD_5 start and the tsum300_day
    - standard end of season

13. ***Domestic, Yard, TurfPark***
    - season start: later of the GDD_5 start and the tsum400_day
    - standard end of season

14. ***Greenhouse (interior greenhouses)***
    - fixed season of April 1 – October 30

15. ***GH Tomato, GH Pepper, GH Cucumber***
    - fixed season of January 15 – November 30

16. ***GH Flower***
    - fixed season of March 1 – October 30

17. ***GH Nursery***
    - fixed season of April 1 – October 30

18. ***Mushroom***
    - all year: January 1 – December 31

19. ***Shrubs/Trees, Fstock, NurseryPOT***

- season start: tsum500_day
- end: Julian day 275

20. ***Floriculture***

- season start: tsum500_day
- end: Julian day 225

21. ***Cranberry***

- season start: tsum500_day
- end: Julian day 275

22. ***Grass, Forage, Alfalfa, Pasture***

- season start: later of the GDD_5 and the tsum600_day
- standard end of season

23. ***Nursery***

- season start: tsum400_day
- standard end of season

Evapotranspiration (ET_o)

The ET_o calculation follows the FAO Penman-Montieth equation. Two modifications were made to the equation:

- Step 6 – Inverse Relative Distance Earth-Sun (d_r)
  Instead of a fixed 365 days as a divisor, the actual number of days for each year (365 or 366) was used.

- Step 19 – Evapotranspiration (ET_o)
  For consistency, a temperature conversion factor of 273.16 was used instead of the rounded 273 listed.

Availability Coefficient (AC)

The availability coefficient is a factor representing the percentage of the soil's total water storage that the crop can readily extract. The factor is taken directly from the crop factors table (crop_factors) based on the cropId value.

Rooting Depth (RD)

The rooting depth represents the crop's maximum rooting depth and thus the depth of soil over which the plant interacts with the soil in terms of moisture extraction. The value is read directly from the crop factors table.

Stress Factor (stressFactor)

Some crops, such as *grasses*, are often irrigated to a less degree than their full theoretical requirement for optimal growth. The *stress factor* (*crop_groups_and_factors*) reduces the calculated demand for these crops.

Available Water Storage Capacity (AWSC)

The available water storage capacity is a factor representing the amount of water that a particular soil texture can hold without the water dropping through and being lost to deep percolation. The factor is taken directly from the soil factors table (*soil_factors*).

Maximum Soil Water Deficit (MSWD)

The maximum soil water deficit is the product of the crop's availability coefficient, rooting depth, and the available water storage capacity of the soil:

$$MSWD = RD \times AWSC \times AC$$

Deep Percolation Factor (soilPercFactor)

The soil percolation factor is used to calculate the amount of water lost to deep percolation under different management practices.

For greenhouse crops, the *greenhouse leaching factor* is used as the basic soil percolation factor. This is then multiplied by a greenhouse recirculation factor, if present, to reflect the percentage of water re-captured and re-used in greenhouse operations.

$$soilPercFactor = soilPercFactor \times (1 - recirculationFactor)$$

For Nursery Pot (Nursery POT) and Forestry Stock (Fstock) crops, the soil percolation factor is fixed at 35%. For other crops, the factor depends on the soil texture, the MSWD, the irrigation system, and the Irrigation Management Practices code. The percolation factors table (*soil_percolation_factors*) is read to find the first row with the correct management practices, soil texture and irrigation system, and a MSWD value that matches or exceeds the value calculated for the current land use polygon.

If the calculated MSWD value is greater than the index value for all rows in the percolation factors table, then the highest MSWD factor is used. If there is no match based on the passed parameters, then a default value of 0.25 is applied.

For example, a calculated MSWD value of 82.5 mm, a soil texture of sandy loam (SL) and an irrigation system of solid set overtree (Ssovertree) would retrieve the percolation factor associated with the MSWD index value of 75 mm in the current table (presently, there are rows for MSWD 50 mm and 75 mm for SL and Ssovertree).

Maximum Evaporation Factor (maxEvaporation)

Just as different soil textures can hold different amounts of water, they also have different depths that can be affected by evaporation. The factor is taken directly from the soil factors table.

Irrigation Efficiency (I_e)

Each irrigation system type has an associated efficiency factor (inefficient systems require the application of more water in order to satisfy the same crop water demand). The factor is read directly from the irrigation factors table (*irrigation_factors*).

Soil Water Factor (swFactor)

For the greenhouse "crop", the soil water factor is set to 1. For other crops, it is interpolated from a table (*soil_water_factors*) based on the MSWD. For Nurseries, the highest soil water factor (lowest MSWD index) in the table is used; otherwise, the two rows whose MSWD values bound the calculated MSWD are located and a soil water factor interpolated according to where the passed MSDW value lies between those bounds.

For example, using the current table with rows giving soil water factors of 0.95 and 0.9 for MSWD index values of 75 mm and 100 mm respectively, a calculated MSWD value of 82.5 mm would return a soil water factor of:

$$0.95 + \left[\frac{82.5 - 75}{100 - 75} \times (0.9 - 0.95) \right]$$
$$= 0.935$$

If the calculated MSWD value is higher or lower than the index values for all of the rows in the table, then the factor associated with the highest or lowest MSWD index is used.

Early Season Evaporation Factor (earlyEvaporationFactor)

The effective precipitation (precipitation that adds to the stored soil moisture content) can be different in the cooler pre-season than in the growing season. The early season evaporation factor is used to determine what percentage of the precipitation is considered effective prior to the growing season.

Crop Coefficient (K_c)

The crop coefficient is calculated from a set of fourth degree polynomial equations representing the crop's ground coverage throughout its growing season. The coefficients for each term are read from the crop factors table based on the crop type, with the variable equalling the number of days since the start of the crop's growing season. For example, the crop coefficient for Grape on day 35 of the growing season would be calculated as:

$$K_c = [0.0000000031 \times (35)^4] + [-0.0000013775 \times (35)^3] + (0.0001634536 \times (35)^2] + (-0.0011179845 \times 35) + 0.2399004137$$
$$= 0.346593241$$

Alfalfa crops have an additional consideration. More than one cutting of alfalfa can be harvested over the course of the growing season, and the terms used for the crop coefficient equation changes for the different cuttings. For alfalfa, the alfalfa cuttings table is first used to determine which cutting period the day belongs to (first, intermediate or last), and after that the associated record in the crop factors table is accessed to determine the terms.

There are two sets of polynomial coefficients used to calculate the crop coefficient; the first set is used for modelling time periods up to the year specified as the *crop curve changeover year*; and the second for modelling into the future. The changeover year will be modified as time goes on and new historical climate observations become available.

Growing Degree Days (GDD)

The Growing Degree Day calculations generate the start and end of GDD accumulation.

1. Start of GDD Accumulation

For each base temperature (bases 5 and 10 are always calculated, other base temperature can be derived), the start of the accumulation is defined as occurring after 5 consecutive days of T_{mean} matching or exceeding the base temperature (BaseT). The search for the start day gets reset if a killing frost ($< -2\ ^oC$) occurs, even after the accumulation has started. The search also restarts if there are 2 or more consecutive days of $T_{min} \leq 0\ ^oC$. The GDD start is limited to Julian days 1 to 210; if the accumulation has not started by that point, then it is unlikely to produce a reasonable starting point for any crop.

2. End of GDD accumulation

The search for the end of the GDD accumulation begins 50 days after its start. The accumulation ends on the earlier of 5 consecutive days where T_{mean} fails to reach BaseT (strictly *less than*) or the first killing frost ($-2\ ^oC$).

During the GDD accumulation period, the daily contribution is the difference between T_{mean} and BaseT, as long as T_{mean} is not less than BaseT:

$$GDD = T_{mean} - BaseT;\ 0 \text{ if negative}$$

Frost Indices

Three frost indices are tracked for each year:

- the last spring frost is the latest day in the first 180 days of the year with a $T_{min} \leq 0\ ^oC$
- the first fall frost is the first day between days 240 and the end of the year where $T_{min} \leq 0\ ^oC$
- the killing frost is the first day on or after the first fall frost where $T_{min} \leq -2\ ^oC$

Corn Heat Unit (CHU)

The Corn Heat Unit is the average of two terms using T_{min} and T_{max}. Prior to averaging, each term is set to 0 individually if it is negative.

$$\text{term1} = [3.33 \times (T_{max} - 10)] - [0.084 \times (T_{max} - 10) \times (T_{max} - 10)]; \text{ 0 if negative}$$

$$\text{term2} = 1.8 \times (T_{min} - 4.44); \text{ 0 if negative}$$

$$\text{CHU} = \frac{(\text{term1} + \text{term2})}{2}$$

Corn Season Start and End

The corn season boundary derivations are similar to the GDD determinations. The start day is established by 3 consecutive days where $T_{mean} \geq 11.2$ ^{o}C. As in the case of the GDD calculations, the search for the corn season start day gets reset if $T_{min} \leq -2$ ^{o}C, or if there are 2 or more consecutive days of -2 ^{o}C $\leq T_{min} \leq 0$ ^{o}C.

The search for the silage corn season end begins 50 days after the start. The season ends on the earlier of a mean temperature dropping below 10.1 or a killing frost.

The end of the sweet corn season is defined as 110 days after the season start.

Tsum Indices

The Tsum day for a given number is defined as the day that the sum of the positive daily T_{mean} reaches that number. For example, the Tsum400 day is the day where the sum of the positive T_{mean} starting on January 1 sum to 400 units or greater.

Days where T_{mean} falls below 0 ^{o}C are simply not counted; therefore, the Model does not restart the accumulation sequence.

Wet/Dry Climate Assessment

Starting with the Lower Mainland, some of the modelling calculations depend on an assessment of the general climatic environment as *wet* or *dry*. For example, when modelling the soil moisture content prior to the start of the crop's growing season, the reservoir can only be drawn down by evaporation except for *grass* crops in *wet* climates which can pull additional moisture out of the soil.

The assessment of wet or dry uses the total precipitation between May 1 and September 30. If the total is more than 125 mm during that period, the climate is considered to be *wet* and otherwise *dry*.

Groundwater Use

The Model generates water sources for irrigation systems. This is done by first determining which farms are supplied by a water purveyor, and then coding those farms as such. Most water purveyors use surface water but where groundwater is used, the farms are coded as groundwater use. The second step is to check all water licences and assign the water licences to properties in the database. The remaining farms that are irrigating will therefore not have a water licence or be supplied by a water purveyor. The assumption is made that these farms are irrigated by groundwater sources.

