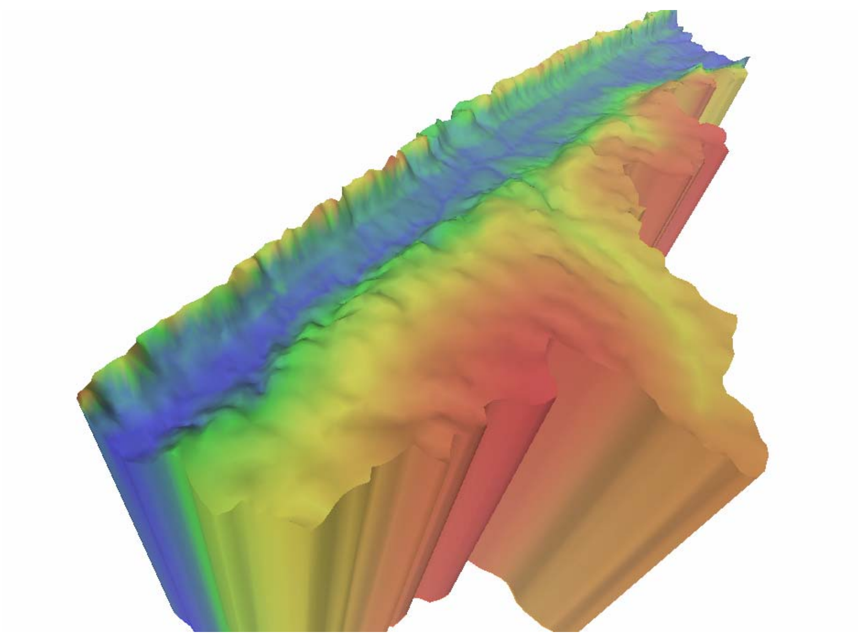
Project No. 081242



Prepared for:
Nova Scotia Federation of Agriculture

Groundwater Use Database – Methodology and Data Summary

Annapolis Valley, Nova Scotia

Final Report

March 2009

CBCL LIMITED
Consulting Engineers

WATER & AQUIFER TECHNICAL ENVIRONMENTAL RESOURCES
TERRY W. HENNIGAR WATER CONSULTING

ISO 9001
Registered Company

CBCL LIMITED
Consulting Engineers

1489 Hollis Street
PO Box 606
Halifax, Nova Scotia
Canada B3J 2R7

Telephone: 902 421 7241
Fax: 902 423 3938
E-mail: info@cbcl.ca
www.cbcl.ca

20 March 2009

Mr. John Drage, M.Sc., P.Geo.
Nova Scotia Environment
5151 Terminal Road, 5th Floor
PO Box 442, Halifax, NS, B3J 2P8

Dear Mr. Drage:

RE: Annapolis Valley Groundwater Use Survey: Final Groundwater Use Database and Report

CBCL Limited is pleased to present three hard copies and one electronic copy of the final report for the above-mentioned work.

I encourage you to contact the undersigned with any questions or concerns at your convenience.

Yours very truly,

CBCL Limited

Colin Walker, M.Sc., P.Geo
Hydrogeologist
Telephone: (902) 421-7241, ext. 2262
E-Mail: colinw@cbcl.ca

Enclosure

cc: Gavin Kennedy, Nova Scotia Department of Natural Resources

Contents

List of Figures

List of Tables

Executive Summary

The availability of water in the Annapolis Valley, Nova Scotia is an on-going concern for private water users, municipal utilities, and farms. Much of the water used in the Annapolis Valley is groundwater drawn from sand and gravel or bedrock aquifers. Increasing demand by municipal utilities, farms, and industry has the potential to create a negative balance for the Valley water budget. Water availability and demand has been the subject of several studies in the past decade, however, quantification of demand has relied on available methods of estimation. The need for a database of actual water use has been the common conclusion of past studies.

A Groundwater Use Database has been prepared to aid efforts to analyse and manage groundwater use in the Valley. The database provides a record for each known user together with map coordinates and the average daily water use. Each record represents an individual farm, business, municipal well, public building or other facility using groundwater. Non-serviced domestic uses were not included as individual records, but were estimated for each watershed.

Records of actual water use, facility information, and standard rates of consumption were used to generate water use data for each record. For most records, actual water use information was unavailable, and the daily water use was calculated. For some records estimates and assumptions were needed to complete the calculation. Calculations were based on established water use rates for livestock, crop types, and facility types. Other items such as user location, water use, and well information were included in the database if available.

User data was collected using existing provincial databases, interviews with municipal utility operators, and a mail-out groundwater use survey. A web-based groundwater use survey was also made available. Interviews with municipal utilities allowed for confirmation of average daily use records, maximum daily use records, well IDs, and allocation of pumping among wells in a given well field. Survey data allowed for collection of specific water use information for some user records, and for the addition of some farms that were not included in the database.

The facility sector, facility type, and facility sub-type were provided for quick filtering and analysis of the data. Consumptive use coefficients were provided to allow for an analysis of consumptive use in a given dataset. Consumptive use distinguishes the amount of pumped water that is permanently removed from a given watershed from pumped water that is recycled within the Valley hydrologic system.

The database contained 562 records upon completion of this study. The database did not account for farms which did not respond to the questionnaire; these farms may represent a significant component of additional groundwater use in the Valley. It is anticipated that the database represents a starting point for future expansion, and for the replacement of estimated water use data with actual water use records.

Chapter 1 Introduction

CBCL Limited and was retained by the Nova Scotia Federation of Agriculture (NSFA), in partnership with the Province of NS, to conduct a groundwater use survey in the Annapolis Valley, Nova Scotia. These agencies are hereafter referred to as the Client. The purpose of the work was to prepare a database of groundwater use for the Annapolis Valley, which can be used to prepare water budgets and promote the management and protection of groundwater resources. This work was undertaken in partnership with Terry W. Hennigar WATER Consulting. The Valley has the highest density of agricultural activity in Nova Scotia and this information will benefit these water users by helping to ensure access to secure, long-term water supplies. The project was funded by the Canada-Nova Scotia Water Supply Expansion Program with matching support from the Provincial Government. Preparation of the database required consolidation of existing data and collection of new data by means of a Groundwater Use Survey.

1.1 Background

The study area was defined by the Client to encompass two primary watersheds as described by provincial mapping (NSDOE, 1981). The Annapolis and Gaspereau primary watersheds comprise the study area boundary, and effectively enclose the Annapolis Valley physiographic area. The Valley setting results in an extended growing season with respect to other parts of the Province, and combined with fertile well drained soils, is among Canada's most productive and intensively farmed regions.

The study area is subdivided into secondary watersheds, also defined by provincial mapping:

- Coastal
- Moose River
- Allains River
- Annapolis
- Cornwallis
- Gaspereau
- Canard
- Habitant
- Pereau

The study area and watershed boundaries are shown on Map 1.1. The Pereau watershed is defined in provincial mapping as a tertiary rather than a secondary watershed, but has been included at the secondary level of resolution at the request of the Client. The Pereau watershed comprises a distinct drainage basin with a relatively high density of agricultural activity, and has been grouped with secondary watersheds in previous studies.

Agricultural activity in the Valley has benefited by a relative abundance of freshwater available in Valley rivers, storage ponds, and groundwater. Annual precipitation consistently exceeds 1000 mm/year (Environment Canada, 2008) providing reliable recharge to Valley aquifers and associated baseflow to rivers. Yet increasing demands by farms, municipal utilities, and industry places increasing pressure on

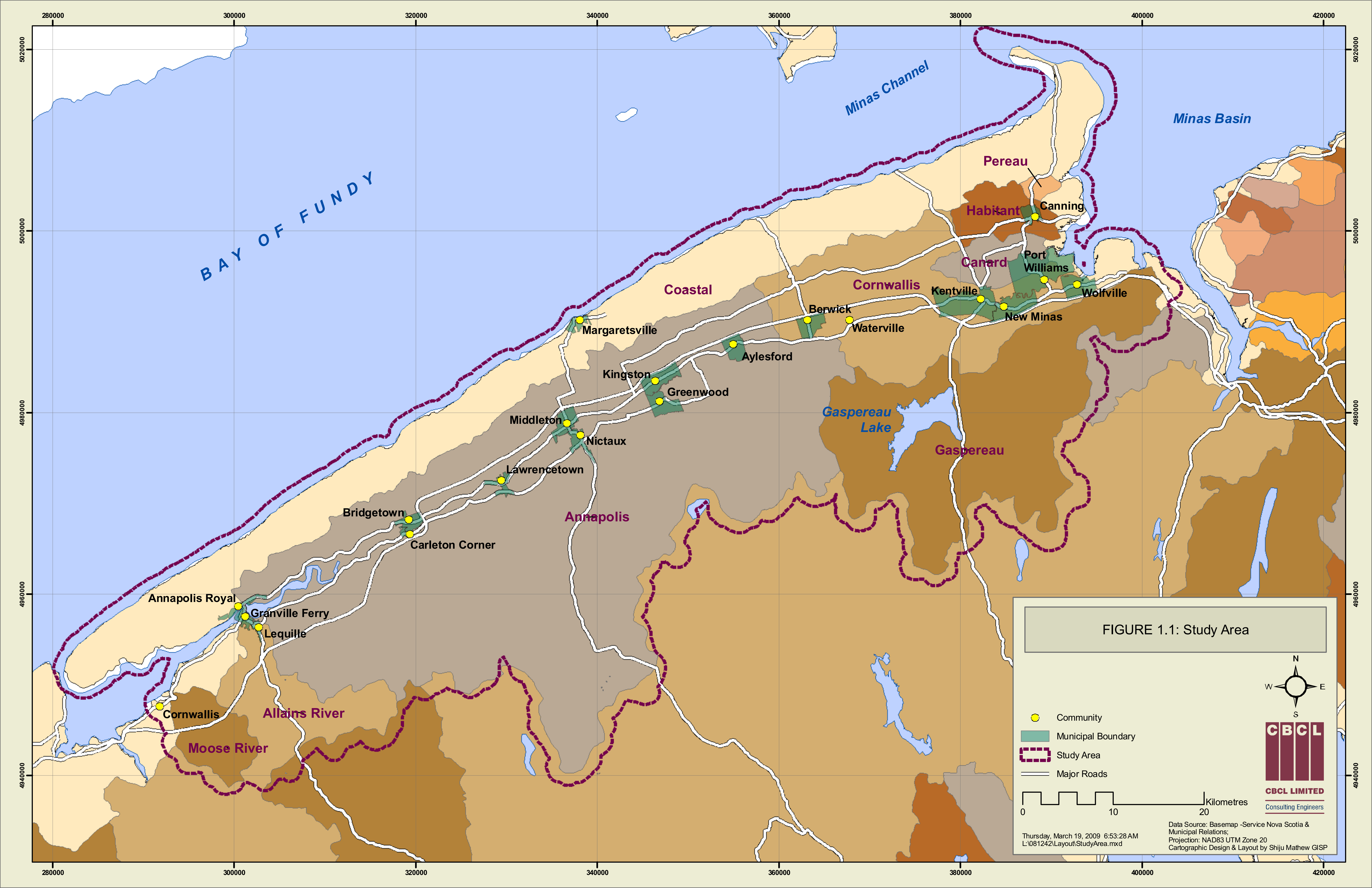


FIGURE 1.1: Study Area

surface and groundwater sources. On-going investigation points to a need for a complete understanding of water inputs and demands in the Valley.

A preliminary water budget for the Annapolis Valley was developed by the Geological Survey of Canada (GSC) in association with several other agencies (Rivard *et al.*, 2006). The water budget incorporated climate data, soil and geological data, hydrological data, and groundwater data gathered from existing sources and as part of an extensive field program. The data were used to develop a groundwater flow model of Valley aquifers, and allowed for calibration of a water budget for the Valley. Groundwater withdrawals were not included in model calibrations. The Groundwater Use Database developed for the current study could be used to build this additional component into future water budget calibrations.

The Valley geology and hydrogeology have been mapped and characterized by Rivard *et al.* (2007, 2006) and Trescott (1968). Groundwater flow in the valley is dominated by the regional topography, directing flow down the valley slopes and into the valley plain where groundwater discharges to the Annapolis and Cornwallis Rivers or flows along the long axis of the Valley as regional flow. Surface soil thicknesses tend to be lesser on the valley sides, providing varying degrees of confinement according to the proportion of fine material present.

The valley floor typically exhibits thicknesses of over 15 m of Quaternary materials, often comprised of sand mixed with silt and clay or sandy till. Outwash, kame and esker gravel features comprise unconfined to semi-confined aquifers in parts of the Valley, providing water of good quantity and quality (private wells obtain water from sand and gravel deposits throughout the valley plain). In many parts of the Annapolis Valley, Quaternary deposits have proven to be very good aquifers supplying groundwater of excellent quality to municipal water systems, industry, and agricultural users. The mean hydraulic conductivity of wells in unconsolidated deposits is 3×10^{-4} m/s (Rivard *et al.*, 2006).

The Wolfville Formation comprises the most significant and widely exploited aquifer in the Valley, supplying water of generally good quality in large quantities to domestic, municipal, industrial and agricultural users along the valley floor. The Wolfville Formation occurs as beds of sedimentary rock, deposited in upward fining cycles as alluvial fans, fluvial floodplains, and shallow lacustrine dunes or playa environments (Rivard *et al.*, 2006). Alternating beds of lower and higher hydraulic conductivity introduce an element of aquifer-aquitard interaction, producing artesian conditions in some of the lower conglomerate units. The high siltstone and shale contents in the upper sequences of the Wolfville Formation have been reported to produce semi-confined conditions in deeper sequences of sandstone and conglomerate.

Owing to the variable thickness and lateral extent of major water bearing strata, yields vary significantly throughout the Valley, and wells need to be installed to site specific depths to obtain optimal yields. The mean hydraulic conductivity of the Wolfville Formation was 6.6×10^{-6} m/s, ranging from 10^{-9} to 10^{-3} m/s (Rivard *et al.*, 2006). Borehole geophysics showed a layered structure suggestive of significantly anisotropic conditions with Khorizontal>>Kvertical (Rivard *et al.*, 2006). Other formations in the Valley provide water of varying quantity and quality and include the South Mountain (granite), the Blomidon Formation (sedimentary sandstone and shale), and the North Mountain Formation (basalt).

The potential for Valley aquifers to meet demand was evaluated by AGRA (2000), AMEC (2002), Dillon (2003), and CBCL Limited (2003). The scope and focus of investigations has varied:

- AGRA (2000): Estimates of water supply and demand in the Annapolis valley were subdivided among the Annapolis, Cornwallis, Gaspereau, Habitant, Canard, and Pereau watersheds. Water availability was estimated using stream flow data. Demand was determined through mail out surveys, estimates of agricultural uses (irrigation and livestock), and a conceptual water allocation formula for remaining non-serviced users.
- AMEC (2002): A comparison of infiltration (supply) and water demand, applied to three high-priority areas in Kings County: Kingston-Aylesford, Waterville-Coldbrook, and Sheffield Mills-Pereau. Each 10 000 hectare area exhibited a predominance of Cornwallis type soils (a high demand, fast draining soil type). Demand estimates were based on available agricultural information (data from the AGRA, 2000 study), NSE databases, and standard rates of consumption, e.g. 100 US gallons/day/person for non-serviced users.
- Dillon (2003): An analysis of demand and supply in the Cornwallis watershed. Municipal supplies, rural domestic demand, agricultural uses, commercial, industrial and institutional uses were incorporated into demand estimates. Known industrial users were inventoried on an individual basis. Crop and livestock consumption were estimated based on land use patterns and municipal livestock housing data from Kings County. The study included GIS mapping on the tertiary watershed scale. The authors noted a shift toward water intensive crops in recent years.
- CBCL (2003): An investigation of new water sources for the Pereau and Habitant watersheds. Water available for irrigation was calculated as groundwater recharge flows, less domestic well use and stream baseflow retention. The study incorporated census data, questionnaires, and GIS-air photo mapping to determine water demands. The authors noted a high loss of incoming precipitation to run-off and tile drains, and estimated spring runoff to be 5 times that of the groundwater recharge rate. Most irrigation water was reported to be drawn from surface water.