Land Use Results

A summary of the land area and the inventoried area of Metro Vancouver is shown in Table 2. The inventoried area includes parcels that are in and partially in the Agricultural Land Reserve (ALR). The primary agricultural use of the ARL area is shown in Tables 3 and 4 where only 9,413 parcels currently have active agriculture. Table 4 provides a breakdown between the larger municipalities within Metro Vancouver. Refer to the Agricultural Land Use Inventory reports for details.

The Model also reports out on groundwater aquifers and water purveyors. Figure 8 provides a schematic of the higher yielding aquifer areas in the Metro Vancouver Region based on the information from B.C. Ministry of Environment. Figure 9 shows the locations of the areas supplied by water purveyors in Metro Vancouver.

Table 2 Overview of Metro Vancouver's Land and Inventoried Area

Area Type	Area (ha)	Number of Parcels
Metro Vancouver		
Total Area	338,940	-
Area of Water Feature	56,711	-
Area of Land (excluding water features)	282,229	-
ALR Area	60,554	12,385
Area of First Nations Reserve	1,808	91
Inventoried Area		
Total Inventoried Area	70,821	16,074
Area of First Nations Reserve in ALR	611	43

Table 3 Summary of Primary Agricultural Activities within the Inventoried Area where Primary Land Use is Agriculture in Metro Vancouver

Primary Agriculture Activity	Total Land Cover (ha)	Number of Parcels
Blueberry	5,527	1,192
Cranberry	2,591	565
Raspberry	177	59
Strawberry	180	53
Berry-other	55	20
Grapes	59	40
Tree Fruits	36	58
Vegetables	4,478	909
Forage	14,867	5,240
Nursery	744	413
Tree Plantation	291	137
Cereal, grains, oilseeds	706	83
Floriculture	6	14
Turf	93	14
Nut Trees	48	40
Glass Greenhouse	325	131
Poly Greenhouse	210	445
Total	**30,393**	**9,413**

Table 4 Summary of Primary Agricultural Activities within the Inventoried Area where Primary Land Use is Agriculture by Local Government in Metro Vancouver

Commodity	Richmond	Delta	Surrey	Township of Langley	Maple Ridge	Pitt Meadows	Other Areas
Blueberry							
Area (ha)	492	848	1,380	870	61	1,526	327
Number of Parcels	401	69	213	138	29	219	-
Cranberry							
Area (ha)	871	305	10	255	57	943	150
Number of Parcels	375	16	1	19	5	94	-
Raspberry							
Area (ha)	5	11	11	141	-	4	5
Number of Parcels	6	5	2	29	-	5	-
Strawberry							
Area (ha)	61	63	5	37	-	2	12
Number of Parcels	12	1	4	9	-	4	-
Vegetables							
Area (ha)	647	2,396	692	109	25	1	645
Number of Parcels	203	292	142	49	17	2	-
Forage & Pasture							
Area (ha)	392	2,149	2,275	6,701	677	1,020	638
Number of Parcels	95	392	535	2,423	458	277	-
Equines							
Number of Parcels	32	71	101	950	309	36	-
Poultry							
Number of Parcels	11	10	56	200	57	6	-
Beef							
Number of Parcels	5	8	33	195	27	6	-
Sheep/Goat							
Number of Parcels	4	3	24	98	20	3	-
Dairy							
Number of Parcels	5	11	16	40	5	10	-

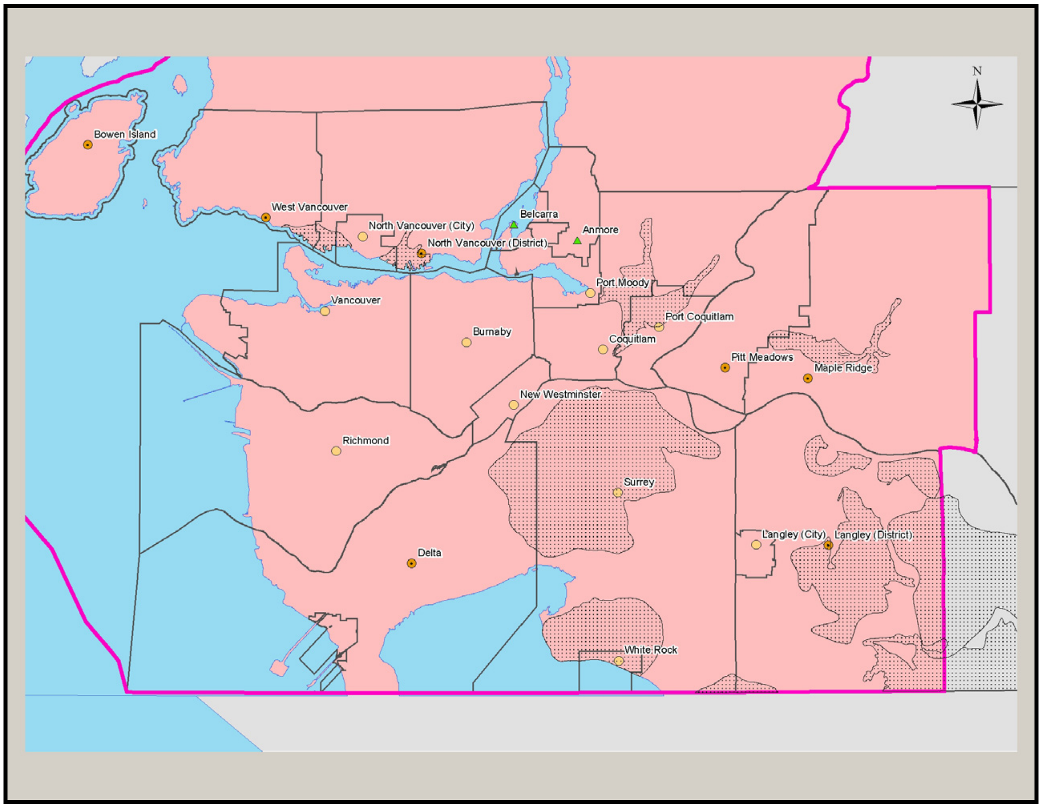

Figure 8 Higher Productive Groundwater Aquifers in Metro Vancouver

Agricultural Water Demand Model Results

The Model has a reporting feature that can save and generate reports for many different scenarios that have been pre-developed. This report will provide a summary of the reported data in the Appendices. Climate data from 1997 and 2003 were chosen as they represent a relatively wet year and dry year respectively. Most reports are based on the 2003 data since the maximum current demand can then be presented.

Annual Crop Water Demand – Tables A and B

The Model can use three different irrigation management factors, good, average and poor. Unless otherwise noted, average management were used in the tables. Table A provides the annual irrigation water demand for current crop and irrigation systems for the year 2003 using average irrigation management, and Table B provides the same data for 1997.

The outdoor irrigated acreage in Metro Vancouver is 13,070 hectares (ha) including 1,170 ha in golf courses. The total annual irrigation demand for this area was 60,722,902 m^3 in 2003 (a dry year), and dropped to 36,622,623 m^3 in 1997 (a wet year). There were 39.8 ha of land surveyed that had an irrigation system but were deemed to be not in use.

Of interest is that during a wet year like 1997, the demand was only 60% of a hot dry year like 2003. Another point to consider is that the actual water demand supplied by an irrigation system may be less than the numbers shown above. The reason is that the Model does not have an adjustment for water supplied to the crop by high water tables. In large portions of the Fraser Valley, agriculture is located in the lowland regions which have predominantly high water tables due to the drainage and irrigation ditch infrastructure. The high water tables will reduce irrigation demand that is not accounted for in the Model outputs. The numbers should therefore be considered the highest estimate demand.

In addition, the Model also calculates demand based on relatively good practices. As such, actual use may actually be higher or lower than what is calculated by the Model.

The predominant irrigated agriculture crop in Metro Vancouver is blueberries, followed by cranberries, vegetables and then forage that includes grass and pasture.

Annual Water Demand Reported by Irrigation System – Table C

The crop irrigation demand can also be reported by irrigation system type as shown in Tables C. The total area irrigated includes indoor irrigation, such as greenhouses and mushroom farms. The total area that is currently irrigated by efficient systems such as drip, microsprinkler or microspray is 3,790 ha or 29% of all areas irrigated.

Annual Water Demand by Soil Texture – Table D

Table D provides the annual water demand by soil texture. Where soil texture data is missing, the soil texture has been defaulted to sandy loam. The defaults are shown in the Table D.

Water Demand by Purveyor – Table E

Many of the local governments in Metro Vancouver supply water to agricultural areas through a network of pumps and drainage channels. In essence, these are purveyors of water to agriculture. Figure 9 shows where these areas are and Table E in the appendix provides a breakdown of the water supplied by purveyors. Water supplied by local governments in Metro Vancouver accounts for 64% of the total water supplied.

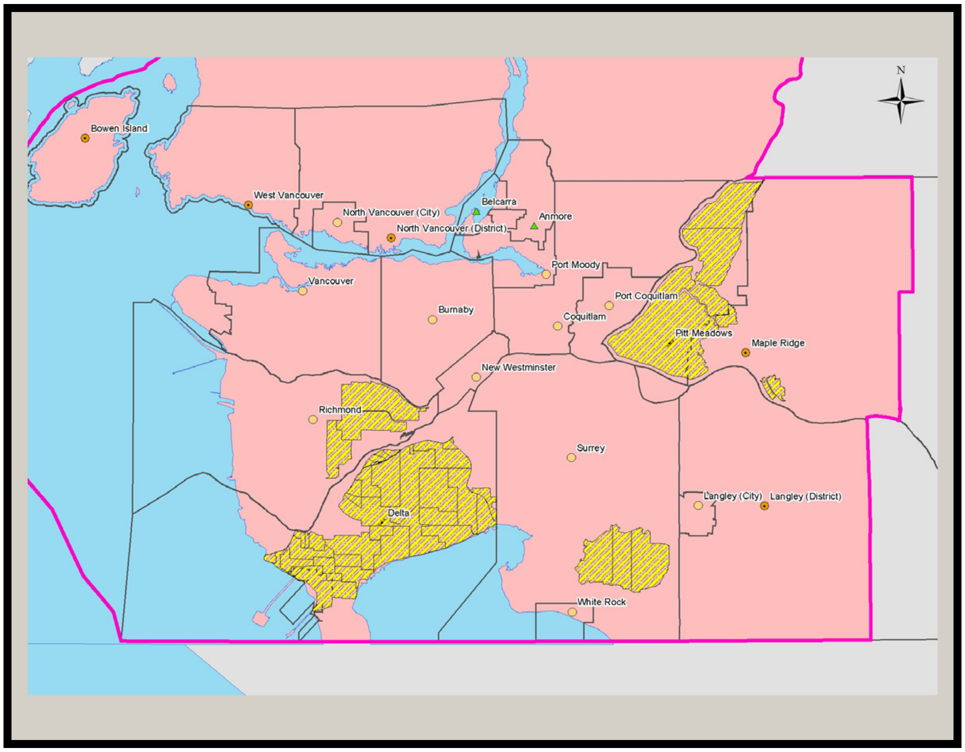

Figure 9 Water Purveyors in Metro Vancouver Region

Irrigated Area within Local Governments – Table F

Table F provides a breakdown of the agriculture irrigated areas within the boundaries of each local government within Metro Vancouver.