MacPherson (2004) provided a more complete summary of these studies, and performed a comparative analysis of supply and demand estimates. Demand estimates varied by as much as 100 000 m^3/day for a given secondary watershed. Most studies noted uncertainties in the method of irrigation demand in particular; estimates varied by as much as ten times between studies. Previous studies have consistently stressed the need for a more comprehensive inventory of major groundwater users in the Valley.

1.2 Study Objectives

The purpose of this study was to prepare a database of groundwater use in the Annapolis Valley. The database is intended to include a record for each major groundwater user in the Valley, including municipal utilities, farms, industries, public buildings, communal supplies, and businesses. The database also includes estimates of non-serviced domestic use grouped by secondary watershed. Key elements of each record include the user or facility name, UTM NAD83 coordinates, and average daily demand. Other groundwater use, well information, and user information is included for additional reference.

Particular attention was directed toward obtaining accurate coordinate data and accurate groundwater demand data. Coordinates were recorded at GPS or property-centroid level accuracy wherever possible. Groundwater demand data were based on records of actual use if possible. The completed database is intended to show the best available record of distribution of actual groundwater use in the Valley. The Groundwater Use database constitutes a dynamic body of information: it is anticipated that records will continue to be updated and refined over time.

Summary maps, figures, and tables are provided for quick reference to the data contained within the database. Interpretation of groundwater use patterns, and application to specific problems was not completed as part of the current study. The database is provided as a tool for the evaluation of groundwater use patterns in the Valley in the context of increasing demand, particularly in densely populated or intensively farmed areas. The database will allow for a more accurate water budget to be prepared for the Valley so that groundwater resources can be wisely managed and protected. This in turn will promote a competitive and sustainable future for agriculture and a high quality of rural life.

Chapter 2 Methodology

The Groundwater Use Database was developed in successive stages, beginning with processing of existing information into a preliminary database. Existing water use studies and methods were reviewed to determine the most efficient and effective ways to collect and improve data. Interviews with municipal utilities and selected major water users were conducted to improve the level of accuracy and/or the amount of information available for each record. Mail-out and internet-based questionnaires were developed to provide additional information for smaller users, and to allow for addition of records not already listed in the database. After processing interview and questionnaire data, remaining data gaps were filled using calculations based on available information, or where necessary by applying a generic use figure. Watershed and aquifer information were added to each record using coordinate data and GIS mapping. Literature values for consumption coefficients were applied to each record based on the water use sector, type, and sub-type.

2.1 Preliminary Database

Existing databases provided by the Client were compiled to form a preliminary Groundwater Use Database for the Annapolis Valley. Creation of this database allowed for the identification of approximately 400 recorded points of water extraction in the Valley. The majority of these locations were drawn from the "GW Sites" database provided by NSDNR. Information from the GW Sites database was cross-referenced with the NSE Provincial Well Logs, NSE Pumping Test, NSE Approved Water Withdrawals, and Municipal Utilities databases to supplement existing records or create new records. Where more than one source of data was available for a given field and record, the data were drawn from the database with the highest assigned priority. Priority was assigned to databases in the following order: Municipal Utilities, NSE Water Withdrawals, GW Sites, NSE Pumping Test Database, NSE Provincial Well Logs.

The fields to be included in the database were selected in consultation with the Client, and are listed in Table A1. The first twelve fields provide a description of the record. Each record was assigned a unique "Facility Code", which serves as an index number for each record. Facilities with more than one well were generally grouped under a single Facility Code. Wells for municipal utilities were not grouped, but were each assigned a unique Facility Code. Municipal wells for a single utility were each assigned a unique Facility Code, but were assigned a common "Group Code" to allow for rapid grouping of records in a single well field.

The next ten fields are related to the record location, coordinates, method and source of coordinate determination, and approximate accuracy. The third grouping of twelve fields covers water use information. These fields include extraction rates, volumes, and the nature of the operation. The final grouping (6 fields) summarizes available well and aquifer information.

The preliminary database served as a starting point for collection of new data. Existing location and contact data were used in an attempt to complete the mailing address field for each record, with an emphasis on non-agricultural users. Contact information and facility names were also used to allocate each record to a groundwater use sector, type and sub-type (where applicable). Missing PID information was also added at this stage if readily accessible. In many cases it was necessary to attempt to locate a PID and or access the record within Nova Scotia Property On-Line in order to determine accurate address information. Confirmation of PIDs formed the basis of improvements on coordinate accuracy for some records. Confirmation of PIDs was labour intensive, and was beyond the scope of this investigation when the PID was not readily determined.

2.2 Interviews

Municipal utilities were identified as the most intensive point-source water users in the study area. The supervising engineer and/or operator for each public utility was contacted to schedule an interview. Interviews were conducted on-site whenever possible, and by phone when a site visit could not be scheduled. There are eleven communities in the study area that depend in part or in whole on groundwater for municipal water supply. These communities are:

- Annapolis Royal / Granville Ferry
- Canning
- Greenwood
- Kentville
- Lawrencetown
- Margaretsville
- Middleton
- New Minas
- Port Williams
- Sandy Court / Aylesford
- Wolfville

A total of 10 interviews were conducted with utility operators, including seven face-to-face interviews and three phone interviews. Interviews were conducted with operators from all of the above referenced communities with the exception of New Minas. It was not possible to arrange an interview with the New Minas facility operators. Prior to interviewing the operator of each utility, the 2007 report of water use submitted to NSE was reviewed. The number of wells, well IDs, well addresses, and withdrawal volumes were compared to fields in the preliminary database drawn from the Municipal Wells and Approved Water Withdrawals database. Any inconsistencies or data gaps were highlighted in order direct the course of the subsequent interview. Interviews were conducted using a template in order to promote consistency between interviews.

Particular emphasis was placed on obtaining and confirming actual water use data for the utilities. Average and maximum withdrawal rates were obtained. A summary of the results of municipal interviews is presented in Appendix H.

Smith (2004) used municipal connection data (residential, commercial, institutional) to estimate water use for Wolfville, Kentville, Greenwood, New Minas, and Port Williams. The Nova Scotia Water Licensing and Review Board was contacted as a preliminary exercise to determine the availability of this data for all communities in the Valley. As annual reports based on utility metering were available for all communities, municipal connection data were not needed or investigated further.

2.3 Questionnaires

A total of 861 survey questionnaires were mailed out to agricultural and non-agricultural water users and a total of 162 questionnaires were returned (19%), including those that were completed via the web-based questionnaire. Questionnaires were developed to gather data from individual water users in the agricultural and non-agricultural sectors. Each questionnaire included a section on Contact Information, Water Use Information, and Well Information. Questions were structured to collect information that was immediately available or easily obtained by the well owner/operator. Information on water use patterns was collected to allow for a calculation or estimate of water use, when records and user estimates were unavailable. Two separate questionnaires were developed to allow for collection of specific information on:

1. The Agricultural Sector; and
2. Commercial, Industrial, and Institutional Users

Interviews were conducted with two agricultural users and one industrial user to test the questionnaires for effectiveness and ease of use. Each questionnaire was modified based on user comments prior to mailing. Copies of each questionnaire are provided in Appendix B. All questionnaires were provided with a covering letter and self-addressed, stamped envelope.

2.3.1 Agricultural Sector

The agricultural questionnaire was prepared by CBCL and forwarded to NSFA for final mailing. NSFA mailed the questionnaire to 581 listed farms and other members of the Federation, under a cover letter prepared and signed by the NSFA president. The agricultural questionnaire was designed to collect information on farm type, acreage, and livestock to allow for calculation of water use. Information on irrigation methods and intensity of use was also collected if available. Local NSFA and Nova Scotia Department of Agriculture representatives were contacted and notified of the survey, with the intent of promoting and supporting the survey at the local level.

Past agricultural questionnaires also targeted members of NSFA. A Nova Scotia Department of Agriculture survey in 1987 received 260 responses from 587 members. A large mail-out survey by AGRA (2000) included 839 users, generating 304 responses and 57 user-based water use estimates.

2.3.2 Non-Agricultural Sectors

A separate questionnaire was prepared for non-agricultural users. The questionnaire was mailed to 280 industrial, commercial, public, and institutional supply operators listed in the preliminary database. Where firm mailing address information could not be readily obtained, the civic address of the record was used. Approximately 50 of the questionnaires were returned by Canada Post due to insufficient or inaccurate address information.

2.3.3 Web Based Questionnaires

Each questionnaire was also made available in an on-line format via the CBCL website. The web-based survey was built using QuestionPro.com, a web-based questionnaire service. The web-based questionnaire incorporated logic to streamline each user's set of questions to the facility type, skipping irrelevant or redundant sections. The mail-out questionnaires provided the URL of the on-line survey.

2.4 Groundwater Use Estimates

The average daily water use for each record in the database was based on actual water use records wherever possible. All water use records for municipal utilities were based on usage data. Water use estimates were also provided by some users. Provided that the user estimate was within tolerable limits for a given user type, this estimate was recorded in the Groundwater Use Database.

In many cases it was necessary to calculate the water use for a given record. The water use was calculated for each individual record where sufficient survey data was available (crop type and acreage, livestock count, customers per day, unit production per day, etc.). If survey data was unavailable, the daily water use for a given record was based on a standardized rate, calculated using relevant census data and established water usage rates. Example calculations are provided in Appendices C, D, E, and F.

In selected cases where existing data and/or methods of estimation were unavailable, the maximum permitted pumping rate (NSE Water Withdrawals Database), or the well yield as determined by a pumping test (NSE Pumping Test Database) was used as the average daily water use.

2.4.1 Calculations for Agricultural Users

Survey data for each farm was subdivided among two basic categories: livestock and crop production (including field crops, berries, tree fruits, and greenhouses). Calculations for livestock were based on a per-animal consumption rate, together with appropriate rates for leakage/loss, animal washing, and equipment washing. As domestic consumption by farms accounts for a nominal part of the farm's water use, it was omitted from calculations. Domestic use by all non-serviced users is furthermore grouped under separate calculations of non-serviced domestic demand (Section 2.4.3).

Appendix C provides a summary of consumption rates used in the calculations, and a set of sample calculations for livestock operations. Methods of calculation and consumption rates followed de Loe (2005). Water use coefficients were developed by Myslik (1991), and updated by Ecologistics (1993) and Ivey (2003). Methods of calculation and tables of standard animal consumption, animal washing, equipment washing, irrigation, losses, and spraying were provided in spreadsheet format by the kind consideration of Dr. Rob de Loe. The basic calculation was as follows:

Number of Animals x Consumption Rate per Animal + Losses + Animal Washing + Equipment Washing

= Average Daily for Animal Type (m^3/day)

Where multiple animal types were listed, water use was calculated for each animal type, and then summed to provide the average daily use for the farm. Calculations for crop production were in some cases based entirely on user data. The standard calculation was as follows:

Crop Area (m^2) x Irrigation amount per event (m) x Number of events per season / Length of Operating Season (days) + Washing + Processing + Spraying

= Average Daily Use of Farm (m^3/day)

For farms where only the acreage of a given crop was available, a standard annual irrigation rate was applied. Rates of spraying, washing and processing were based on the standards provided in Appendix D. For multiple crop types and/or mixed livestock-crop operations, the water use was calculated for each animal and crop type, and then summed to provide the average daily water use for the farm.

Data from the Statistics Canada Census of Agriculture was compiled for Kings and Annapolis Counties (census data are available for subdivisions within Kings and Annapolis counties, but these subdivisions do not relate to watershed mapping boundaries used in this study). Average rates of daily water use were calculated based on the methods presented in Appendices C and D using the census data. Rates of consumption were calculated for each individual crop type, and aggregated into the following categories: Livestock, Field Crops, Fruit Orchards and Berries, Vegetables, and Greenhouses. The average produced for each category was used as a standard rate of consumption where the farm type was known, but no data were available. An average water use rate for all farm census data was used for records in the Agricultural Sector but with no discernible farm type. Rates of consumption for fish farms were assigned solely on permitted pumping rates and/or pumping test data.

The water use coefficients used by de Loe (2005) were developed in Ontario based on conditions relating to Ontario farms. Factors such as climate, soil conditions, technologies, local growing practices and farm size are built into the coefficients. Water use coefficients have not been developed for conditions specific to the Annapolis Valley. Should such data become available, recalculation of water use by farms would be necessary.

2.4.2 Calculations for Non-Agricultural Users

Calculations for non-Agricultural users were based on the Nova Scotia Design Flows for On-Site Sewage Systems (2007; *"Table F3"*). Standard flow rates were applied according to the number of persons, beds, bathrooms, kitchens, units etc. for a given facility type. Wastewater flows were assumed to be approximately equal to water withdrawal rates. The number of users or other relevant units was drawn from survey data where available. If the number of users / units was unknown, a standard quantity was applied for each facility type and sub-type in order to complete the calculation. Standard rates of flow, assumed unit quantities, and example calculations are provided in Appendix E.

Wastewater design flows were not used to calculate water use rates for records in the Industrial sector or for Water Co-ops. Consumption by these users was assumed to be dependent on rates of product production, washing, and other sources of demand. If survey data on the nature of the operation were unavailable, the permitted withdrawal rate or test pumping rate was assigned as the average daily water use. The permitted water withdrawal rate is generally determined as the long term pumping rate that can be sustained by the well without significant additional drawdown in the well, without effecting surrounding wells and natural features, and without causing permanent subsidence of the water table. This pumping rate tends to be lower than the maximum pumping rate or well yield, which is the highest rate that can be sustained over a two to 72 hour period. As such the permitted withdrawal rate provides a more realistic estimate of water use, but where necessary, the test pumping rate provides the best available approximation. In practice, actual water use rates tend to be lower than the permitted withdrawal rate.

Four records for earth exchange systems are included in the Groundwater Use Database. These systems represent open loop earth exchange systems, which draw groundwater from a pumping well. Groundwater exiting these systems is either discharged directly to surface water, or returned to the aquifer using a return/recharge well. If known, the practice of discharging to surface water or groundwater is indicated under the facility sub-type for each record. This parameter forms an important distinction between systems which conserve groundwater (discharge to groundwater) and those which do not (discharge to surface water). Increasing use of open loop earth exchange system in recent years is a topic of concern for the Valley. It is anticipated that records for earth exchange systems will be added to the Groundwater Use Database as user information becomes available, and that these records will comprise a significant additional component of groundwater use in the Valley.

2.4.3 Calculation of Domestic Demand

Bulk rates of consumption were calculated for non-serviced domestic users. The calculation was based on a standard rate of consumption of 320 L/person/day, the rate provided for the Annapolis Valley region of Nova Scotia by Natural Resources Canada (1999). The number of domestic users was determined for each secondary watershed using a combination of GIS mapping and census data. Serviced boundaries were obtained from Kings and Annapolis Counties and applied to the study area (Figure 1.1). Civic unit data were overlaid and subtracted from the areas within the serviced boundaries. The number of remaining residential civic units was assumed to represent the number of non-serviced domestic users in each secondary watershed. The number of persons per residential civic unit (2.1) was calculated as the total population in Kings and Annapolis counties divided by the total number of residential units in Kings and Annapolis Counties. Calculations and census data are provided in Appendix F.

2.5 Watershed and Aquifer Data

The primary, secondary, and tertiary watershed for each record was determined based on map coordinates using GIS software. The coordinates for each record were similarly overlain with bedrock geology mapping to determine the most likely contributing geologic formation for drilled wells. Records indicating dug wells or wells drawing water from a sand and gravel formation were listed as Quaternary wells. All other drilled wells were assumed to draw water from bedrock formations. Map 2.1 shows the database records and underlying geologic formations.