Irrigation Management Factors – Table G

The Model can estimate water demand based on poor, average and good irrigation management factors. This is accomplished by developing an irrigation management factor for each crop, soil and irrigation system combination based on subjective decision and percolation rates. The Maximum Soil Water Deficit (MSWD) is the maximum amount of water that can be stored in the soil within the crop rooting zone. An irrigation system applying more water than what can be stored will result in percolation beyond the crop's rooting depth. Irrigation systems with high application rates will have a probability of higher percolation rates, a stationary gun for instance.

For each soil class, a range of four MSWD are provided, which reflect a range of crop rooting depths. An irrigation management factor, which determines the amount of leaching, is established for each of the MSWD values for the soil types (Table 5). The management factor is based on irrigation expertise as to how the various irrigation systems are able to operate. For example, Table 5 indicates that for a loam soil and a MSWD of 38 mm, a solid set overtree system has a management factor of 0.10 for good management while the drip system has a management factor of 0.05. This indicates that it is easier to prevent percolation with a drip system than it is with a solid set sprinkler system. For poor management, the factors are higher.

There are a total of 1,344 irrigation management factors established for the 16 different soil textures, MSWD and 21 different irrigation system combinations used in the Model.

Table 5 Irrigation Management Factors

Soil Texture	MSWD	Solid Set Overtree			Drip		
		Good	Average	Poor	Good	Average	Poor
Loam	38	0.10	0.15	0.20	0.05	0.10	0.15
	50	0.05	0.10	0.15	0.05	0.075	0.10
	75	0.05	0.10	0.15	0.05	0.075	0.10
	100	0.05	0.075	0.10	0.05	0.075	0.10
Sandy loam	25	0.20	0.225	0.25	0.10	0.15	0.20
	38	0.10	0.15	0.20	0.10	0.125	0.15
	50	0.05	0.10	0.15	0.05	0.10	0.10
	75	0.05	0.10	0.15	0.05	0.075	0.10

The management factors increase as the MSWD decreases because there is less soil storage potential in the crop rooting depth. For irrigation systems such as guns, operating on a pasture which has a shallow rooting depth, on a sandy soil which cannot store much water, the poor irrigation management factor may be as high as 0.50.

The management factor used in the Model assumes all losses are deep percolation while it is likely that some losses will occur as runoff as well.

Table G provides an overview of the impacts on the management factors and irrigation systems used. Since a large portion of the crops in the region are irrigated with drip systems, the impacts of improved management are not that significant. An improvement of 7% in total water use reduction could be achieved by improved management. A further reduction could be achieved by improving irrigation efficiencies as shown in Table I.

Table G also provides percolation rates based on good, average and poor management using 2003 climate data. In summary, good management is 5,193,669 m^3, average is 6,833,451 $m^3$and poor management is 8,473,232 m^3. Percolation rates for poor management are 63% higher than for good management.

Deep Percolation – Table H

The percolation rates vary by crop, irrigation system type, soil and the management factor used. Table H shows the deep percolation amounts by irrigation system type for average management. The last column provides a good indication of the average percolation per hectare for the various irrigation system types.

Landscape systems have a high percolation rate predominantly because application rates are high and the crop rooting depth is quite shallow. Microspray and microsprinklers are also shown to have high percolation rates but these systems are likely inside greenhouse nursery systems and the water may be recirculated.

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 berry 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 Metro Vancouver, using good irrigation management. The water demand for 2003 would reduce from 60,722,902 m^3 to 54,160,497 m^3 if sprinkler systems were converted to drip and good management practices were implemented. Since many of the horticultural crops are already using drip systems, (e.g., blueberries) the reduction achieved is 10%.

Water Demand for Frost Protection, Greenhouse and Crop Harvesting – Table J

Greenhouse water use is calculated with separate algorithms as the water demand may not be directly related to ET_o during times of the year when the greenhouse is heated. The estimated water demand is therefore shown separately from other crops in Table J. Other crops that fall in this category are potted nursery plants, forestry stock found inside plastic shelters and mushroom house water use.

Irrigation systems are also used for frost protection for crops such as cranberries. An estimate of frost protection is also provided. The Model calculates a water demand for frost protection whenever the temperature drops to 0^oC in the spring. In 1997, only about 10% of the cranberry area had one or more frost events. In 2003, no frost events were indicated. In reality, growers would have applied more water than what is indicated by the Model, as frost protection systems are often started prior to a frost to eliminate any risk.

Cranberries also use water for harvesting purposes. An estimate of the cranberry harvesting water requirements are provided in Table J.

Livestock Water Use – Table K

The Model provides an estimate of water use for livestock. The estimate is based on the number of animals in Metro Vancouver 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 K. For Metro Vancouver, the amount of livestock water is estimated at 1.055 million m^3.

Climate Change Water Demand for 2050 – Table L

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 2050's were selected to give a representation of climate change. Figure 10 shows the climate data results which indicate that 2053, 2056, and 2059 generate the highest annual ET_o and lowest annual precipitation. These three years were used in this report.

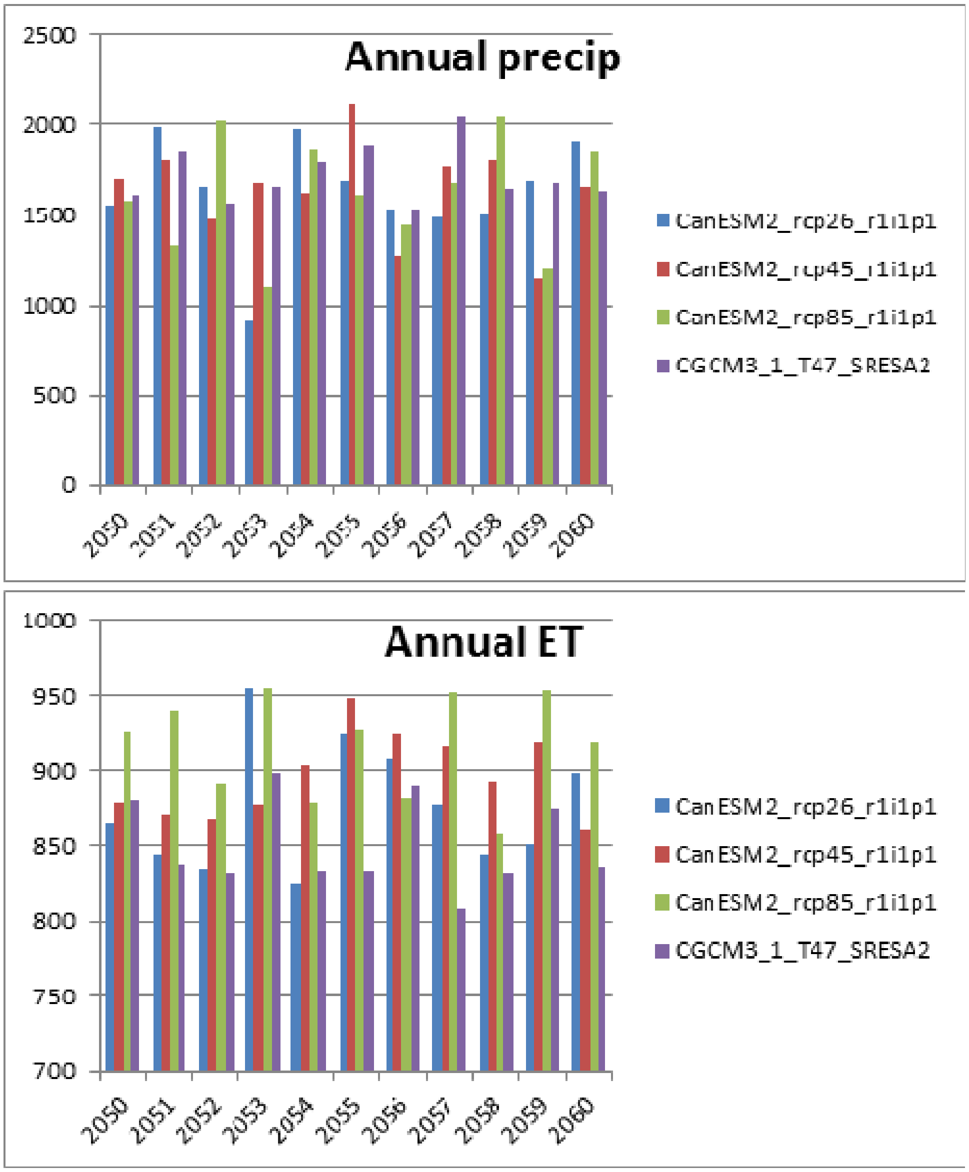

Figure 10 Annual ET and Effective Precipitation in 2050's

Table L provides the results of climate change on irrigation demand for the three years selected using current crops and irrigation systems. Current crops and irrigation systems are used to show the increase due to climate change only, with no other changes taking place.

The three climate change scenarios used in this report are RCP26, RCP45 and RCP85. While the data is shown from each Model for all three years, it is best to average the results from each Model. Without running many climate datasets, it is difficult to get a reliable trend.

However, the preliminary data indicates that without changing crops and irrigation systems, climate change may have a significant impact in drier years. On average, the three climate model results for the three hottest and driest years in the 2050's increase water demand from 60.7 million m^3 in 2003 to 69.7 million m^3. RCP85 generates an average of 77.9 million m^3 in the 2050's. These results show an average increase of 14% with possible increases of 28% in extreme years.

Figure 11 shows all of the climate change scenario runs for the Okanagan using 12 climate models from 1960 to 2100. This work was compiled by Denise Neilsen at the Agriculture and Agri-Food Canada – Summerland Research Station. There is a lot of scatter in this figure, but it is obvious that there is a trend of increasing water demand.