2.6 Consumptive Use Coefficients

Consumptive Use Coefficients were assigned to each record to allow for an assessment of Consumptive Use of pumped groundwater. Consumptive Use distinguishes the amount of pumped water that is permanently removed from a given watershed from pumped water that is recycled within the Valley hydrologic system. Consumptive Use Coefficients are assumed to apply at the primary watershed scale for the Groundwater Use Database. Coefficients were drawn from an Ontario Ministry of the Environment Study (2006), and a review of data for the Great Lakes Climatic Region by the USGS (Shaffer and Runkle, 2007). The latter study compared Consumptive Use Coefficients within several districts of the Great Lakes region with other areas worldwide.

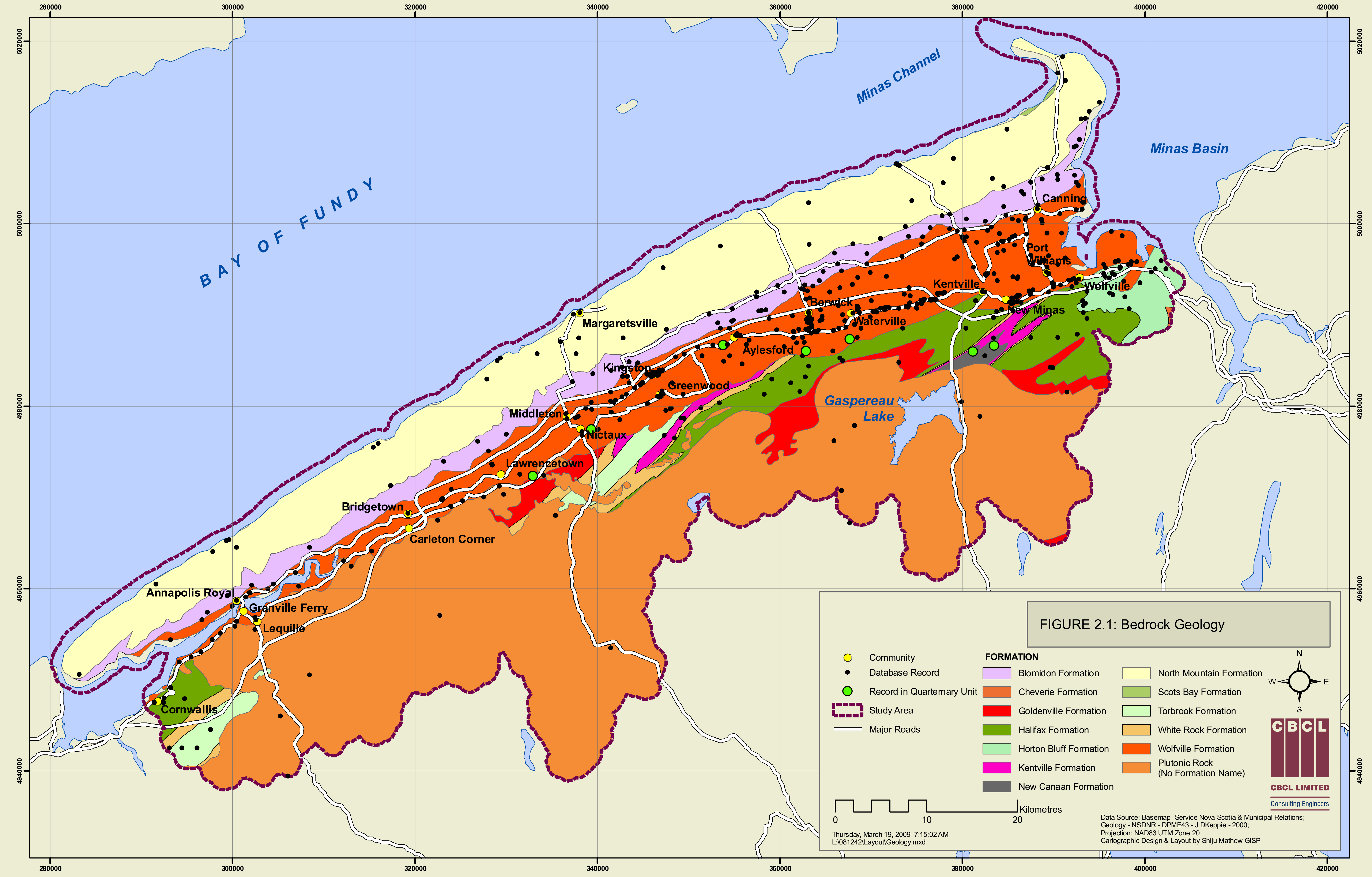


FIGURE 2.1: Bedrock Geology
BAY OF FUNDY
Minas Channel
Minas Basin
Gaspereau Lake
Annapolis Royal
Granville Ferry
Lequille
Cornwallis
Bridgetown
Carleton Corner
Lawrencetown
Middleton
Nictaux
Margaretsville
Kingston
Greenwood
Aylesford
Berwick
Waterville
Kentville
New Minas
Port Williams
Canning
Wolfville
Community
Database Record
Record in Quaternary Unit
Study Area
Major Roads
FORMATION
Blomidon Formation
Cheverie Formation
Goldenville Formation
Halifax Formation
Horton Bluff Formation
Kentville Formation
New Canaan Formation
North Mountain Formation
Scots Bay Formation
Torbrook Formation
White Rock Formation
Wolfville Formation
Plutonic Rock (No Formation Name)
N
S
E
W
CBCL LIMITED
Consulting Engineers
0 10 20 Kilometres
Thursday, March 19, 2009 7:15:02 AM
L:\081242\Layout\Geology.mxd
Data Source: Basemap -Service Nova Scotia & Municipal Relations;
Geology - NSDNR - DPME43 - J DKeppie - 2000;
Projection: NAD83 UTM Zone 20
Cartographic Design & Layout by Shiju Mathew GISP
280000
300000
320000
340000
360000
380000
400000
420000
4940000
4960000
4980000
5000000
5020000

Chapter 3 Data Summaries

3.1 Completed Database

Upon compiling all new information, the database contained 562 records, including a record representing domestic groundwater use for each of nine secondary watersheds. A total of 162 survey responses were processed, composed of 97 surveys from agricultural users and 65 surveys from non-agricultural users. Web-based surveys accounted for 15 agricultural users and 35 non-agricultural users. Municipal wells accounted for 34 records, agricultural users for 215 records, commercial users for 124 records, industrial users for 35 records, and non-municipal, non-domestic water supplies for 139 records. Six records represented recreational water uses or earth exchange systems.

It is anticipated that although most groundwater users in the valley are represented in the database, that some users could not be identified. Agricultural users in particular may represent a significant component of additional groundwater use in the valley, not tabulated in the Groundwater Use Database. It is anticipated that additional records will be added as they are identified over time.

Groundwater use estimates and pumping records were available for 46 records, and the water use was calculated for an additional 121 records based on survey data. Facility Type estimates and calculations accounted for 358 groundwater use records. Eleven records were assigned based on the permitted water withdrawal rate, and 26 records were assigned based on the pumping test rate. Survey data was not available for many industrial users in the database, and follow-up calls and emails were largely unsuccessful in generating responses. These records should receive priority in future attempts to update water use figures with user data. Well yields were unavailable for 319 of the records, suggesting that the supply capacity for up to 57% of the users in this dataset is unknown. Follow-up work could provide a better understanding of the capacity of individual groundwater supplies in the Valley.

Interviews with municipal operators allowed for improved detail in well information and pumping records. Pumping records were available for all utilities drawing groundwater in the study area, and were supplemented with anecdotal information from the supervising engineers and operators. Maximum daily pumping rates were provided for each record. Operators were able to clarify the locations and municipal IDs of each well, but did not in general have records of the NSE well number or borehole construction information. Many utilities did not keep individually metered records of pumping from each well, but were able to provide sufficient information on the cycling between wells, or rough allocations between primary and back-up wells. In many cases the interviews revealed differences between the 2007 reports submitted to NSE and the updated data provided to CBCL Limited for this study. No interview data was obtained for the New Minas utility.

There was PID information for 377 of the records in the Groundwater Use Database. Coordinate accuracy for records with PID information was maintained or improved beyond the accuracy of data available in the preliminary database. There were 190 records with an accuracy of better than or equal to 50 m. There were 152 records with an accuracy of 100 to 700 m. There were 86 records determined using a property centroid from the Nova Scotia Mapbook, generating an estimated accuracy of 707 metres. Fifty-three records were determined using a community centroid from the Gazeteer, generating an estimated accuracy of 7,829 m. It may be possible with additional research to determine PID information for any remaining records. Property centroid estimates would improve the coordinate accuracy of these records significantly beyond 7,829 m, and potentially beyond 707 m.

3.2 Groundwater Use Summary

Summary figures are presented to show the nature of the data available in the Groundwater Use Database. The term "Groundwater Use" is used to represent total withdrawals for a given area or sector. Figure 3.1 shows the groundwater use for each sector within the Annapolis Valley. The supply sector accounts for 41% of the groundwater used in the valley, followed by industrial users (26%). Industrial uses were estimated based on allotted withdrawals and pumping test rates. User data from these sources may reveal the actual usage rates to be lower. Agricultural uses may also be higher than shown, as the number of farms not listed in the database is expected to be significant. Table 3.1 provides a summary of water use data from the database.

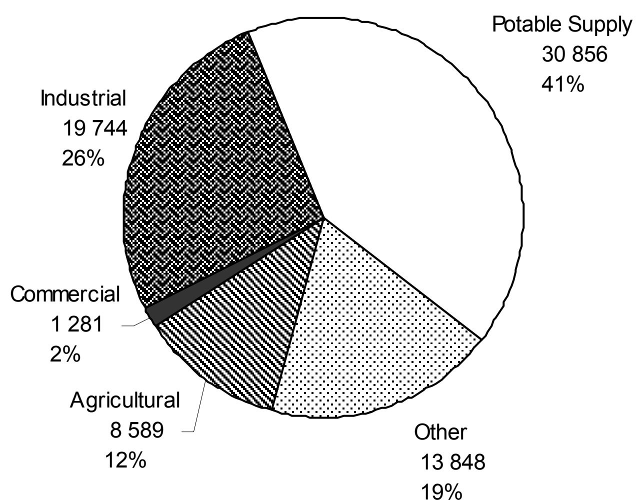


Figure 3.1: Daily Groundwater Use by Sector for Study Area (m^3/year)

Table 3.1: Summary of Groundwater Use Data for Each Secondary Watershed and Groundwater Use Sector

Primary Watershed	Sub-Watershed	Daily Groundwater Use by Sector (m^3/day)					Sub-Total
		Water Supply[1]	Agriculture	Commercial	Industrial	Other	
Annapolis	Annapolis	6 677	1 869	568	5 585	1 538	16 237
	Allains River	181	8	14	0	2	205
	Moose River	231	15	1	0	66	313
	Coastal[2]	1 053	702	37	234	987	3 014
	Sub-Total =	8 142	2 594	621	5 819	2 592	19 769
Gaspereau	Cornwallis	16 941	2 479	424	9 697	8 191	37 733
	Canard	1 098	280	13	2 680	71	4 142
	Habitant	567	647	101	901	53	2 268
	Pereau	70	3	0	0	0	72
	Gaspereau	1 134	648	19	0	216	2 017
	Coastal[2]	2 905	1 937	103	646	2 724	8 315
	Sub-Total =	22 714	5 994	660	13 924	11 255	54 548
Grand Totals =		30 856	8 589	1 281	19 744	13 848	74 317

[1]Water supply for municipal utilities and private domestic users

Table 3.1 (Revised: April 17, 2009)

Primary Watershed	Sub-Watershed	Daily Groundwater Use by Sector (m^3/day)					Sub-Total
		Water Supply[1]	Agriculture	Commercial	Industrial	Other	
Annapolis	Annapolis	6 677	1 869	568	5 585	1 538	16 237
	Allains River	181	8	14	0	2	205
	Moose River	231	15	1	0	66	313
	Coastal	3 958	1 541	97	65	193	5 855
	Sub-Total =	11 047	3 433	681	5 651	1 798	22 610
Gaspereau	Cornwallis	16 941	2 479	424	9 697	8 191	37 733
	Canard	1 098	280	13	2 680	71	4 142
	Habitant	567	647	101	901	53	2 268
	Pereau	70	3	0	0	0	72
	Gaspereau	1 134	648	19	0	216	2 017
	Coastal	0	1 098	43	815	613	2 569
	Sub-Total =	19 809	5 155	600	14 093	9 145	48 802
Grand Totals =		30 856	8 589	1 281	19 744	10 943	71 412

[1]Potable Water supply for municipal utilities and private domestic users

[2]Groundwater use in coastal areas is reported as a total for the Annapolis and Gaspereau primary watersheds in the Groundwater Use Database. Provincial mapping does not distinguish the coastal sub-watershed in the Annapolis watershed from the coastal sub-watershed in the Gaspereau watershed. The sub-totals in this table were derived by subdividing water used in the coastal sub-watershed between the Annapolis (27%) and Gaspereau (73%) primary watersheds according to the proportion water uses in other sub-watersheds.

Figure 3.2 presents a map of the study area showing the relative groundwater use for each sector within each of the nine secondary watersheds. Groundwater used for potable water supply tends to predominate, particularly in the smaller watersheds where industrial activity is limited or absent. Agricultural activity and industry are the second largest consumers. The Canard watershed in particular shows a high percentage of use by industry, likely reflecting a concentration of food processing and bottling plants in the region.

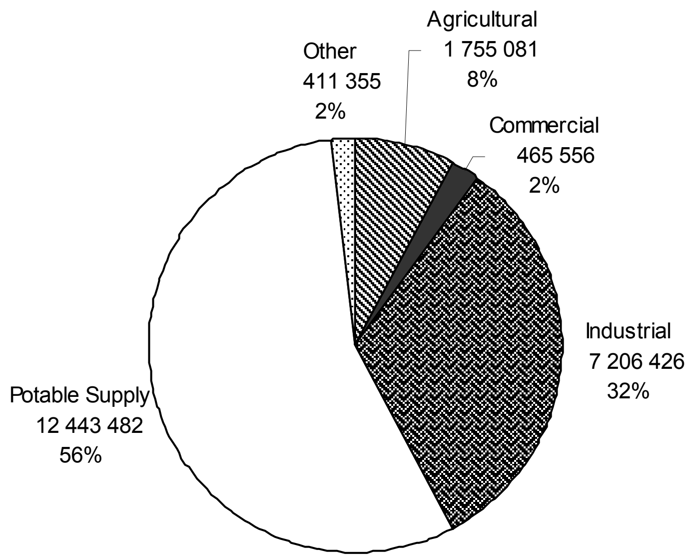


Figure 3.3: Yearly Groundwater Use by Sector for Study Area (m^3/year)

Figure 3.3 shows the yearly groundwater use calculated for each sector within the Annapolis Valley as a whole. Yearly groundwater uses account for differences in operating season lengths for each sector. The agricultural and industrial sectors show a lesser proportion of use due to operating seasons that are generally six to eight months long. The growing season affects industrial users because many are canning and food processing facilities.