The three climate change models used in this report are RCP26, RCP45 and RCP85. Running only three climate change models on three selected future years in RDN is not sufficient to provide a trend like in Figure 11. What the results do show is that in an extreme climate scenario, it is possible to have an annual water demand that is 30% higher than what was experienced in 2003. Averaging the data between the three climate change models shows that if the data for just the year 2053 is examined, the increase in demand is 10% higher than 2003. More runs of the climate change models will be required to better estimate a climate change trend for RDN.

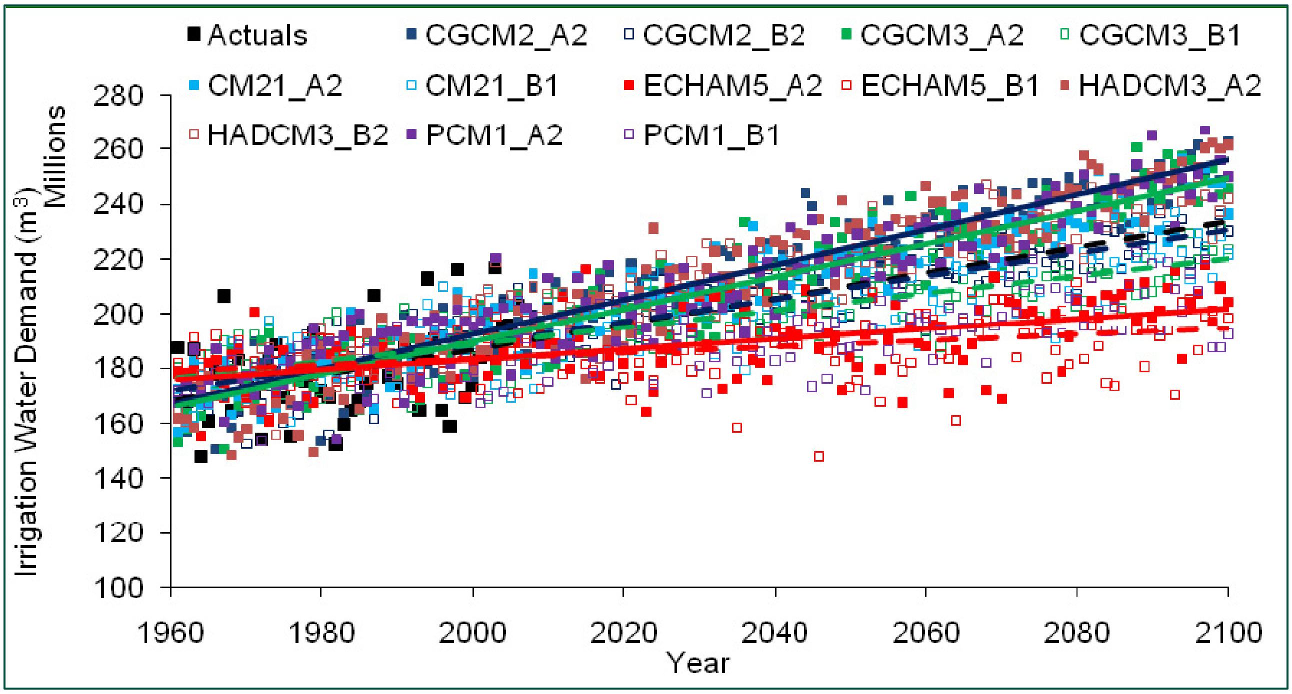

Figure 11 **Future Irrigation Demand for All Outdoor Uses in the Okanagan in Response to Observed Climate Data (Actuals) and Future Climate Data Projected from a Range of Global Climate Models**

Agricultural Buildout Crop Water Demand Using 2003 Climate Data – Table M

An agricultural 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:

For Metro Vancouver except for Langley

- 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

- with Ag Capability class 1-4 only where available
- must be within the ALR
- below 100 m average elevation

Within the Township of Langley

- within 0 m of water supply (lake)
- within 0 m of water supply (water course)
- within 0 m of water supply (wetland)
- within 0 m of high productivity aquifer
- within 0 m of water purveyor
- with Ag Capability class 1-4 only where available
- must be within the ALR
- below 100 m average elevation

Langley has different rules applied as there are too many aquifers present that allowed all of Langley to be potentially irrigated. Since the aquifers did not have that capacity, the rules were changed. The amount of land that could potentially be irrigated in Langley is still quite high.

For the areas that are determined to be eligible for future buildout, a crop and irrigation system need to be applied. Where a crop already existed in the land use inventory, that crop would remain and an irrigation system assigned. If no crop existed, then a crop and irrigation system are assigned as per the criteria below:

- **Delta**: vegetable with drip irrigation
- **Richmond**: blueberry and drip irrigation
- **Surrey**: 50% vegetable with drip irrigation and 50% blueberry with drip irrigation
- **Langley**: 50% forage with sprinkler irrigation and 50% blueberry with drip irrigation
- **Maple Ridge**: blueberry with drip irrigation
- **Burnaby, Barnston Island, Bowen Island, Langley City**: blueberry and drip irrigation
- **Coquitlam, Port Moody, Port Coquitlam, Tssawassen, Vancouver**: vegetable and drip irrigation

Figure 12 indicates the location of agricultural land that is currently irrigated (dark green) and the land that can be potentially irrigated (red). Based on the scenario provided for Metro Vancouver and Langley, the additional agricultural land that could be irrigated is 21,604 ha. The water demand for a year like 2003 is about 140 million m^3 assuming efficient irrigation systems and good management.

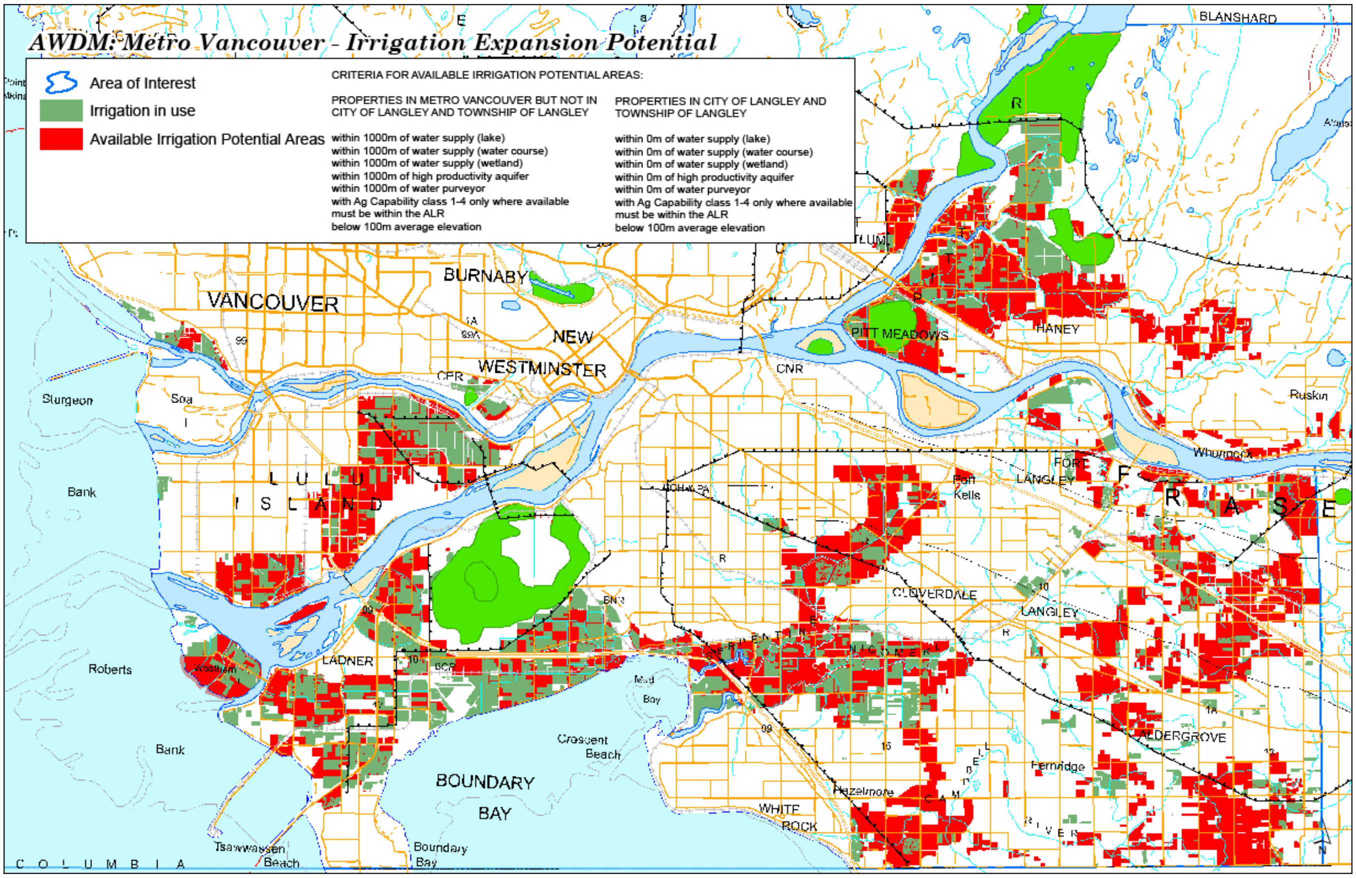

Figure 12 Metro Vancouver Irrigation Expansion Potential

Agricultural Buildout Crop Water Demand for 2050 – Table N

The same irrigation expansion and cropping scenario used to generate the values in Table M were used to generate the climate change water demand shown in Table N. Three climate models were used and the results averaged. See discussion under Table L section. When climate change is added to the buildout scenario, the water demand increases from 140 million m^3 to 164 million m^3.

Irrigation Systems Used for the Buildout Scenario for 2003 – Table O

Table O provides an account of the irrigation systems used by area for the buildout scenario in the previous two examples. Note that drip irrigation is the predominant system type.

Water Demand for the Buildout Area by Purveyor 2003 Climate Data – Table P

Table P provides the water demand within the current water purveyed regions of Metro Vancouver 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 for the purveyed areas.

Water Demand for the Buildout Area by Local Government 2003 Climate Data – Table Q

Table Q provides the future water demand within local government boundaries using previous scenarios. Comparing these values with the result in Table F will provide information on the possible increased water demand within local governments if the buildout scenarios actually occurred in the future.