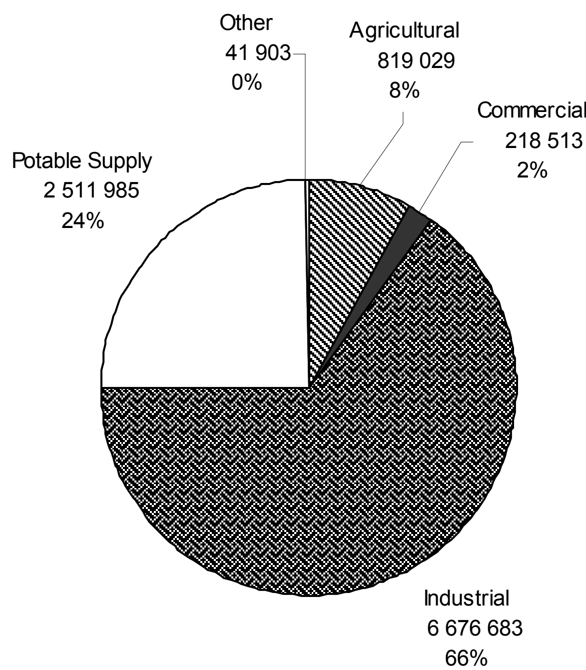


Figure 3.5: Yearly Groundwater Consumption by Sector for Study Area (m^3/year)

A map of the relative proportion of yearly groundwater use by each sector is shown for each secondary watershed on Figure 3.4. Yearly withdrawals reflect the trends observed for average daily use. Slight reductions in agricultural and industrial activity are reflected in each watershed.

The term "Groundwater Consumption" is used to represent total withdrawals multiplied by the consumptive use coefficient. Yearly groundwater consumption in the Annapolis Valley varies

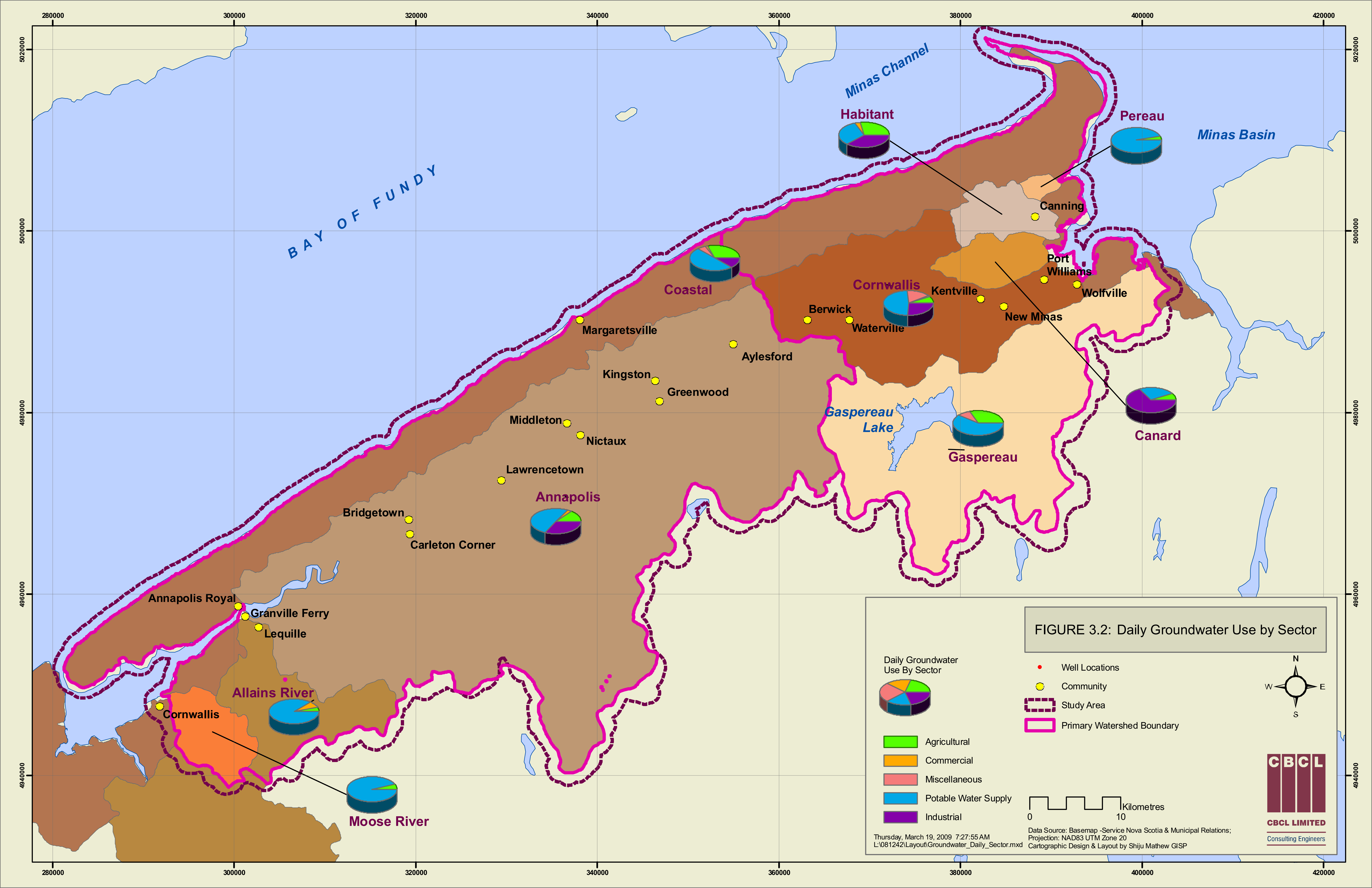


FIGURE 3.2: Daily Groundwater Use by Sector
BAY OF FUNDY
Minas Channel
Minas Basin
Gaspereau Lake
Habitant
Pereau
Coastal
Cornwallis
Canard
Gaspereau
Annapolis
Allains River
Moose River
Canning
Port Williams
Wolfville
Kentville
New Minas
Berwick
Waterville
Aylesford
Margaretsville
Kingston
Greenwood
Middleton
Nictaux
Lawrencetown
Bridgetown
Carleton Corner
Annapolis Royal
Granville Ferry
Lequille
Cornwallis
Daily Groundwater Use By Sector
Agricultural
Commercial
Miscellaneous
Potable Water Supply
Industrial
Well Locations
Community
Study Area
Primary Watershed Boundary
N
S
E
W
Kilometres
0
10
Thursday, March 19, 2009 7:27:55 AM
L:\081242\Layout\Groundwater_Daily_Sector.mxd
Data Source: Basemap -Service Nova Scotia & Municipal Relations;
Projection: NAD83 UTM Zone 20
Cartographic Design & Layout by Shiju Mathew GISP
CBCL LIMITED
Consulting Engineers
280000
300000
320000
340000
360000
380000
400000
420000
5020000
5000000
4980000
4960000
4940000

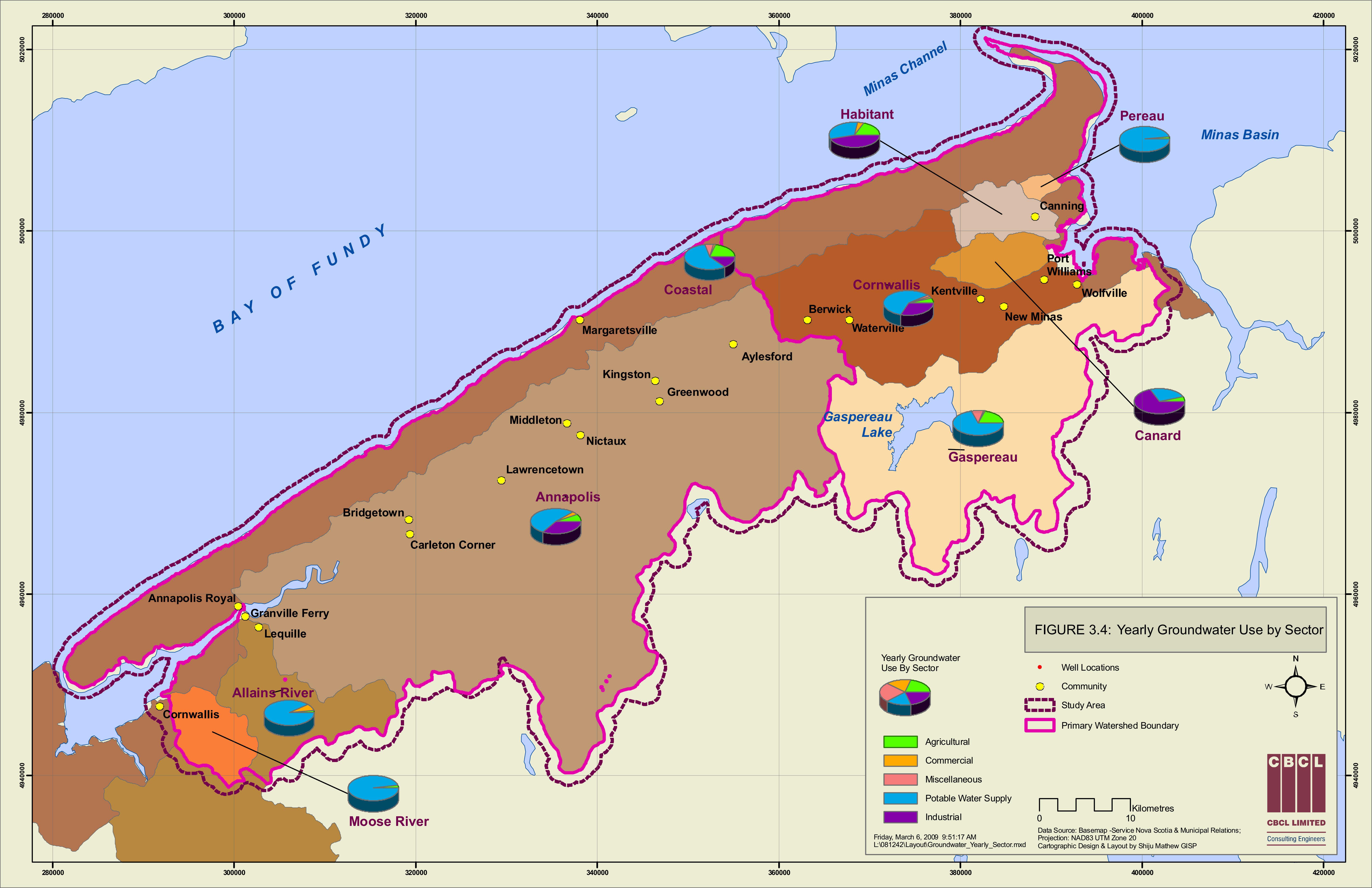


FIGURE 3.4: Yearly Groundwater Use by Sector

according to the consumptive use coefficient assigned to each record. Figure 3.5 shows the consumptive use by each sector in the Annapolis Valley. The industrial sector accounts for 2/3 of groundwater lost from Valley watersheds. Consumptive use coefficients for bottled water and food processing tend to be relatively high, representing water that is packaged and sold in areas outside of the Annapolis Valley.

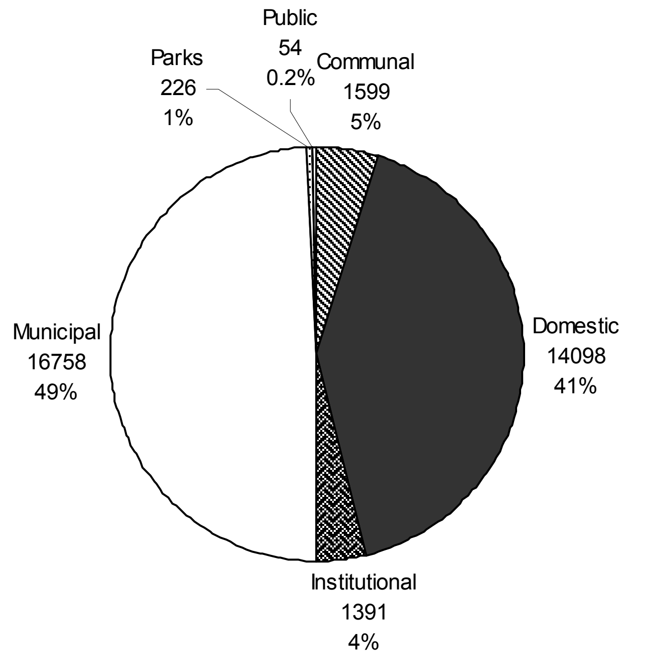


Figure 3.6: Average Daily Groundwater Use in the Potable Supply Sector by Facility Type (m^3/day)

The supply sector accounts for the highest daily rates of groundwater withdrawals (as indicated on Figure 3.1). This amount can be further subdivided by facility type, as shown on Figure 3.6. Municipal utilities account for approximately half of the water grouped under the supply sector. Estimates of domestic consumption account for much of the remaining water used for the supply sector (41%).

Figure 3.7 presents a map of daily groundwater use by secondary watershed. The Cornwallis watershed shows the most intensive use in the study area. Groundwater use was lower for smaller watersheds, and in areas that were more sparsely populated (Moose River, Allains River, and Gaspereau).

Daily groundwater use is further mapped by tertiary watershed on Figure 3.8. Water use by sub-watershed varies significantly, even between adjacent watersheds. This type of data could be helpful in determining aquifers or zones of aquifers experiencing the greatest intensity of use. It is noted, however, that tertiary watershed boundaries do not provide the most

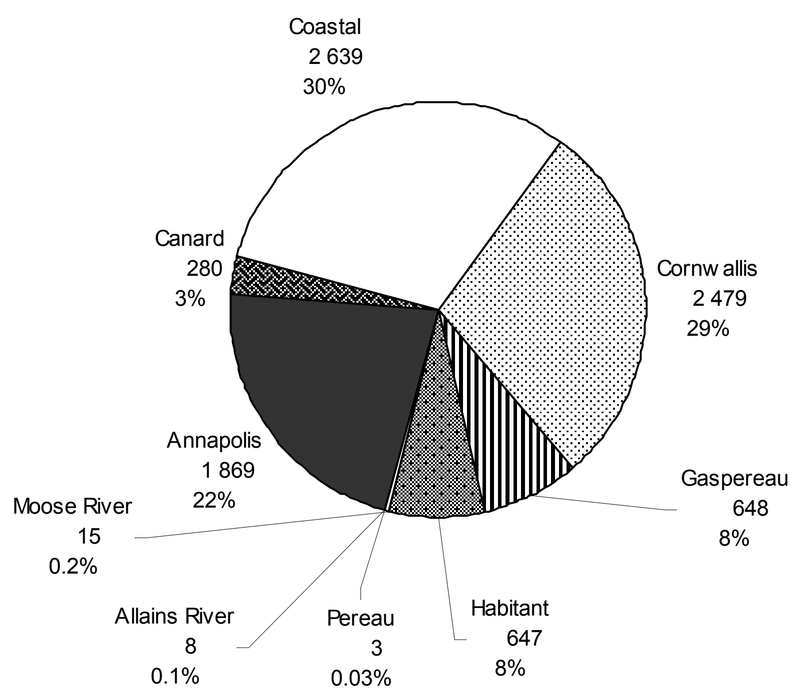


Figure 3.9: Average Daily Groundwater Use by the Agricultural Sector in each Secondary Watershed (m^3/day)

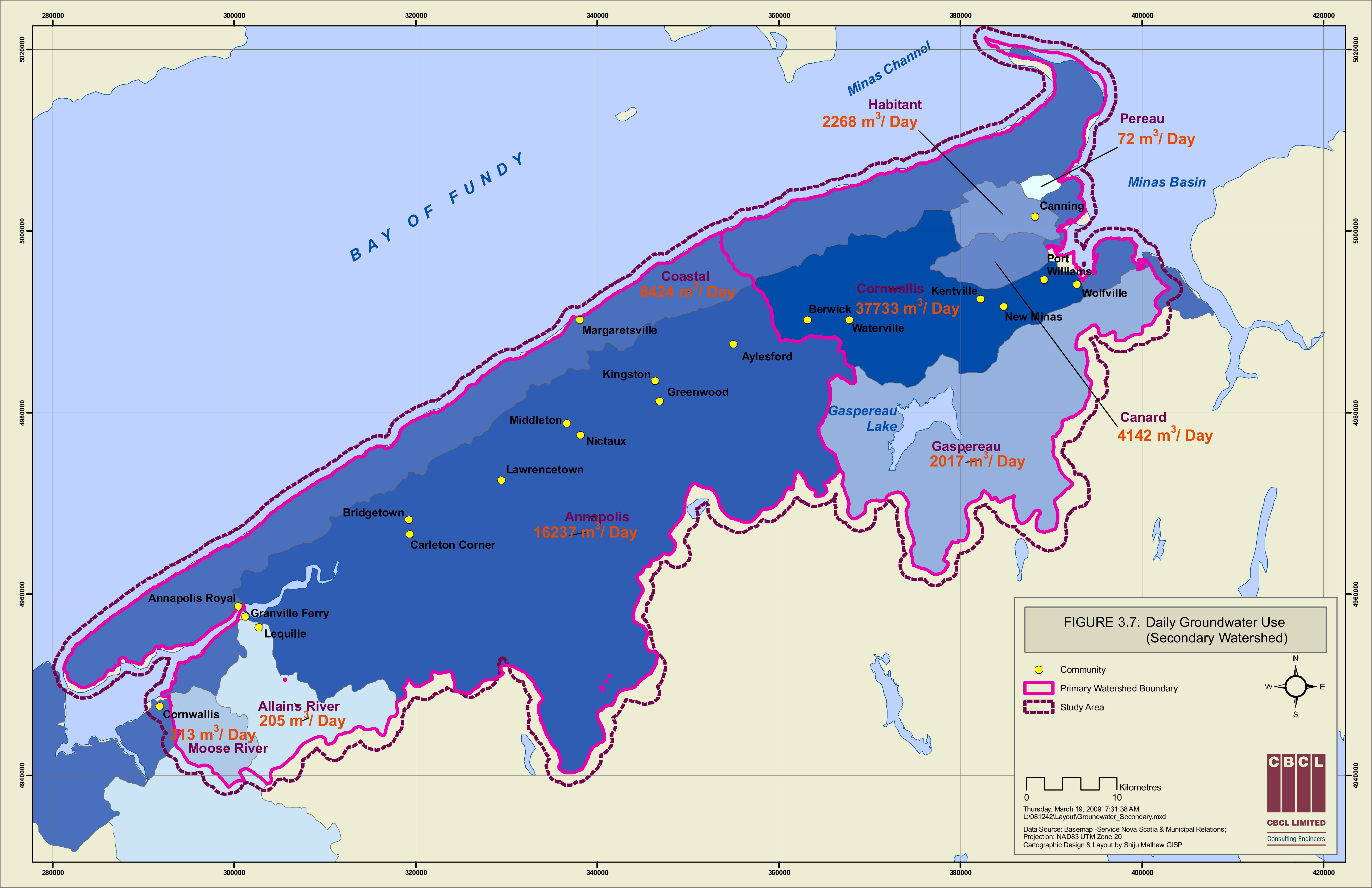
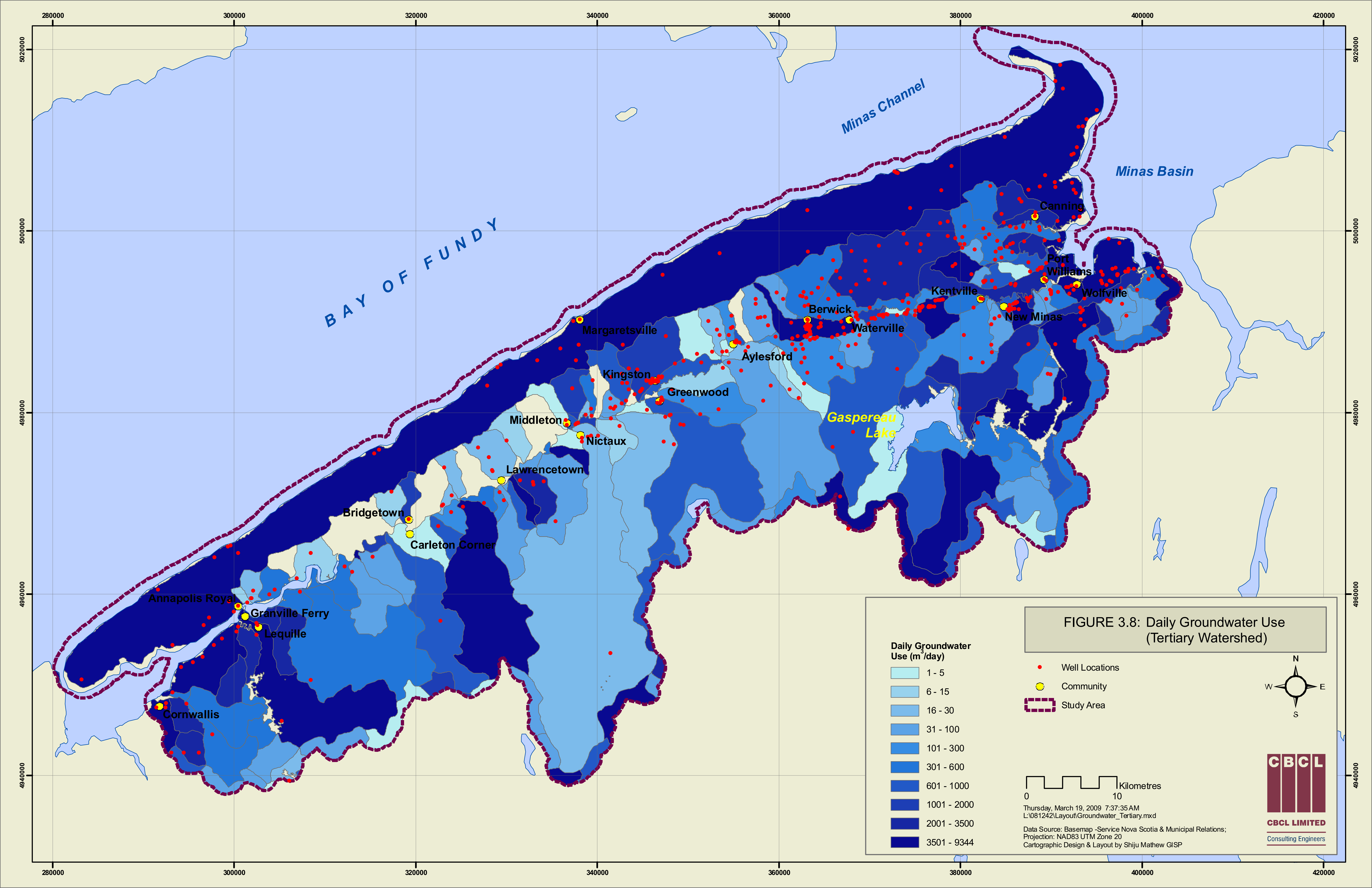


FIGURE 3.7: Daily Groundwater Use
(Secondary Watershed)
BAY OF FUNDY
Minas Channel
Minas Basin
Habitant
2268 m3/ Day
Pereau
72 m3/ Day
Coastal
8424 m3/ Day
Cornwallis
37733 m3/ Day
Canard
4142 m3/ Day
Gaspereau
2017 m3/ Day
Gaspereau Lake
Annapolis
16237 m3/ Day
Allains River
205 m3/ Day
313 m3/ Day
Moose River
Canning
Port Williams
Wolfville
Kentville
New Minas
Berwick
Waterville
Aylesford
Margaretsville
Kingston
Greenwood
Middleton
Nictaux
Lawrencetown
Bridgetown
Carleton Corner
Annapolis Royal
Granville Ferry
Lequille
Cornwallis
Community
Primary Watershed Boundary
Study Area
N
W
E
S
Kilometres
0
10
Thursday, March 19, 2009 7:31:38 AM
L:\081242\Layout\Groundwater_Secondary.mxd
Data Source: Basemap -Service Nova Scotia & Municipal Relations;
Projection: NAD83 UTM Zone 20
Cartographic Design & Layout by Shiju Mathew GISP
CBCL LIMITED
Consulting Engineers



BAY OF FUNDY
Minas Channel
Minas Basin
Gaspereau Lake
Canning
Port Williams
Wolfville
Kentville
New Minas
Berwick
Waterville
Aylesford
Margaretsville
Kingston
Greenwood
Middleton
Nictaux
Lawrencetown
Bridgetown
Carleton Corner
Annapolis Royal
Granville Ferry
Lequille
Cornwallis
FIGURE 3.8: Daily Groundwater Use (Tertiary Watershed)
Daily Groundwater Use (m3/day)
1 - 5
6 - 15
16 - 30
31 - 100
101 - 300
301 - 600
601 - 1000
1001 - 2000
2001 - 3500
3501 - 9344
Well Locations
Community
Study Area
N
W
E
S
0
10
Kilometres
Thursday, March 19, 2009 7:37:35 AM
L:\081242\Layout\Groundwater_Tertiary.mxd
Data Source: Basemap -Service Nova Scotia & Municipal Relations;
Projection: NAD83 UTM Zone 20
Cartographic Design & Layout by Shiju Mathew GISP
CBCL LIMITED
Consulting Engineers

accurate description of groundwater flow divides in the study area. Coordinate accuracy may also become an issue for mapping at this level of detail. For example, coordinates with an accuracy of 7,829 m cannot be placed with confidence within a given tertiary watershed.

Agricultural groundwater users can be grouped by secondary watershed, as shown on Figure 3.9. The Cornwallis watershed, which is one of the largest and intensively farmed watersheds accounts for 29% of agricultural water uses. The coastal watershed accounts for an additional 30% of agricultural uses, likely reflecting the high concentration of farms bordering the Minas Basin, and the high rates of use assigned to fish farms. Aquaculture has been grouped with agricultural users, whereas other studies have grouped aquaculture with industrial users. Although spread over a relatively large area, farms in the Annapolis watershed also account for 22% of agricultural water use.

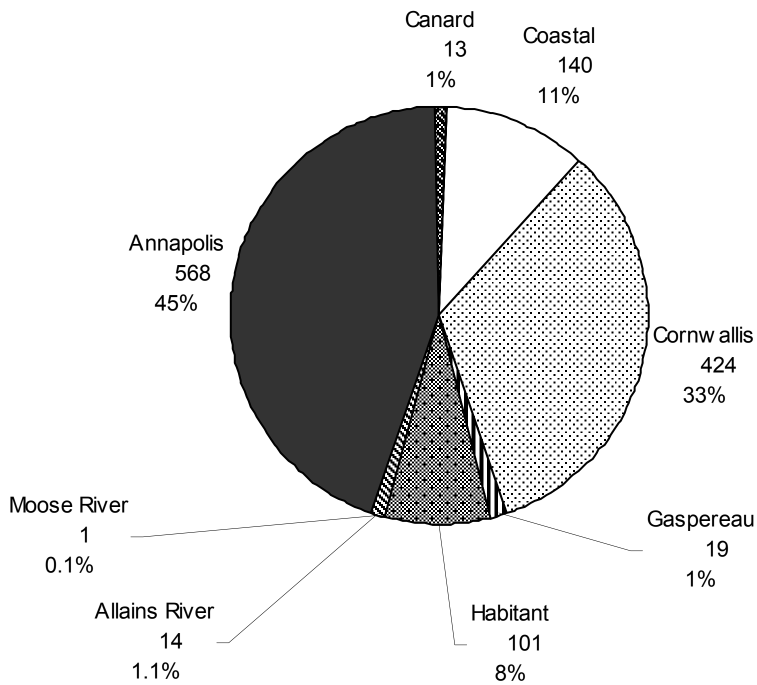


Figure 3.10: Average Daily Groundwater Use by the Commercial Sector in each Secondary Watershed (m^3/day)

Commercial activity is concentrated in the larger town centres of the valley, as illustrated on Figure 3.10. Concentrated in the Annapolis and Cornwallis watersheds, these areas account for the highest commercial uses of water. The Annapolis watershed accounts for 45% of use, and the Cornwallis watershed for 33% of use.

Industrial groundwater uses are also highest in the Annapolis (28%) and Cornwallis (49%) watersheds, shown on Figure 3.11. This may reflect the need for food processing plants to be placed in balanced proximity to the most productive areas, and close to the infrastructure provided by larger town centres. The Cornwallis watershed likely provides a good balance of these benefits.

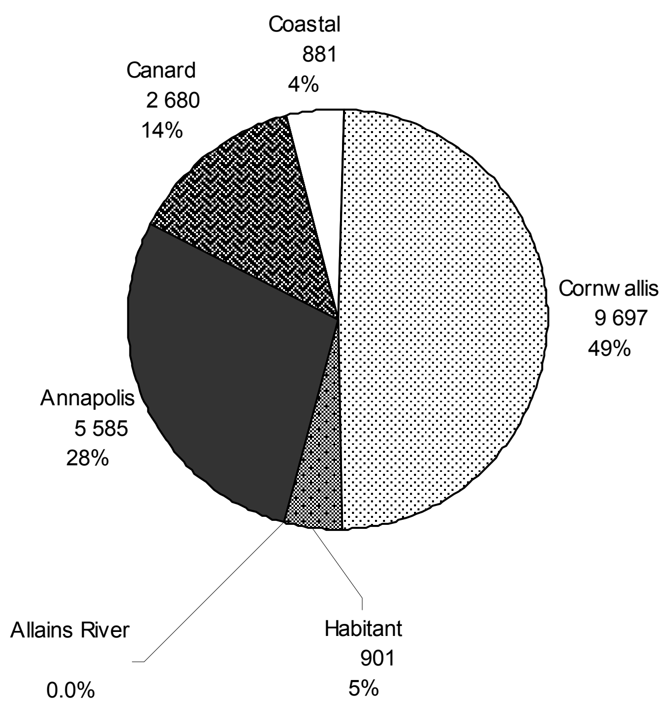


Figure 3.11: Average Daily Groundwater Use by the Industrial Sector in each Secondary Watershed (m^3/day)

Figure 3.12 summarizes both the total yearly groundwater consumption in each secondary watershed, and the distribution of this consumption among water use sectors. Consumption by industry predominates in the Annapolis, Cornwallis, and Canard watersheds, where overall consumption rates are highest. Groundwater consumption is lowest in the Moose River, Allains River, Gaspereau and Pereau watersheds, where the predominant sector is water supply. Normalized groundwater consumption rates are presented in Table 3.2. The Canard, Cornwallis, and Habitant watersheds show the most intensive rates of use, reflecting the highest densities of population and consumptive use practices.

Table 3.2: Yearly Groundwater Consumption Normalized to Watershed Area

Primary Watershed	Sub-Watershed	Yearly Groundwater Consumption (m^3)	Watershed Area (ha)	Normalized Groundwater Consumption (mm/year)
Annapolis	Annapolis	2 720 195	160 186	1.70
	Allains River	15 998	14 476	0.11
	Moose River	22 696	6 570	0.35
	Coastal[1]	203 830	46 364	0.44
	Sub-Total =	2 962 719	227 597	1.30
Gaspereau	Cornwallis	5 215 398	36 045	14.47
	Canard	1 115 497	5 323	20.95
	Habitant	431 981	5 517	7.83
	Pereau	5 548	851	0.65
	Gaspereau	124 460	52 011	0.24
	Coastal[1]	551 096	33 637	1.64
	Sub-Total =	7 443 981	133 385	5.58
Grand Totals =		10 406 700	360 982	2.88

[1]Groundwater use in coastal areas is reported as a total for the Annapolis and Gaspereau primary watersheds in the Groundwater Use Database. Provincial mapping does not distinguish the coastal sub-watershed in the Annapolis watershed from the coastal sub-watershed in the Gaspereau watershed. The sub-totals in this table were derived by subdividing water used in the coastal sub-watershed between the Annapolis (27%) and Gaspereau (73%) primary watersheds according to the proportion of non-coastal water use in each watershed.