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Appendix Tables

Appendix Table A 2003 Water Demand by Crop with Average Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Agriculture 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	0.2	1,455	663	-	-	-	-	-	-	0.2	**1,455**	663
Berry	9.5	39,533	415	-	-	-	8.0	33,401	419	17.5	**72,934**	416
Blueberry	3,536.5	11,688,826	331	-	-	-	569.6	1,959,414	344	4,106.1	**13,648,240**	332
Cranberry	2,543.0	14,408,583	567	-	-	-	27.6	155,765	565	2,570.6	**14,564,348**	567
Forage	1,505.2	8,261,618	549	-	-	-	46.5	282,325	608	1,551.7	**8,543,943**	551
Golf	898.2	5,490,431	611	-	-	-	272.1	1,687,713	620	1,170.4	**7,178,144**	613
Grape	6.6	11,192	170	-	-	-	23.9	28,995	122	30.4	**40,187**	132
Greenhouse	366.9	3,946,533	1046	-	-	-	99.8	1,054,873	1,089	466.6	**5,001,408**	1057
Mushroom	5.0	2,190	44	-	-	-	19.9	7,665	39	24.9	**9,855**	40
Nursery Floriculture	2.4	7,743	327	-	-	-	0.2	401	223	2.5	**8,143**	320
Nursery Shrubs/Trees	152.3	750,174	519	-	-	-	74.9	381,686	340	227.2	**1,131,861**	518
Pasture/Grass	102.7	600,704	585	-	-	-	0.8	5,349	640	103.5	**606,053**	585
Raspberry	45.0	189,916	422	-	-	-	74.3	256,607	345	119.3	**446,523**	374
Recreational Turf	20.5	109,284	533	-	-	-	2.6	16,841	644	23.1	**126,125**	545
Strawberry	60.6	206,143	340	-	-	-	21.7	58,292	269	82.3	**264,435**	321
Sweetcorn	91.4	138,214	151	-	-	-	11.7	19,588	167	103.1	**157,803**	153
Turf Farm	91.1	535,143	587	-	-	-	14.2	84,442	595	105.3	**619,585**	588
Vegetable	2,286.9	7,953,694	348	-	-	-	78.9	348,169	441	2,365.7	**8,301,863**	351
TOTALS	11,724.0	**54,341,376**	456	-	-	-	1,346.6	**6,381,526**	439	13,070.6	**60,722,902**	451

Appendix Table B 1997 Water Demand by Crop with Average Management												
Water Source	**Surface Water**			**Reclaimed Water**			**Groundwater**			**Total**		
Agriculture 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	0.2	531	242	-	-	-	-	-	-	0.2	**531**	242
Berry	9.5	16,425	172	-	-	-	8.0	18,950	237	17.5	**35,375**	202
Blueberry	3,536.5	5,852,562	165	-	-	-	569.6	1,073,149	188	4,106.1	**6,925,711**	169
Cranberry	2,543.0	8,421,170	331	-	-	-	27.6	95,164	345	2,570.6	**8,516,333**	331
Forage	1,505.2	3,928,592	261	-	-	-	46.5	132,536	285	1,551.7	**4,061,128**	262
Golf	898.2	3,530,297	393	-	-	-	272.1	1,115,144	410	1,170.4	**4,645,441**	397
Grape	6.6	3,382	51	-	-	-	23.9	9,152	38	30.4	**12,533**	41
Greenhouse	366.9	3,825,601	1,014	-	-	-	99.8	1,020,021	1,055	466.6	**4,845,621**	1,024
Mushroom	5.0	2,190	44	-	-	-	19.9	7,665	39	24.9	**9,855**	40
Nursery Floriculture	2.4	4,478	189	-	-	-	0.2	191	106	2.5	**4,669**	183
Nursery Shrubs/Trees	152.3	442,510	334	-	-	-	74.9	238,624	213	227.2	**681,134**	335
Pasture/Grass	102.7	315,934	308	-	-	-	0.8	3,157	378	103.5	**319,091**	308
Raspberry	45.0	95,837	213	-	-	-	74.3	141,133	190	119.3	**236,970**	199
Recreational Turf	20.5	68,762	335	-	-	-	2.6	12,659	484	23.1	**81,421**	352
Strawberry	60.6	131,377	217	-	-	-	21.7	40,604	187	82.3	**171,981**	209
Sweetcorn	91.4	50,202	55	-	-	-	11.7	5,824	50	103.1	**56,026**	54
Turf Farm	91.1	338,841	372	-	-	-	14.2	59,443	419	105.3	**398,283**	378
Vegetable	2,286.9	5,431,454	238	-	-	-	78.9	189,062	240	2,365.7	**5,620,517**	238
TOTALS	11,724.0	**32,460,145**	274	-	**-**	-	1,346.6	**4,162,478**	286	13,070.6	**36,622,623**	276

Appendix Table C 2003 Water Demand by Irrigation System with Average Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Agriculture 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	3,342.1	12,839,773	384	-	-	-	325.8	1,515,175	465	3,667.9	**14,354,948**	391
Golfsprinkler	915.2	5,580,089	610	-	-	-	272.1	1,687,713	620	1,187.3	**7,267,802**	612
Gun	8.1	39,284	488	-	-	-	-	-	-	8.1	**39,284**	488
Handline	577.6	1,743,131	302	-	-	-	40.9	175,330	428	618.5	**1,918,460**	310
Landscapesprinkler	1.9	11,134	590	-	-	-	2.7	17,019	629	4.6	**28,153**	613
Microspray	1.7	6,388	368	-	-	-	1.1	15,515	1,412	2.8	**21,904**	772
Microsprinkler	67.7	522,752	772	-	-	-	27.7	239,623	838	120.2	**762,377**	415
Overtreedrip	246.3	1,024,714	416	-	-	-	409.3	1,483,135	362	655.6	**2,507,850**	383
Pivot	2.7	4,649	175	-	-	-	-	-	-	2.7	**4,649**	175
SDI	95.3	340,553	357	-	-	-	-	-	-	95.3	**340,553**	357
Sprinkler	1.9	11,015	581	-	-	-	-	-	-	1.9	**11,015**	581
Ssovertree	263.5	1,407,896	534	-	-	-	30.3	124,863	412	293.8	**1,532,758**	522
Sssprinkler	2,390.3	13,483,925	564	-	-	-	72.4	413,884	571	2,462.7	**13,897,809**	564
Ssundertree	168.2	916,358	545	-	-	-	10.2	47,729	470	178.4	**964,087**	541
Travgun	3,529.3	15,798,158	448	-	-	-	120.0	577,098	481	3,649.2	**16,375,255**	449
Wheelline	107.3	611,557	570	-	-	-	14.2	84,442	595	121.5	**695,999**	573
TOTALS	11,724.0	**54,341,376**	456	-	-	-	1,346.6	**6,381,526**	439	13,070.6	**60,722,902**	451

Appendix Table D   2003 Water Demand by Soil Texture with Average Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Agriculture 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)
Clay	-	-	-	-	-	-	6.6	33,237	501	6.6	**33,237**	501
Cultured Medium	438.6	4,380,020	999	-	-	-	156.9	1,298,034	827	595.4	**5,678,053**	954
Fine Sandy Loam	4.1	18,135	439	-	-	-	-	-	-	4.1	**18,135**	439
Loam	53.8	400,691	745	-	-	-	4.5	17,260	387	58.2	**417,951**	718
Loamy Sand	139.6	903,545	647	-	-	-	32.2	136,194	423	171.9	**1,039,738**	605
Peat	2,543.0	14,408,583	567	-	-	-	27.6	155,765	565	2,570.6	**14,564,348**	567
Sand	50.1	267,010	533	-	-	-	127.9	556,481	435	177.9	**823,491**	463
Sandy Loam	21.2	122,498	578	-	-	-	37.9	188,795	499	59.1	**311,293**	527
Sandy Loam (defaulted)	2,163.8	8,700,460	402	-	-	-	259.2	1,450,285	556	2,423.0	**10,150,745**	230
Silt Loam	3,850.2	15,194,283	395	-	-	-	536.0	1,885,202	352	4,386.1	**17,079,486**	389
Silty Clay	427.9	1,401,279	327	-	-	-	47.7	139,338	292	475.6	**1,540,617**	324
Silty Clay Loam	2,031.8	8,544,873	421	-	-	-	110.2	520,936	473	2,142.0	**9,065,808**	423
TOTALS	11,724.0	**54,341,376**	456	-	-	-	1,346.6	**6,381,526**	439	13,070.6	**60,722,902**	451

Appendix Table E 2003 Water Demand by Purveyor with Average Management												
Water Source	**Surface Water**			**Reclaimed Water**			**Groundwater**			**Total**		
Agriculture 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)**
Burrows (Surrey)	189.5	601,428	317	-	-	-	-	-	-	189.5	**601,428**	317
Erickson (Surrey)	246.1	933,028	379	-	-	-	-	-	-	246.1	**933,028**	379
Old Logging (Surrey)	212.6	728,698	343	-	-	-	-	-	-	212.6	**728,698**	343
Surrey Total	648.2	**2,263,154**	1,039	-	-	-	-	-	-	648.2	**2,263,154**	1,039
Delta	4,026.8	**18,018,118**	459	-	-	-	-	-	-	4,026.8	**18,018,118**	459
Dyke Area 1 (Pitt Meadows)	393.5	1,401,574	356	-	-	-	-	-	-	393.5	**1,401,574**	356
Fenton Drainage Area (Pitt Meadows)	76.1	270,499	355	-	-	-	-	-	-	76.1	**270,499**	355
Kennedy Drainage Area (Pitt Meadows)	966.9	4,259,706	441	-	-	-	-	-	-	966.9	**4,259,706**	441
Pitt Polder Catchment Area (Pitt Meadows)	900.8	3,980,323	442	-	-	-	-	-	-	900.8	**3,980,323**	442
Pitt Meadows Total	2,337.3	9,912,102	399	-	-	-	-	-	-	2,337.3	**9,912,102**	399
Maple Ridge	28.7	104,628	365	-	-	-	-	-	-	28.7	**104,628**	365
Greater Vancouver	370.0	2,291,920	619	-	-	-	-	-	-	370.0	**2,291,920**	619
Richmond	1,209.0	**6,367,154**	515	-	-	-	-	-	-	1,209.0	**6,367,154**	515
Purveyor Totals	8,620.1	38,957,076	452	-	-	-	-	-	-	8,620.1	**38,957,076**	452
First Nation	-	**-**	-	-	-	-	114.7	650,485	567	114.7	**650,485**	567
Private	3,104.0	15,384,300	496	-	-	-	1,231.9	5,731,041	465	4,335.8	**21,115,341**	487
TOTALS	11,724.0	**54,341,376**	456	-	-	-	1,346.6	**6,381,526**	439	13,070.6	**60,722,902**	451