The Wolfville Formation is a productive and generally readily accessed aquifer in the Annapolis Valley. The majority of well locations are underlain by the Wolfville Formation, suggesting this to be the aquifer providing water to these users. Figure 3.13 shows the high volume of water likely drawn from Wolfville Formation aquifers. Although quaternary aquifers can be excellent local sources, they are not always available or situated ideally to provide reliable water sources.

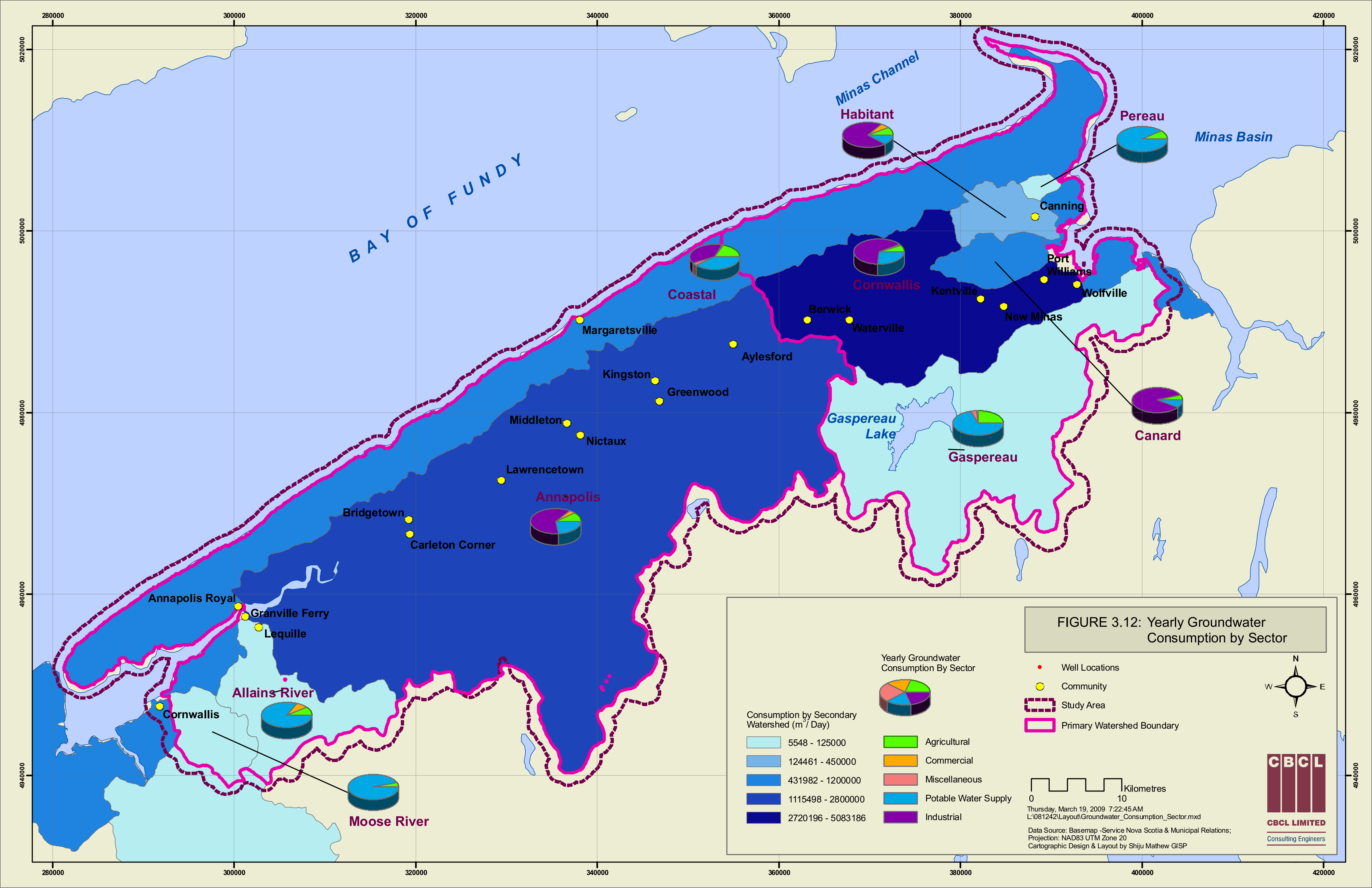
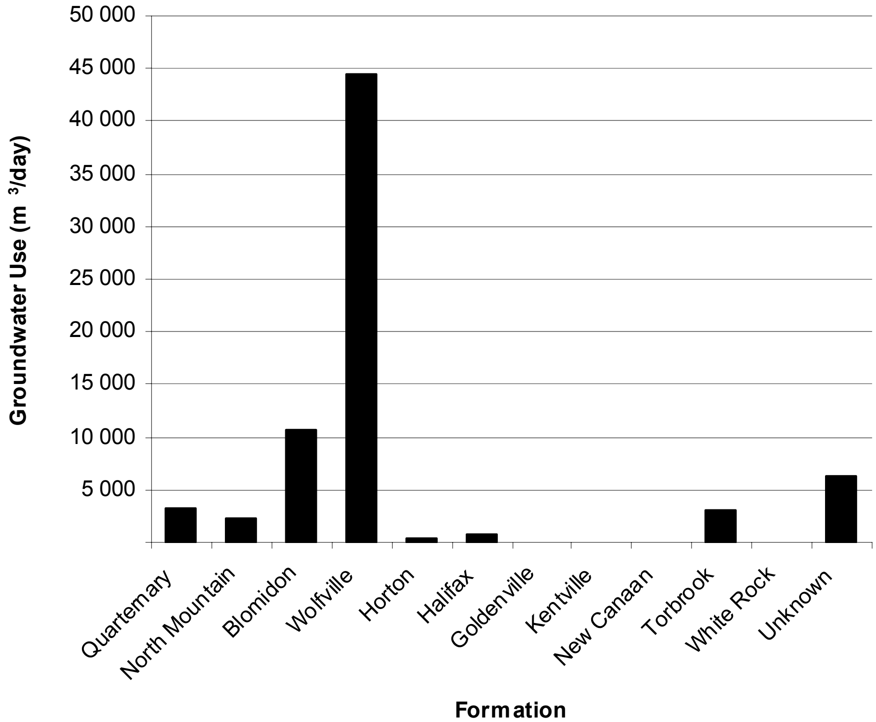


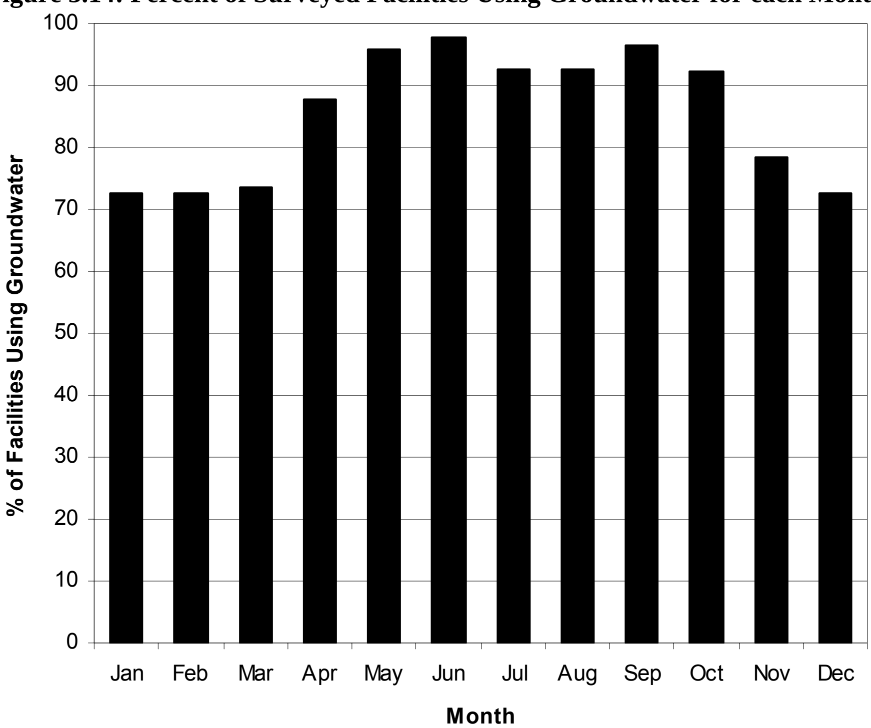
FIGURE 3.12: Yearly Groundwater Consumption by Sector
BAY OF FUNDY
Minas Channel
Minas Basin
Gaspereau Lake
Habitant
Pereau
Coastal
Cornwallis
Canard
Gaspereau
Annapolis
Allains River
Moose River
Canning
Port Williams
Kentville
Wolfville
New Minas
Berwick
Waterville
Margaretsville
Aylesford
Kingston
Greenwood
Middleton
Nictaux
Lawrencetown
Bridgetown
Carleton Corner
Annapolis Royal
Granville Ferry
Lequille
Cornwallis
Yearly Groundwater Consumption By Sector
Consumption by Secondary Watershed (m3 / Day)
5548 - 125000
124461 - 450000
431982 - 1200000
1115498 - 2800000
2720196 - 5083186
Agricultural
Commercial
Miscellaneous
Potable Water Supply
Industrial
Well Locations
Community
Study Area
Primary Watershed Boundary
N
E
S
W
0
10
Kilometres
Thursday, March 19, 2009 7:22:45 AM
L:\081242\Layout\Groundwater_Consumption_Sector.mxd
Data Source: Basemap -Service Nova Scotia & Municipal Relations;
Projection: NAD83 UTM Zone 20
Cartographic Design & Layout by Shiju Mathew GISP
CBCL
CBCL LIMITED
Consulting Engineers
280000
300000
320000
340000
360000
380000
400000
420000
5020000
5000000
4980000
4960000
4940000

Figure 3.13: Average Daily Groundwater Use by Underlying Geologic Formation (m^3/day)



Groundwater uses are most intense during the summer months as shown on Figure 3.14. This data is drawn from the available pool of questionnaire respondents, but is expected to reflect water use in the valley as a whole. As more agricultural records are obtained, the bias toward higher summer demands could increase beyond the relative rates shown in this dataset.

Figure 3.14: Percent of Surveyed Facilities Using Groundwater for each Month of the Year



The total daily groundwater use reported in the present study is 71 411 m^3/day. The ACVAS study (Rivard *et al.*, 2006) reported total groundwater demand to be between 31 000 and 404 000 m^3/day, placing the current estimate toward the lower end of this range. As additional agricultural users are added to the Groundwater Use Database the current estimate will increase, but it is likely to remain within the lower bounds of the estimate provide by the GSC.

AGRA (2000) reported a total demand of 583 765 m^3/day including both surface and groundwater sources but excluding water used for hydroelectric power generation. Figures for domestic use were based on “entitlement”, assuming that each household consumed 22 999 L/day, and totalled 254 747 m^3/day. Using this figure, groundwater use in the Valley would account for 12% of total demand. The method employed in the current study generated an estimate of 14 098 m^3/day for domestic use.   If this figure (14 098 m^3/day) were substituted for domestic use as determined by water entitlement (254 747 m^3/day), groundwater use would account for 21% of the demand reported by AGRA (2000).

Chapter 4 Closure

The Groundwater Use Database has been prepared for the sole benefit of the Nova Scotia Federation of Agriculture and the Province of Nova Scotia. Any use which a third party makes of the database or this report, or any reliance on decisions made based on it, is the responsibility of such third parties. CBCL Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on the database or this report. The information and conclusions contained in this report are based upon work undertaken by trained professional and technical staff in accordance with generally accepted engineering and scientific practices current at the time the work was performed. Conclusions presented in this report should not be construed as legal advice.

Chapter 5 References

AGRA Earth and Environmental Limited. 2000. Water Resources Needs of the Agricultural Industry in the Annapolis Valley, Nova Scotia. Submitted to the Growers Group, Horticulture Nova Scotia.

AMEC Earth and Environmental Limited. 2002. Groundwater Resources and the Cornwallis Soils in Kings County Nova Scotia. Final Report to The Nova Scotia Department of Agriculture & Fisheries and the Municipality of Kings.

Bellamy S., and Boyd D. 2005. Water Use in the Grand River Watershed. Prepared by the Grand River Conservation Authority.

CBCL Limited. 2003. Watershed Assessment in the Pereau and Habitant Watersheds in the Annapolis Valley, Nova Scotia. Prepared for Agriculture and Agri-Food Canada – Prairie Farm Rehabilitation Administration.

De Loe, R.C. 2005. Agricultural Water Use: A Methodology and Estimates for Ontario. Canadian Water Resources Journal Vol. 30(2). pp 111-128.

Dillon Consulting Limited, SGE Acres, Acadia Centre for Estuarine Research, and Pro-Agri Consulting. 2003. Cornwallis Watershed Assessment Study. Prepared for Agriculture and Agri-Food Canada – Prairie Farm Rehabilitation Administration.

Ecologistics Limited. 1993. A Review of Water Use and Water Use Efficiency in Ontario Agriculture: Final Report. Prepared for Water Efficiency Ontario, Agricultural Working Group, Ontario Ministry of Food and Agriculuture.

Environment Canada. 2008. Canadian Climate Normals and Averages, 1971-2000. http://climate.weatheroffice.ec.gc.ca/climate_normals/stnselect_e.html?Province=NS%20%20&StationName=&SearchType=&LocateBy=Province&Proximity=25&ProximityFrom=City&StationNumber=&IDType=MSC&CityName=&ParkName=&LatitudeDegrees=&LatitudeMinutes=&LongitudeDegrees=&LongitudeMinutes=&NormalsClass=A&SelNormals=&StnId=&&selRowPerPage=25&startRow=1. Accessed February 25, 2009.

Fisher, B.E., and Poole, J.C. (compilers of digital version). DP ME 43, Version 2, 2006, Digital Version of Nova Scotia Department of Natural Resources Map ME 2000-1, Geological Map of the Province of Nova Scotia, scale 1:500 000. Original compiled by J.D. Keppie, 2000.

Freeze, R.A. and Cherry, J.A., 1979. Groundwater. Prentice-Hall, Inc., Englewood Cliffs, N.J.

Greenough, J.D., 1995. Mesozoic Rocks, in H. Williams (ed.), Geology of the Appalachian-Caledonian Orogen in Canada and Greenland, Geological Survey of Canada, Geology of Canada, no.6, p.567-600.

Hutson, S (compiler). 2005. Guidelines for the Preparation of State Water Use Estimates. Techniques and Methods Book 4, Chapter E1. Prepared by the United States Geological Survey.

Isaacman, L., and Daborn, G. 2006. A Water Soft Path for the Annapolis Valley, Nova Scotia: A Case Study of Sustainable Freshwater Management at a Watershed-Scale. Prepared for Friends of the Earth Canada.

Ivey, J. 1998. Agricultural and Rural Water Use in Ontario. A Report to the Agricultural Adaptation Council under the National Soil and Water Conservation Program.

Jacques-Whitford Associates Limited. 2008. Final Report: Background Study for Integrated Community Sustainability Plans: Annapolis Valley Municipalities. Submitted to Kings Community Economic Development Agency.

Kennedy, G.W., and Drage, J.D. 2008. Groundwater Regions map of Nova Scotia. Nova Scotia Department of Natural Resources, Mineral Resources Branch, Open File Map ME2008-3. Scale 1:500 000.

Keppie, J.D. (compiler) 2000. Geological Map of the Province of Nova Scotia; Nova Scotia Department of Natural Resources, Mines and Energy Branch. Map ME 2000-1. Scale 1:500 000.

Klein, G. 1962. Triassic sedimentation, Maritime Provinces, Canada. Geological Society of America Bulletin, v.73, p.1127-1145.

MacPherson, 2004. Kings County and Annapolis County Groundwater Survey. Submitted to the Geological Survey of Canada.

MGI Limited. 2002. Assessment Studies of Water and Waste Water Systems and Associated Water Management Practices at Annapolis Valley First Nation Cambridge Station, NS (Site #06035) Atlantic Region. Submitted to Indian and Northern Affairs Canada.

Myslik, J.P. 1991. Water Use by Agriculture: Summary Report for Water Efficient Ontario. Ontario Ministry of Agriculture and Food.

Natural Resources Canada. 1999. The Atlas of Canada: Water Consumption. http://atlas.nrcan.gc.ca/site/english/maps/freshwater/consumption/. Accessed February 25, 2009.

Nova Scotia Department of Environment and Labour (NSEL), 2006. Pumping Test Database. NSEL Open File Report 1973-2001.

Nova Scotia Department of Environment and Labour (NSEL), 2006. Water Well Database (1978 to Present).

Nova Scotia Department of Environment and Labour. 2007. On-Site Sewage Disposal Systems Technical Guidelines.

Nova Scotia Department of Environment. 1981. Natural History of Nova Scotia Volume 1 Sec T8.1.

Ontario Ministry of the Environment. 2006. Assessment Report: Draft Guidance Module 7: Water Budget and Water Quantity Risk Assessment.

Rivard, C., Deblonde, C., Boivin, R., Bolduc, A., Paradis, S.J., Paradis, D., Liao, S., Gauthier, M.J., Blackmore, A., Trepanier, S., Castonguay, S., Drage, J., and Michaud, Y. 2007. Canadian Groundwater Inventory: Hydrogeological Atlas of the Annapolis Valley, Nova Scotia. Geological Survey of Canada, Open File 5541.

Rivard, C., Paradis, D., Paradis, S., Bolduc, A., Morin, R.H., Liao, S., Pullan, S., Gauthier, M.J., Trepanier, S., Blackmore, A., Spooner, I., Deblonde, C., Fernandes, R., Castonguay, S., Hamblin, T., Michaud, Y., Drage, J., and Paniconi, C. 2006. Canadian Groundwater Inventory: Regional Hydrogeological Characterization of the Annapolis-Cornwallis Valley Aquifers. Geological Survey of Canada.

Shaffer, K.H., and Runkle, D.L. 2007. Consumptive Water Use Coefficients for the Great Lakes Basin and Climatically Similar Areas. Scientific Investigations Report 2007 – 5179. Prepared for the USGS National Water Availability and Use Program.

Smith, M.L. 2004. Groundwater Supply and Demand Issues in Kings County, Nova Scotia. Master of Environmental Studies Thesis, Dalhousie University.

Statistics Canada. 2006 Census of Agriculture. Area of fruit, berries and nuts, vegetables, sod, nursery and greenhouse products, by province (Census of Agriculture, 1986 to 2006) . (Nova Scotia) http://www40.statcan.gc.ca/l01/cst01/agrc31d-eng.htm. Accessed February 25, 2009.

Statistics Canada. 2006 Census of Agriculture. Crops. http://www.statcan.gc.ca/pub/95-629-x/2007000/4123849-eng.htm. Accessed February 25, 2009.

Statistics Canada. 2006 Census of Agriculture. Farms, by farm type and province (Census of Agriculture, 2001 and 2006). http://www40.statcan.gc.ca/l01/cst01/agrc35d-eng.htm. Accessed February 25, 2009.

Statistics Canada. 2006 Census of Agriculture. Livestock, Poultry, and Bees. http://www.statcan.gc.ca/pub/95-629-x/2007000/4123855-eng.htm. Accessed February 25, 2009.

Statistics Canada. 2006 Census of Agriculture. Table 7.5-15. Farm machinery inventory and market value - Irrigation equipment on Census Day, 2006 and 2001. http://www.statcan.gc.ca/pub/95-629-x/7/4124675-eng.htm#12. Accessed February 25, 2009.

Statistics Canada. 2006 Census of Agriculture. Total farm area, land tenure and land in crops, by province (Census of Agriculture, 1986 to 2006). http://www40.statcan.gc.ca/l01/cst01/agrc25d-eng.htm. Accessed February 25, 2009.

Statistics Canada. 2006 Census of Agriculture. Table 4.12-1 Irrigation for the calendar year prior to census year - All irrigation use, 2005 and 2000 http://www.statcan.gc.ca/pub/95-629-x/4/4123968-eng.htm#12. Accessed February 25, 2009.

Statistics Canada. 2006 Census. Population and dwelling counts, for Canada, provinces and territories, census divisions, and census subdivisions (municipalities), 2006 and 2001 censuses - 100% data. http://www12.statcan.ca/english/census06/data/popdwell/Table.cfm?T=304&SR=11&S=1&O=A&RPP=10&PR=12&CMA=0. Accessed February 25, 2009.

Stea, R.R., Conley, H., and Brown, Y. (compilers) 1992. Surficial Geology of the Province of Nova Scotia; Nova Scotia Department of Natural Resources. Map 92-3. Scale 1:500 000.

Timmer, D.K., de Loe, R.C., and Kreutzwiser, R.D. 2007. Source Water Protection in the Annapolis Valley, Nova Scotia: Lessons for Building Local Capacity. Land Use Policy Vol. 24. pp 187-198.

Trescott, P.C., 1968. Groundwater resources and hydrogeology of the Annapolis-Cornwallis Valley, Nova Scotia, Nova Scotia Department of Mines, Memoir 6, 159p.

Appendix A
Quick Reference Guide

Quick Reference Guide

The Groundwater Use Database provides information on the location and average daily water use of well owners in the Annapolis Valley.

- Each record is identified by the user name (organization, institution, business, municipality etc.) and a unique Facility Code.
- The location of the well is provided as Easting and Northing coordinates (NAD83 UTM).
- The average daily water use is shown in m^3/day.

Other components of user, location, water use, and well information are provided if available. The database was built using a combination of existing provincial databases and a survey of groundwater use in the Annapolis Valley. Each record represents an individual farm, business, municipal well, public building or other facility using groundwater. Non-serviced domestic users were not included as individual records, but were estimated for each watershed.

The database covers records for users within the Annapolis and Gaspereau primary watersheds as indicated by provincial mapping.

<u>Database Structure</u>
The database can be subdivided into four sections:

1. User Data (12 fields)
2. Location Data (10 fields)
3. Water Use Data (11 fields)
4. Well Data (6 fields)

Table A1 provides a summary of the database fields and an explanation of each field. Table A2 provides a glossary of codes used in the database.

<u>Water Use Data</u>
Records of actual water use, facility information, and standard rates of consumption were used to generate water use data for each record. For most records, actual water use information was unavailable, and the daily water use was calculated. For some records estimates and assumptions were needed to complete the calculation. Calculations were based on established water use rates for livestock, crop types, and facility types. The average daily water use must be multiplied by the operating season length as indicated by the NUM_MONTH field to obtain the yearly water consumption for a given record. Other water use information (Maximum Daily Volume Taken and Maximum Pumping Rate) are provided if available. These data may be useful for an analysis of the maximum instantaneous demand experienced by a given area.

The Facility Sector, Facility Type, and Facility Sub-Type are provided for quick filtering and analysis of the data. Consumptive Use Coefficients are provided to allow for an analysis of consumptive use by a given dataset. Consumptive Use distinguishes the amount of pumped water that is permanently removed from a given watershed from pumped water that is recycled within the Valley hydrologic system.

For a complete description of database construction and methodologies refer to: Groundwater User Database: Methodology and Data Summary, CBCL Limited, 2009.

Table A1: Database Fields

Field	Full Title	Explanation	Units
F_CODE	Facility Code	Unique ID for each record	
GS_CODE	Group Code	Common group ID for wells with distinct F_Codes that are part of a common well field	
PID	Property ID	From provincial property registration database	
WELLNUM	NSE Well Number	From provincial well logs database	
NAME	Name of well user	Name of facility, institution, or business	
DBASE_SRC	Database source	Original source of record from NSE and NSDNR databases	
CIVIC_ADD	Civic address	Actual location of well	
MAIL_ADD	Mailing address	Administrative address of well operator or owner	
POSTAL	Postal Code		
PHONE	Telephone Number	Phone number of property owner or technical contact	
CONTACT	Contact Name	Name of person responsible for well - property owner or technical contact	
EMAIL	Electronic Mail Address		
EASTING	UTM NAD83 Easting Coordinate	Well location	metres (UTM NAD83)
NORTHING	UTM NAD83 Northing Coordinate	Well location	metres (UTM NAD83)
GEOREF_M	Georeference Method	Method of determination of well coordinates	
GEOREF_S	Georeference Source	Source of mapping information used to determine well coordinates	
GEOREF_A	Georeference Accuracy	Estimated accuracy of coordinates based on GPS output or map resolution	
1_WATERSHD	Primary Watershed	Watershed boundaries and levels are based on provincial mapping and drawn from NSDNR GIS data	
2_WATERSHD	Secondary Watershed	Watershed boundaries and levels are based on provincial mapping and drawn from NSDNR GIS data	
3_WATERSHD	Tertiary Watershed	Watershed boundaries and levels are based on provincial mapping and drawn from NSDNR GIS data	
COUNTY	County		
COMMUNITY	Nearest Community	Based on communities in Nova Scotia Gazeteer	
QUESTIONNR	Questionnaire Completed?	Indicates whether data is supplemented by a 2008 questionnaire completed by the well owner/operator	
F_SECTOR	Facility Sector	Broad category of water use	
F_TYPE	Facility Type	Description of facility type within each sector of groundwater use	
F_STYPE	Facility Sub-type	Specific designation where multiple sub-types are relevant for the facility type	
VOL_AVG	Average Volume Taken	Daily pumping volume averaged over the 2007 operating season	m3/day
VOL_MAX	Maximum Volume Taken	Maximum daily pumping volume observed in 2007 (from municipal records or permitted withdrawal rate)	m3/day
VOL_METHOD	Method of estimating volume	Indicates wheter data is drawn from pumping records, a questionnaire, or other methods of estimation	
RATE_MAX	Maximum Pumping Rate	Maximum instantaneous pumping rate when (all) pumps are engaged (from Pumping Test)	L/min
NUM_MONTH	Total number of months of pumping	Indicates length of pumping season, from 0 to 12 months	
NAME_MONTH	List months of pumping	Lists names of months in pumping season	
CONS_COEFF	Consumptive Use Coefficient	Factor assigned based on facility type, ranges from 0 for re-circulated water to 1.0 for total removal from watershed	dimensionless
WELL_TYPE	Type of well	Indicates dug or drilled well	
GEOLOGY_HU	Hydrostratigraphic unit of well	Name of geologic formation/hydrostratigraphic unit that well is installed in	
DEPTH	Depth of well	As indicated by Drilling Contractor at time of well installation	metres
BEDROCK	Depth to bedrock in well	Indicates thickness of overburden overlying the bedrock formation	metres
STATIC	Static water level in well	Depth to water when well is not pumping	metres
YIELD	Well yield	Test pumping rate based on pumping test or driller's estimate	L/min

Table A2: Glossary of Codes Used in Groundwater Use Database

Code	Explanation
Georeferencing Method	
G	GPS
M	Map
D1	Property Centroid - NSPRD
D2	Property Location - NSPRD
A1	Property Centroid - Nova Scotia Map Book
A2	Property Centroid - Nova Scotia Atlas
B1	Property Centroid - NTS Claim
B2	Property Centroid - NTS Tract
C	Community Centroid - Gazeteer
U	Unknown
Groundwater Use Sector	
SUPP	Potable Water Supply
AG	Agricultural
COMM	Commercial
DEWAT	Dewatering
INDUST	Industrial
MISC	Miscellaneous
Geologic Unit of Aquifer	
Q	Quarternary
NO	North Mountain
BL	Blomidon
WO	Wolfville
SO	South Mountain
HO	Horton
HX	Halifax
GO	Goldenville
KE	Kentville
NC	New Canaan
TO	Torbrook
WH	White Rock
A	Unknown

Appendix B

Groundwater Use Questionnaires

Annapolis Valley Groundwater Use Study

Well Water Use Questionnaire

Prepared for
The Nova Scotia Federation of Agriculture
by
CBCL Limited

Individual survey responses will be kept strictly confidential. Please forward a copy of your responses by email, fax or mail to:

Michelle Whidden, Environmental Technologist
Environmental Department
CBCL Limited
PO Box 606, Halifax NS, B3J 2R7
Phone: (902) 421-7241 extension #2512
Fax: (902) 423-3938
E-mail: michellew@cbcl.ca

CBCL LIMITED
Consulting Engineers

You can also complete this questionnaire on-line by going to:
http://www.cbcl.ca/annapolis/well_water_questionnaire.html

Please return your survey by **January 30, 2009**.

Thank you very much for your interest and time.

Annapolis Valley Water Supply Questionnaire

A. Contact Information and Location

Do you use well water?

- ✕ *No* ☞ *(There is no need to complete this questionnaire)*
- ✕ *Yes, but only for my home* ☞ *(There is no need to complete this questionnaire)*
- ❑ *Yes, for the farm*

Please fill out as many sections as you can. All of the information you can provide is useful. Guesses and estimates are okay.

Name of Farm or Business ______________________________

Contact Name ______________________________

Civic address of well location ______________________________

____

PID ______________________________

"PID" stands for "Property Identification Number". You may have a record of this number in your property assessment.

Phone Number ______________________________

Email ______________________________

Well Number(s) ______________________________

This number was assigned when your well was drilled. You can find this number in the top left-hand corner if you have a copy of the drilling record for your well.

Annapolis Valley Water Supply Questionnaire
B. Water Use

1. What crops do you irrigate with well water? (i.e. field crops, orchards and greenhouses.)

❑ *No Crop Irrigation with Well Water (Please skip to Question 3)*

Area:	Crop area (indicate acres or hectares) – use the maximum area irrigated
Amount:	Amount of water sprayed for one application during a dry season (indicate mm, inches, Imp gal, US gal, or litres)
Duration:	Length of time for one application (indicate hours, days, or weeks)
Season:	Length of irrigation season (indicate weeks or months)

❑ *Greenhouse*	*Area* ________	*Amount* ________	*Duration* ________	*Season* ________
❑ *Potatoes / Onions*	*Area* ________	*Amount* ________	*Duration* ________	*Season* ________
❑ *Pumpkin / Squash*	*Area* ________	*Amount* ________	*Duration* ________	*Season* ________
❑ *Asparagus*	*Area* ________	*Amount* ________	*Duration* ________	*Season* ________
❑ *Tomatoes*	*Area* ________	*Amount* ________	*Duration* ________	*Season* ________
❑ *Sweet Corn*	*Area* ________	*Amount* ________	*Duration* ________	*Season* ________
❑ *Other Vegetables*	*Area* ________	*Amount* ________	*Duration* ________	*Season* ________
❑ *Grains*	*Area* ________	*Amount* ________	*Duration* ________	*Season* ________
❑ *Alfalfa*	*Area* ________	*Amount* ________	*Duration* ________	*Season* ________
❑ *Cranberries*	*Area* ________	*Amount* ________	*Duration* ________	*Season* ________

There are more crop types on the next page

↓

❑ *Other Berry Crops* *Area* ____________ *Amount*____________ *Duration*____________ *Season*____________

❑ *Fruit Orchard* *Area* ____________ *Amount*____________ *Duration*____________ *Season*____________

❑ *Grapes* *Area* ____________ *Amount*____________ *Duration*____________ *Season*____________

❑ *Frost Protection* *Area* ____________ *Amount*____________ *Duration*____________ *Season*____________

❑ *Other*______________________________

Area ____________ *Amount*____________ *Duration*____________ *Season*____________

❑ *Other*______________________________

Area ____________ *Amount*____________ *Duration*____________ *Season*____________

2. What kind of sprinkler system(s) do you have?

❑ *Hand move small sprinklers* *Flow rate* ____________________ *Number* ____________

❑ *Solid set small sprinklers* *Flow rate* ____________________ *Number* ____________

❑ *Hand move volume gun* *Flow rate* ____________________ *Number* ____________

❑ *Hard hose reel* *Flow rate* ____________________ *Number* ____________

❑ *Pivot system* *Flow rate* ____________________ *Nozzles* ____________

❑ *Trickle or drip system* *Flow rate* ____________________ *Length* ____________

❑ *Other* ______________ *Flow rate* ____________________ ____________

3. Do you water livestock with well water?

- ❑ *No (Please skip to Question 5)*
- ❑ *Yes*

4. What kind of livestock do you have?

❑ *Beef Cattle*	*Number*________________	❑ *Hens/Poultry*	*Number*________________
❑ *Dairy Cattle*	*Number*________________	❑ *Turkeys*	*Number*________________
❑ *Hogs*	*Number*________________	❑ *Sheep and Goats*	*Number*________________
❑ *Other*___________________________	*Number*________________		
❑ *Other*___________________________	*Number*________________		

5. What is your growing season?

❑ *All year* ❑ *Jan* ❑ *Feb* ❑ *Mar* ❑ *Apr* ❑ *May* ❑ *Jun* ❑ *Jul* ❑ *Aug* ❑ *Sep* ❑ *Oct* ❑ *Nov* ❑ *Dec*

6. Do you pump water from a dugout pond?

- ❑ *No*
- ❑ *Yes*

7. Where does the water in the pond come from? Please check all that apply:

- ❑ *Seepage and Run-off* *Number of Ponds* ________________________
- ❑ *Well Water* *Number of Ponds* ________________________
- ❑ *Stream* *Number of Ponds* ________________________

8. How many active wells do you have?

- ❑ *For the house:* ________________ ❑ *dug* ❑ *drilled*
- ❑ *For the farm:* ________________ ❑ *dug* ❑ *drilled*
- ❑ *For the house and farm:* ________________ ❑ *dug* ❑ *drilled*

Dug wells are shallow, and often have a 3 foot diameter concrete crock at the ground surface.