Appendix Table F 2003 Water Demand by Local Government with Average Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Agriculture 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)
Bowen Island	0.2	1,976	1,053	-	-	-	-	-	-	0.2	1,976	1,053
Burnaby	151.0	835,230	553	-	-	-	-	-	-	151.0	835,230	553
Coquitlam	84.9	218,184	257	-	-	-	-	-	-	84.9	218,184	257
Delta	4,235.7	19,468,698	460	-	-	-	-	-	-	4,235.7	19,468,698	460
Greater Vancouver	214.4	1,003,555	468	-	-	-	0.1	1,250	1,377	214.5	1,004,806	468
Langley (City)	-	-	-	-	-	-	24.4	144,725	594	24.4	144,725	594
Langley (Township)	787.4	4,282,444	544	-	-	-	983.1	4,309,033	438	1,770.4	8,591,476	485
Maple Ridge	121.4	700,331	577	-	-	-	4.4	36,467	824	125.8	736,798	586
Musqueam	-	-	-	-	-	-	114.7	650,485	567	114.7	650,485	567
New West	1.3	3,797	296	-	-	-	-	-	-	1.3	3,797	296
Pitt Meadows	2,426.4	10,356,643	427	-	-	-	0.5	1,882	365	2,426.9	10,358,525	427
Port Coquitlam	45.1	258,410	573	-	-	-	3.5	9,736	280	48.6	268,146	552
Richmond	1,379.0	7,083,230	514	-	-	-	75.7	408,518	540	1,454.7	7,491,748	515
Surrey	2,145.3	9,414,254	439	-	-	-	140.2	819,429	585	2,285.5	10,233,684	448
Vancouver	131.9	714,623	542	-	-	-	-	-	-	131.9	714,623	542
TOTALS	11,724.0	54,341,376	456	-	-	-	1,346.6	6,381,526	439	13,070.6	60,722,902	451

Appendix Table G 2003 Management Comparison on Irrigation Demand and Percolation Volumes

Water Source	Surface Water				Reclaimed Water				Groundwater				Total				
Agriculture Management	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Deep Percolation (m^3)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Deep Percolation (m^3)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Deep Percolation (m^3)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Deep Percolation (m^3)	Percolation (m^3/ha)
Poor	11,724.0	56,493,965	482	7,429,655	-	-	-	-	1,346.6	6,511,369	484	1,043,577	13,070.6	63,005,334	482	8,473,232	648
Avg	11,724.0	54,977,134	469	5,912,823	-	-	-	-	1,346.6	6,388,419	474	920,628	13,070.6	61,365,553	469	6,833,451	523
Good	11,724.0	53,460,302	456	4,395,992	-	-	-	-	1,346.6	6,265,469	465	797,678	13,070.6	59,725,771	457	5,193,669	397

Appendix Table H 2003 Percolation Volumes by Irrigation System with Average Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total			
Agriculture Irrigation System	Irrigated Area (ha)	Irrigation Demand (m^3)	Deep Percolation (m^3)	Irrigated Area (ha)	Irrigation Demand (m^3)	Deep Percolation (m^3)	Irrigated Area (ha)	Irrigation Demand (m^3)	Deep Percolation (m^3)	Irrigated Area (ha)	Irrigation Demand (m^3)	Deep Percolation (m^3)	Percolation (m^3/ha)
Drip	3,342.1	12,839,773	1,511,777	-	-	-	325.8	1,515,175	227,900	3,667.9	**14,354,948**	**1,739,677**	474
Golfsprinkler	915.2	5,580,089	875,346	-	-	-	272.1	1,687,713	308,970	1,187.3	**7,267,802**	**1,184,316**	997
Gun	8.1	39,284	7,071	-	-	-	-	-	-	8.1	**39,284**	**7,071**	873
Handline	577.6	1,743,131	219,626	-	-	-	40.9	175,330	20,045	618.5	**1,918,460**	**239,671**	388
Landscapesprinkler	1.9	11,134	2,030	-	-	-	2.7	17,019	3,652	4.6	**28,153**	**5,683**	1,235
Microspray	1.7	6,388	1,267	-	-	-	1.1	15,515	3,202	2.8	**21,904**	**4,469**	1,596
Microsprinkler	67.7	522,753	125,056	-	-	-	27.7	239,623	55,974	95.3	**752,522**	**181,030**	1,900
Overtreedrip	246.3	1,024,714	94,722	-	-	-	409.3	1,483,135	123,375	655.6	**2,507,850**	**218,096**	333
Pivot	2.7	4,649	423	-	-	-	-	-	-	2.7	**4,649**	**423**	157
SDI	95.3	340,553	28,130	-	-	-	-	-	-	95.3	**340,553**	**28,130**	295
Sprinkler	1.9	11,015	1,224	-	-	-	-	-	-	1.9	**11,015**	**1,224**	644
Ssovertree	263.5	1,407,896	198,009	-	-	-	30.3	124,863	15,525	293.8	**1,532,758**	**213,534**	727
Sssprinkler	2,390.3	13,483,925	1,233,811	-	-	-	72.4	413,884	73,404	2,462.7	**13,897,809**	**1,307,214**	531
Ssundertree	168.2	916,358	90,150	-	-	-	10.2	47,729	9,845	178.4	**964,087**	**99,995**	561
Travgun	3,529.3	15,798,158	1,451,444	-	-	-	120.0	577,098	65,502	3,649.2	**16,375,255**	**1,516,947**	416
Wheelline	107.3	611,557	72,736	-	-	-	14.2	84,442	13,235	121.5	**695,999**	**85,971**	708
TOTALS	11,724.0	**54,341,376**	5,912,823	-	-	-	1,346.6	**6,381,526**	920,628	13,070.6	**60,722,902**	**6,833,451**	740

Appendix Table I 2003 Crop Water Demand for Improved Irrigation System Efficiency and Good Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Agriculture 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	0.2	855	389	-	-	-	-	-	-	0.2	855	389
Berry	9.5	21,988	231	-	-	-	8.0	22,286	279	17.5	44,275	253
Blueberry	3,536.5	10,741,288	304	-	-	-	569.6	1,636,023	287	4,106.1	12,377,311	301
Cranberry	2,543.0	13,755,382	541	-	-	-	27.6	148,685	539	2,570.6	13,904,067	541
Forage	1,505.2	8,074,957	536	-	-	-	46.5	273,894	590	1,551.7	8,348,851	538
Golf	898.2	5,376,062	599	-	-	-	272.1	1,654,828	608	1,170.4	7,030,891	601
Grape	6.6	8,938	136	-	-	-	23.9	25,259	106	30.4	34,197	112
Greenhouse	366.9	3,946,533	1,046	-	-	-	99.8	1,054,873	1,089	466.6	5,001,408	1,057
Mushroom	5.0	2,190	44	-	-	-	19.9	7,665	39	24.9	9,855	40
Nursery Floriculture	2.4	7,451	315	-	-	-	0.2	391	218	2.5	7,843	308
Nursery Shrubs/Trees	152.3	735,649	513	-	-	-	74.9	376,304	504	227.2	1,111,953	513
Pasture/Grass	102.7	586,518	571	-	-	-	0.8	5,235	626	103.5	591,753	572
Raspberry	45.0	97,150	216	-	-	-	74.3	189,448	255	119.3	286,598	240
Recreational Turf	20.5	106,805	521	-	-	-	2.6	16,511	631	23.1	123,316	533
Strawberry	60.6	103,343	170	-	-	-	21.7	30,967	143	82.3	134,311	163
Sweetcorn	91.4	135,594	148	-	-	-	11.7	19,133	163	103.1	154,727	150
Turf Farm	91.1	524,590	576	-	-	-	14.2	83,528	589	105.3	608,118	577
Vegetable	2,286.9	4,202,624	184	-	-	-	78.9	187,550	238	2,365.7	4,390,174	186
TOTALS	11,724.0	48,427,917	391	-	-	-	1,346.6	5,732,580	406	13,070.6	54,160,497	393

Appendix Table J 2003 Water Demand for Frost Protection, Harvesting and Other Use with Average Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Agriculture 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)
Cranberry Harvesting	2,544.2	636,047	25	-	-	-	27.6	6,893	25	2,571.8	642,940	25
Forestry Stock	2.5	13,533	532	-	-	-	-	-	-	2.5	13,533	532
Greenhouse Cucumber	23.4	250,399	1,071	-	-	-	17.1	189,070	1,109	40.4	439,470	1,087
Greenhouse Flower	61.4	498,687	812	-	-	-	27.1	229,533	845	88.6	728,220	822
Greenhouse Pepper	158.1	1,591,889	1,007	-	-	-	38.3	403,197	1,052	196.4	1,995,087	1,016
Greenhouse Tomato	124.0	1,605,558	1,295	-	-	-	17.3	233,073	1,350	141.2	1,838,631	1,302
Mushroom	5.0	2,190	44	-	-	-	19.9	7,665	39	24.9	9,855	40
Nursery Pot	64.2	419,953	654	-	-	-	37.2	243,160	654	101.4	663,113	654
TOTALS	2,982.7	5,018,257	168	-	-	-	184.4	1,312,592	712	3,167.2	6,330,848	200

Appendix Table K 2003 Water Demand by Animal Type

Animal Type	Demand (m^3)
Beef	206,243
Dairy - dry	162,881
Dairy - milking	276,898
Goats	3,717
Horses	136,090
Poultry - broiler	156,342
Poultry - laying	82,769
Sheep	13,610
Swine	17,424
TOTALS	**1,055,975**

Appendix Table L Climate Change Water Demand Circa 2050 for High Demand Year with Good Management Using Current Crops and Irrigation Systems

Climate Change	rcp26			rcp45			rcp85			Average		
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	13,070.6	74,225,442	568	13,070.6	63,129,135	483	13,070.6	99,139,164	758	13,070.6	78,831,247	603
2056	13,062.2	66,611,253	510	13,070.6	77,196,444	591	13,070.6	48,551,753	371	13,062.2	64,119,817	491
2059	13,070.6	40,761,044	312	13,070.6	71,594,218	548	13,070.6	86,118,425	659	13,070.6	66,157,896	506
Average	13,070.6	60,532,580	463	13,070.6	70,639,932	541	13,070.6	77,936,447	596	13,070.6	69,702,986	533

Appendix Table M Buildout Crop Water Demand for 2003 Climate Data with Good Management												
Water Source	**Surface Water**			**Reclaimed Water**			**Groundwater**			**Total**		
Agriculture 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	5.8	16,153	277	-	-	-	2.8	7,326	266	8.6	**23,479**	274
Berry	26.8	82,692	309	-	-	-	8.0	32,656	409	34.8	**115,348**	332
Blueberry	8,609.0	27,734,280	322	-	-	-	2,392.2	7,245,978	303	11,001.2	**34,980,258**	318
Cranberry	2,565.3	13,880,263	541	-	-	-	27.6	148,685	539	2,592.8	**14,028,947**	541
Domestic Outdoor	403.4	2,212,726	549	-	-	-	264.5	1,397,985	529	667.9	**3,610,711**	541
Forage	4,679.3	23,135,100	494	-	-	-	3,376.4	17,751,362	526	8,055.7	**40,886,461**	508
Fruit	5.1	16,978	334	-	-	-	7.0	22,284	316	12.1	**39,261**	324
Golf	1,008.8	6,093,565	604	-	-	-	274.9	1,669,507	607	1,283.7	**7,763,071**	605
Grape	14.3	19,769	139	-	-	-	26.5	30,795	116	40.7	**50,564**	124
Greenhouse	366.9	3,946,533	1,046	-	-	-	99.8	1,054,873	1,089	466.6	**5,001,408**	1,057
Mushroom	5.0	2,190	44	-	-	-	19.9	7,665	39	24.9	**9,855**	40
Nursery Floriculture	4.3	14,182	327	-	-	-	0.5	1,386	269	4.9	**15,569**	321
Nursery Shrubs/Trees	236.7	1,186,704	508	-	-	-	84.1	414,193	336	320.8	**1,600,897**	509
Pasture/Grass	1,430.4	7,872,213	550	-	-	-	810.0	4,326,124	534	2,240.4	**12,198,337**	544
Raspberry	68.0	237,792	350	-	-	-	97.8	307,234	314	165.8	**545,025**	329
Recreational Turf	27.3	145,809	534	-	-	-	2.6	16,511	631	29.9	**162,320**	542
Strawberry	131.1	296,168	226	-	-	-	22.5	57,119	254	153.6	**353,287**	230
Sweetcorn	277.4	313,356	113	-	-	-	11.9	19,217	162	289.3	**332,573**	115
Turf Farm	93.9	540,041	575	-	-	-	14.2	83,528	589	108.1	**623,570**	577
Vegetable	6,971.6	17,172,348	246	-	-	-	201.9	648,422	321	7,173.4	**17,820,770**	248
TOTALS	26,930.3	**104,918,862**	379	-	-	-	7,745.1	**35,242,850**	447	34,675.4	**140,161,712**	394

Appendix Table N Buildout Crop Water Demand for Climate Change Data Circa 2050 and Good Management

Climate Change	rcp26			rcp45			rcp85			Average		
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	34,675.3	170,390,384	491	34,675.3	146,532,463	423	34,675.3	245,600,791	708	34,675.3	187,507,879	541
2056	34,666.9	157,743,468	455	34,675.3	179,073,457	516	34,675.3	109,977,408	317	34,675.3	148,931,444	429
2059	34,675.3	87,399,947	252	34,675.3	167,010,184	482	34,675.3	214,941,804	620	34,675.3	156,450,645	451
Average	34,675.3	138,511,266	399	34,675.3	164,205,368	474	34,675.3	190,173,334	548	34,675.3	164,296,656	474

Appendix Table O Buildout Irrigation System Demand for 2003 Climate Data and Good Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Agriculture 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	11,458.7	31,482,615	275	-	-	-	2,160.8	6,693,563	310	13,619.5	**38,176,178**	280
Golfsprinkler	915.2	5,463,728	597	-	-	-	272.1	1,654,828	608	1,187.3	**7,118,556**	600
Gun	8.1	40,908	508	-	-	-	-	-	-	8.1	**40,908**	508
Handline	1,674.2	7,644,658	457	-	-	-	802.1	4,244,812	529	2,476.3	**11,889,471**	480
Landscapesprinkler	1.9	11,085	588	-	-	-	2.7	16,685	617	4.6	**27,770**	605
Microspray	1.7	6,257	360	-	-	-	1.1	15,515	1,412	2.8	**21,772**	768
Microsprinkler	72.4	538,880	741	-	-	-	54.6	261,870	732	107.1	**800,750**	738
Overtreedrip	246.3	1,002,882	407	-	-	-	409.3	1,449,815	354	655.6	**2,452,698**	374
Pivot	2.7	4,649	175	-	-	-	-	-	-	2.7	**4,649**	175
SDI	95.3	332,742	349	-	-	-	-	-	-	95.3	**332,742**	349
Sprinkler	3,531.9	17,822,645	505	-	-	-	3,399.5	17,791,478	523	6,931.5	**35,614,124**	514
Ssovertree	993.9	5,014,364	504	-	-	-	78.0	366,855	470	1,071.9	**5,381,219**	502
Sssprinkler	2,793.7	15,086,571	540	-	-	-	336.9	1,802,881	535	3,130.6	**16,889,452**	539
Ssundertree	196.3	963,292	491	-	-	-	18.6	75,074	403	215.0	**1,038,366**	483
Travgun	4,825.7	18,904,458	392	-	-	-	195.0	785,947	403	5,020.7	**19,690,405**	392
Wheelline	107.3	599,126	558	-	-	-	14.2	83,528	589	121.5	**682,654**	562
TOTALS	26,930.3	**104,918,862**	379	-	-	-	7,745.1	**35,242,850**	447	34,675.4	**140,161,712**	394

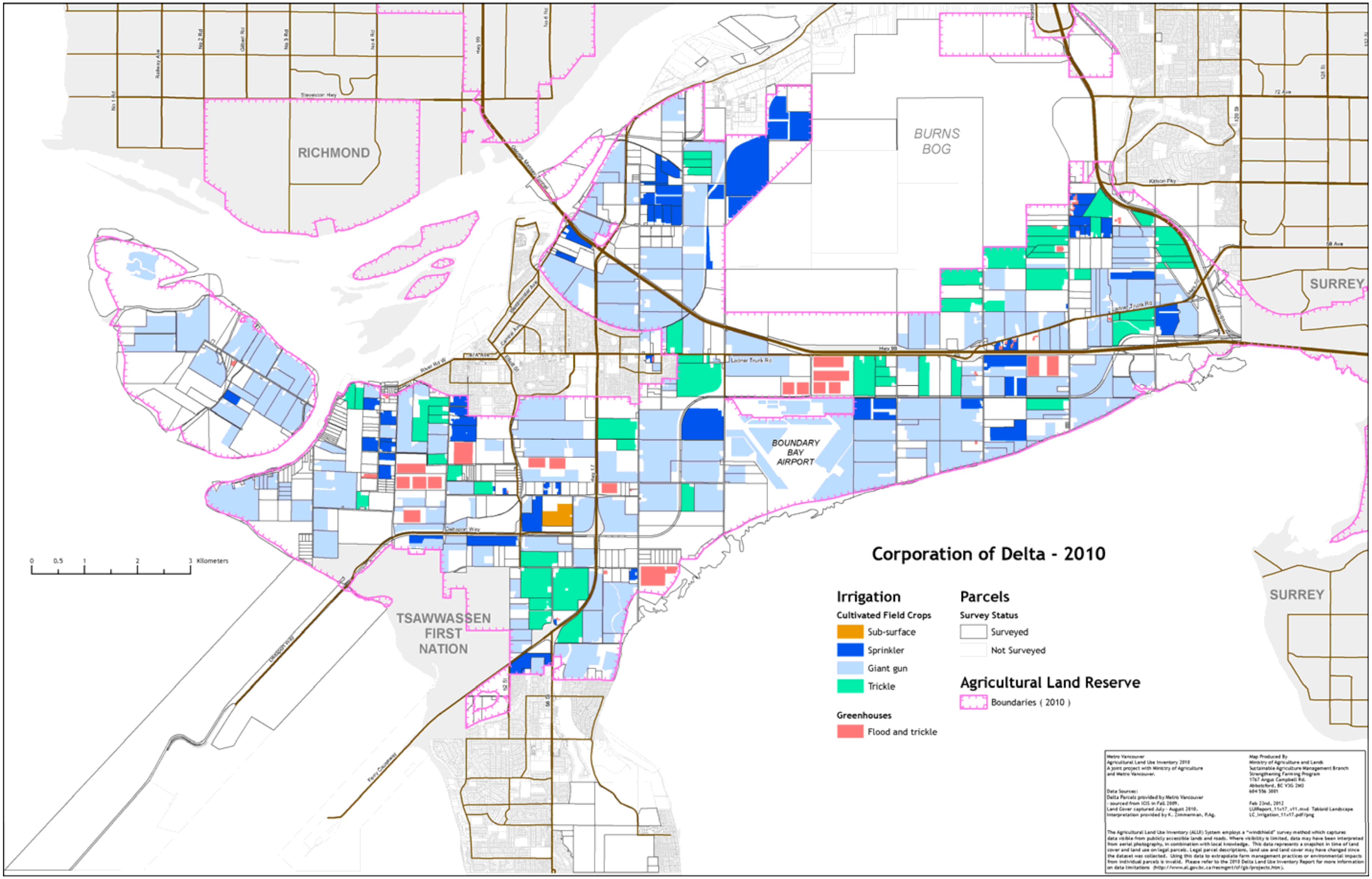
Appendix Table P Buildout Water Demand by Purveyor for 2003 Climate Data and Good Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Agriculture 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)**
Burrows	343.3	1,057,750	308	-	-	-	-	-	-	343.3	1,057,750	308
Erickson	534.5	2,059,802	385	-	-	-	-	-	-	534.5	2,059,802	385
Old Logging	366.8	1,146,529	313	-	-	-	-	-	-	366.8	1,146,529	313
Surrey Total	1,244.6	4,264,081	1,006	-	-	-	-	-	-	1,244.6	**4,264,081**	1,006
Delta	6,285.2	24,822,392	393	-	-	-	-	-	-	6,285.2	**24,822,392**	393
Dyke Area 1 (Pitt Meadows)	445.4	1,521,632	342	-	-	-	-	-	-	445.4	1,521,632	342
Fenton Drainage Area (Pitt Meadows)	348.7	1,230,825	353	-	-	-	-	-	-	348.7	1,230,825	353
Kennedy Drainage Area (Pitt Meadows)	2,634.6	10,216,544	388	-	-	-	-	-	-	2,634.6	10,216,544	388
Pitt Polder Catchment Area (Pitt Meadows)	1,045.0	4,217,682	404	-	-	-	-	-	-	1,045.0	4,217,682	404
Pitt Meadows Total	4,473.7	17,186,683	371.75	-	-	-	-	-	-	4,473.7	**17,186,683**	372
Greater Vancouver	5,324.9	17,621,017	331	-	-	-	-	-	-	5,324.9	17,621,017	331
Maple Ridge	5,510.4	18,252,834	337	-	-	-	-	-	-	5,510.4	18,252,834	337
Richmond	22,597.8	81,903,762	370	-	-	-	-	-	-	22,597.8	**81,903,762**	370
Purveyor Totals	20,143.6	75,550,719	375	-	-	-	-	-	-	20,143.6	75,550,719	375
First Nation	-	-	-	-	-	-	114.7	637,612	556	114.7	637,612	556
Private	6,786.7	29,368,142	433	-	-	-	7,630.3	34,605,240	453	14,417.0	63,963,526	444
TOTALS	26,930.3	104,918,862	379	-	-	-	7,745.1	35,242,850	447	34,675.4	140,161,712	394

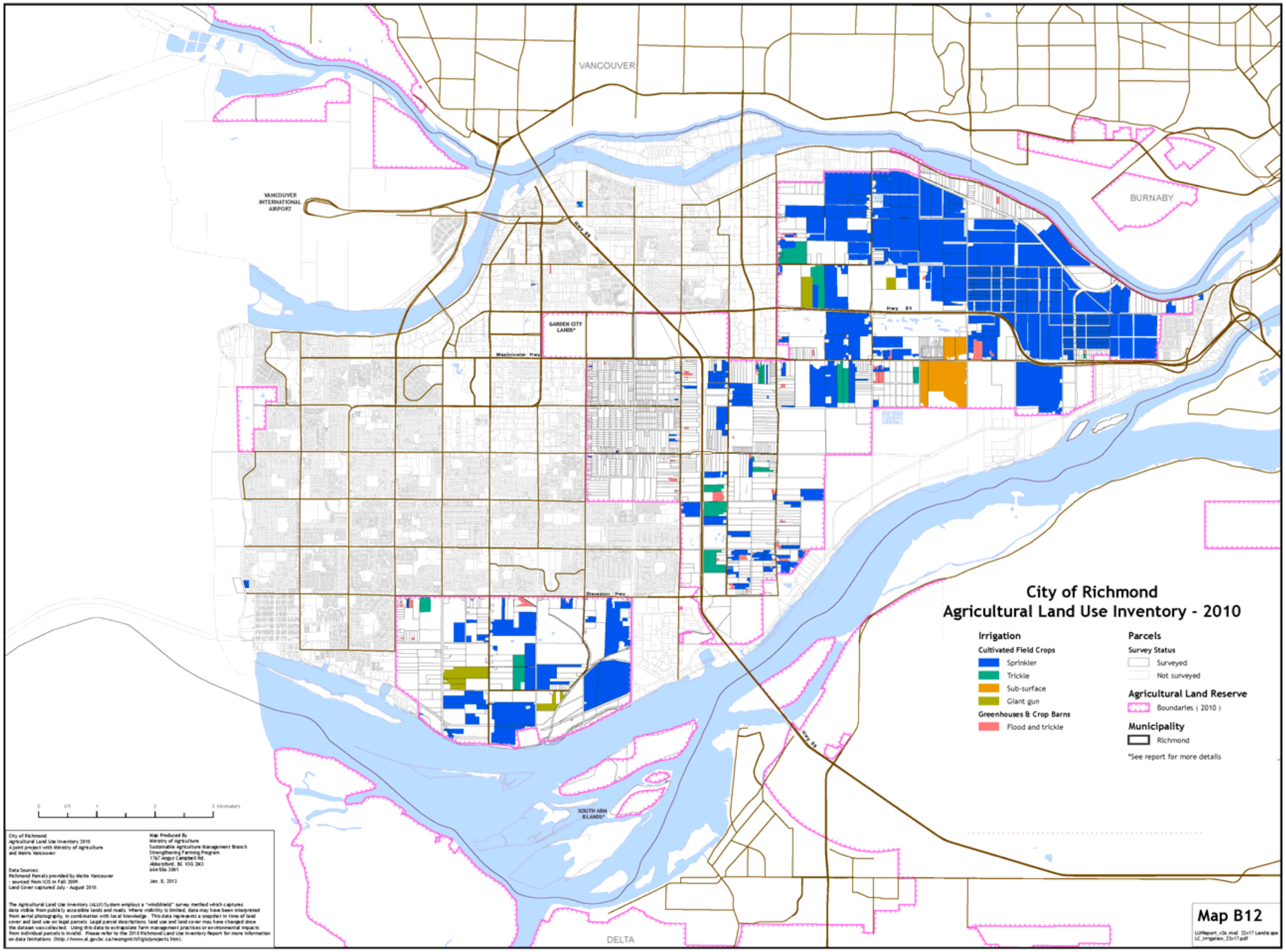
Appendix Table Q Buildout Water Demand by Local Government for 2003 Climate Data and Good Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Agriculture 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)**
Bowen Island	108.8	254,406	234	-	-	-	0.9	933	99	109.7	**255,339**	233
Burnaby	204.2	899,180	440	-	-	-	-	-	-	204.2	**899,180**	440
Coquitlam	207.0	627,775	303	-	-	-	-	-	-	207.0	**627,775**	303
Delta	6,765.8	27,810,628	411	-	-	-	-	-	-	6,765.8	**27,810,628**	411
Greater Vancouver	557.2	2,036,271	365	-	-	-	223.6	942,355	421	780.8	**2,978,626**	381
Langley (City)	0.1	363	266	-	-	-	28.5	153,699	539	28.6	**154,062**	538
Langley (Township)	1,571.6	7,899,020	502	-	-	-	6,745.7	30,745,653	456	8,317.3	**38,644,674**	465
Maple Ridge	1,942.3	6,639,397	342	-	-	-	57.3	236,043	412	1,999.6	**6,875,441**	344
Musqueam	-	-	-	-	-	-	114.7	637,612	556	114.7	**637,612**	556
New West	1.3	3,612	282	-	-	-	-	-	-	1.3	**3,612**	282
Pitt Meadows	4,483.9	17,026,634	380	-	-	-	0.5	1,800	349	4,484.4	**17,028,435**	380
Port Coquitlam	250.8	931,607	371	-	-	-	9.3	31,720	341	260.1	**963,327**	370
Richmond	3,674.3	14,399,421	392	-	-	-	135.4	562,495	415	3,809.7	**14,961,916**	393
Surrey	6,940.6	25,420,236	366	-	-	-	429.0	1,930,540	450	7,369.6	**27,350,777**	371
Vancouver	222.3	970,309	436	-	-	-	-	-	-	222.3	**970,309**	436
TOTALS	26,930.3	**104,918,862**	379	-	-	-	7,745.1	**35,242,850**	447	34,675.4	**140,161,712**	394

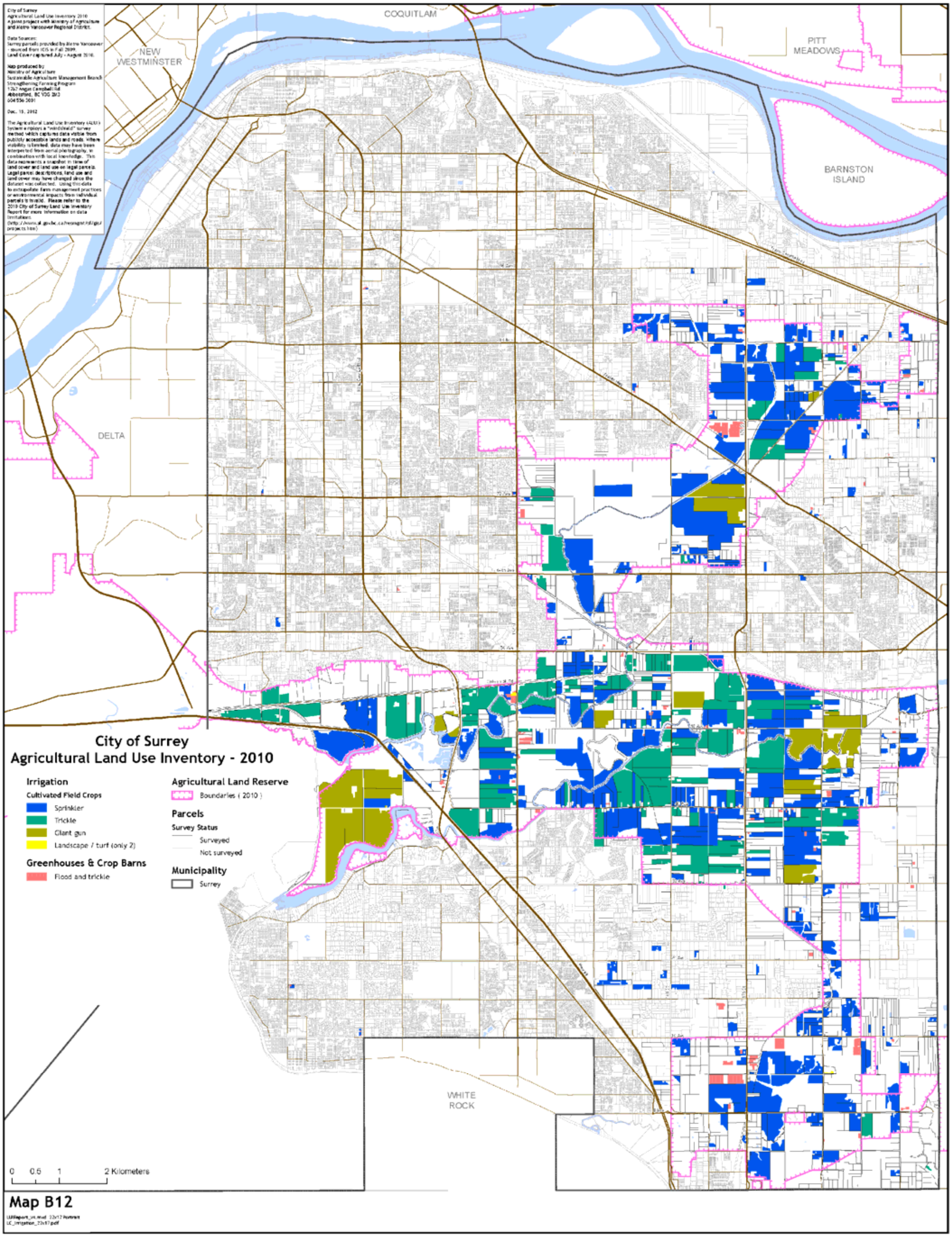
Appendix Figures



Appendix Figure 1 Irrigated Areas in the Corporation of Delta



Appendix Figure 2 Irrigated Areas in the City of Richmond



Appendix Figure 3 Irrigated Areas in the City of Surrey