Drilled wells are usually deeper than dug wells, and have a 4 to 12 inch diameter steel casing at the ground surface.

9. What is your water source for the farm? ❑ *Bedrock* ❑ *Sand / Gravel / Overburden* ❑ *Don't Know*

10. Does water overflow from any of your wells without pumping? (Do you have a flowing artesian well?) ❑ *No* ❑ *Yes* ❑ *Don't Know*

11. How deep are your farm well(s)?________________________________(circle*: feet metres)* ❑ *Don't Know*

12. Where are the pump(s) set? ________________________________(circle*: feet metres*) ❑ *Don't Know*

13. Have you had any problems with water quantity in the past? ❑ *No* ❑ *Yes*

Additional Comments:

____

____

____

Annapolis Valley Groundwater Use Study

Well Water Use Questionnaire

Prepared for
The Nova Scotia Federation of Agriculture
by
CBCL Limited

Background

The Nova Scotia Federation of Agriculture is working with the province to complete a well water use survey in the Annapolis Valley. The goal of this survey is to gather feedback from water users in the Annapolis Valley to determine current well water needs and usage patterns. This information will be used to maintain and protect existing water supplies in the Annapolis Valley, and to show the amount of well water used in the Valley as a whole. If you have any questions about this questionnaire, please contact CBCL at the number shown below.

Individual survey responses will be kept strictly confidential. Please forward a copy of your responses by email, fax or mail to:

Michelle Whidden, Environmental Technologist
Environmental Department
CBCL Limited
PO Box 606, Halifax NS, B3J 2R7
Phone: (902) 421-7241 extension #2512
Fax: (902) 423-3938
E-mail: michellew@cbcl.ca

CBCL LIMITED
Consulting Engineers

You can also complete this questionnaire on-line by going to:
http://www.cbcl.ca/annapolis/well_water_questionnaire.html

Please return your survey by **January 30, 2009**.

Thank you very much for your interest and time.

Annapolis Valley Water Supply Questionnaire

A. Contact Information and Location

Do you use well water?

- ❑ *No (There is no need to complete this questionnaire)*
- ❑ *Yes*

Name of Facility or Business ______________________________

____

Please fill out as many sections as you can. All of the information you can provide is useful. Estimates and guesses are okay.

Contact Name ____

Civic Address of Pumping Location ______________________________

____

____

"PID" stands for "Property Identification Number". You may have a record of this number in your property assessment.

PID ____

GPS Coordinates: Easting ______________________________

Northing ______________________________

Mailing Address (if different from above) ______________________

____

____

Phone Number ____

Email ____

NSE Well Number(s) ____________________________________

____

This number was assigned when your well was drilled. You can find this number in the top left-hand corner if you have a copy of the drilling record for your well.

B. Facility Type

- ❑ ***Potable Water Supply***
  - ❑ *Municipal Supply*
  - ❑ *Campground:*
    - ❑ Day Use
    - ❑ Serviced/RVs
    - ❑ Summer Camp
  - ❑ *Communal:*
    - ❑ First Nations
    - ❑ Water Group / Co-op
    - ❑ Apartment Building
    - ❑ Day Use
  - ❑ *Institutional:*
    - ❑ Hospital
    - ❑ Long term care facility
    - ❑ Fire Station
    - ❑ Police Station
    - ❑ Elementary School
    - ❑ Junior School
    - ❑ High School
    - ❑ Day Care
    - ❑ Correctional Facility
  - ❑ *Public:*
    - ❑ Library
    - ❑ Museum
    - ❑ Church
    - ❑ Arena
    - ❑ Community Centre
  - ❑ *Other* _________________

- ❑ ***Commercial***
  - ❑ *Restaurant*
  - ❑ *Grocery Store*
  - ❑ *Variety Store*
  - ❑ *Gas Retailer*
  - ❑ *Bottled Water*
  - ❑ *Golf Course Irrigation*
  - ❑ *Business Office*
  - ❑ *Inn / Motel*
  - ❑ *Automotive*
  - ❑ *Other* _______________

- ❑ ***Miscellaneous***
  - ❑ *Recreational*
  - ❑ *Heat Pump / Geothermal:*
    - ❑ Discharge to groundwater
    - ❑ Discharge to surface water
  - ❑ *Aesthetics*
  - ❑ *Other* _________________

- ❑ ***Industrial***
  - ❑ *Aggregate Washing*
  - ❑ *Brewing and Soft Drinks*
  - ❑ *Cooling Water*
  - ❑ *Food Processing*
  - ❑ *Remediation*
  - ❑ *Manufacturing*
  - ❑ *Other* _______________

- ❑ ***Dewatering***
  - ❑ *Construction*
  - ❑ *Pits and Quarries*
  - ❑ *Other* _______________

C. Water Use

1. What are your hours of operation? ________________________

____

"Operation" refers to pumping, or activities that use water.

2. How many days out of each month do you operate?___________

❑ *Weekdays only*

3. What are your months of operation?

❑ *All year*

❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*

4. How many people work at or attend your facility each day? ______________

5. What kind of pump do you have in your well?

____

❑ *Don't Know*

6. Do you have a record of your pumping rate or overall water use?

❑ *No (Please skip to the next page)*
❑ *Yes*

7. What is your pumping rate? ______________________________

❑ *Imperial Gallons per minute (igpm)*
❑ *US gallons per minute (USgpm)*
❑ *Litres per minute (Lpm)*
❑ *Cubic metres per day (m^3/day)*

❑ *Don't Know*

8. What is the most you have pumped in one day? _____________

❑ *Don't Know*

❑ *Imperial Gallons*
❑ *US gallons*
❑ *Litres*
❑ *Cubic metres*

9. How much water do you pump each year? ________________

❑ *Don't Know*

C. Water Use (Continued)

10. How many fixtures do you have?

- ❑ *Bathrooms* ________________
- ❑ *Showers* __________________
- ❑ *Other Sinks* _______________

11. Is your water used mainly for kitchens and bathrooms?

- ❑ *No*
- ❑ *Yes (Please skip to Section D)*

12. Is your water used in food preparation?

- ❑ *No*
- ❑ *Yes* *Number of customers per day:* ______________

13. Do you irrigate a golf course?

- ❑ *No* *(Please skip to the next question)*
- ❑ *Yes*

Number of nozzles spraying at the same time _____________________________

Nozzle Rating ____________________________

Hours per Day ____________________________*Days per Year* ____________________________

14. Do you use water in processing or manufacturing?

- ❑ *No* *(Please skip to the next question)*
- ❑ *Yes*

Product ____ *Units per day* ________________

List other uses:
Washing Equipment _____________________________ *Hours per day* _______________

Other ____

Other ____

D. Well Information

15. How many active wells do you have? ____________________

16. What type of well(s) do you have?

❑ *Dug* *How many?* ______

❑ *Drilled* *How many?* ______ ❑ *Don't Know*

Dug wells are shallow, and often have a 3 foot diameter concrete crock at the ground surface.

Drilled wells are usually deeper than dug wells, and have a 4 to 12 inch diameter steel casing at the ground surface.

17. What is your main water source?

❑ *Bedrock*
❑ *Sand / Gravel / Overburden*
❑ *Don't Know*

18. Does water overflow from your well without pumping?
(Do you have a flowing artesian well?)

❑ *No*
❑ *Yes* ❑ *Don't Know*

19. How deep is your well?____________________(circle: *feet* *metres*) ❑ *Don't Know*

20. What is the depth to water?__________________(circle: *feet* *metres*) ❑ *Don't Know*

21. Where is the pump set? ____________________(circle: *feet* *metres*) ❑ *Don't Know*

22. Date of well construction______________________________________ ❑ *Don't Know*

23. Have you had any problems with water quantity in the past?

❑ *No*
❑ *Yes*

Additional Comments: ____

____

____

____

Appendix C

Coefficients and Example Calculations for Livestock

Table C1 provides a summary of coefficients used for the calculation of consumption by livestock. The methods used in the present study are similar aspects employed by Dillon (2003). In the Dillon study livestock demand was estimated by using land use patterns and municipal livestock housing data from Kings County. Livestock consumption was calculated from individual barn data subdivided among small, medium, and large livestock. AGRA (2000) estimated a continuous demand of 1000 USgpm for the valley as a whole. The current investigation used coefficients for each animal type, drawn from de Loe (2005).

Methods of calculation and tables of standard animal consumption, animal washing, equipment washing, irrigation, losses, and spraying were provided in spreadsheet format by the kind consideration of Dr. Rob de Loe.

Example Calculation

Animal Drinking = # Animals x Drinking Rate (L/animal/day)
Losses = Animal Consumption x Loss Fraction
Animal Washing = # Animals x Washing Rate (L/animal/day)
Equipment Washing = Lump Sum per Animal Type (L/day/farm)

Total Water Use for Animal Type 1
= Animal Drinking + Losses + Animal Washing + Equipment Washing

Total Water Use by Livestock
= Animal type 1 total + Animal type 2 total + Animal type *n* total…

Average Daily Use
= Water Use (L/day) x 365 days/year / Operating Season (days) / 1000 (L/m^3)

Record: FC2495
Data from Questionnaire:
Swine (Boars) – 15
Swine (Sows) – 15
Beef Cattle – 85
Chickens (other) – 18 000

Swine (Boars)

Animal Drinking	=	15 animals x 12.5 (L/animal/day)
	=	187.5 L/day
Losses	=	187.5 L/day x 4.2
	=	787.5 L/day
Animal Washing	=	15 animals x 1.2 (L/animal/day)
	=	18 L/day
Equipment Washing	=	0 (L/day/farm)

Total Water Use for *Swine (Boars)*
= 187.5 L/day + 787.5 L/day + 18 L/day + 0 L/day
= 993 L/day

Total Water Use by Livestock
= 993 L/day + 1617 L/day + 4016.25 L/day + 6609 L/day
= 13 239 L/day

Average Daily Use
= 13 239 L/day x 365 / 365 / 1000 (L/m^3)
= 13.2 m^3/day

Table C1: Standard Consumption Rates for Livestock Calcuations

Animal	Coefficient	Losses	Animal Washing	Equipment Washing
	L/day/animal		L/day/animal	L/day/farm
Chicken Pullets < 19	0.2	0.02	0	0
Chicken Pullets > 19	0.27	0.02	0	0
All other chickens	0.36	0.02	0	0
Turkeys	0.45	0.02	0	0
Other poultry	0.5	0.02	0	0
Bulls	36	0.05	0	0
Beef Cows	45	0.05	0	0
Heifers (beef)	27	0.05	0	0
Steers	30	0.05	0	0
Calves	15	0.05	0	0
Milking Cows	90	0.05	4	1442*
Dry Cows	40	0.05	0	0
Swine: Boars	12.5	4.2	1.2	0
Swine: Sows	20.5	4.2	1.2	0
Swine: Dry Sows	12.5	4.2	1.2	0
Swine: Other	5	1.6	0.55	0
Sheep: Rams	7.4	0.05	0	0
Sheep: Ewes	7.4	0.05	0	0
Sheep: Lambs	4	0.05	0	0
Horses/ ponies	42	0	0	0
Goats	4	0.05	0	0
Rabbits	0.2	0.05	0	0
Mink	0.18	0.05	0	500
Fox	0.23	0.05	0	0

*assumes parlour style facility

Appendix D

Coefficients and Example Calculations for Crops, Berries, and Greenhouses

Tables D1, D2, D3, D4, and D5 provide summaries of coefficients used for the calculation of crop irrigation and production. Water used for crop irrigation and production was calculated from coefficients for each type of field crop, berry or tree fruit. A separate coefficient was used to summarize all use within a greenhouse or nursery. The coefficients and method of calculation are drawn from de Loe (2005).

Present methods of calculation are more specific than those employed in previous studies. AGRA (2000) assumed a standard irrigation rate of 1.43 inches/acre (90 mm/ha), with a minimum irrigation period of 2 to 8 weeks and a maximum irrigation period of 16 to 52 weeks. A previous study by CBCL (2003) assumed 250 mm/crop/year, using census data to determine the number of farms and acreages irrigated. Dillon (2003) considered demand based on land use patterns and calculated specific demands for each crop based on standard irrigation tables from the Ontario Ministry of Agriculture, Farms, and Rural Affairs (OMAFRA). A standard demand of 125 to 175 mm/crop/year was considered representative of most rotational crops.

Methods of calculation and tables of standard animal consumption, animal washing, equipment washing, irrigation, losses, and spraying were provided in spreadsheet format by the kind consideration of Dr. Rob de Loe.

<u>Example Calculation: Vegetable Irrigation</u>

Irrigation
= # Applications per Year x Application Rate (m/event) x Farm Area (m^2) x Fraction of Area Irrigated*

Spraying
= # Sprays per Year x Application Amount (L/ha) x Farm Area (ha)

Equipment Washing
= Percentage of Spraying Water

On-farm Processing
= Processing Rate (L/ha/year) x Farm Area (ha) / 1000 (L/m^3)

Other Water Uses
= Other Uses Rate (L/ha/year) x Farm Area (ha) / 1000 (L/m^3)

Sub-Total Water Use for Irrigation
= Irrigation + Spraying + Equipment Washing + On-farm Processing + Other Water Uses

Average Daily Sub-Total
= Irrigation Use (m^3/year) / Operating Season (days irrigation/year)

Total Water Use for Irrigation
= Crop type 1 sub-total + Crop type 2 sub-total + Crop type *n* sub-total…

***NB**: Survey data in some cases provided all of the items listed in the calculation for "Irrigation". Where one or more of the items was not available, standard values were substituted from de Loe (2005).

Record: FC2595
Data from Questionnaire:
Corn – 1.82 ha
Potatoes – 1.82 ha

Corn
Irrigation
= 3 Applications per Year x 0.03 (m/event) x 18 200 (m^2) x 0.055
= 90 m^3/year

Spraying
= 3 Sprays per Year x 225 (L/ha) x 1.82 (ha)
= 1228.5 L
= 1.23 m^3/year

Equipment Washing
= 0.1 x 1.23 m^3/year
= 0.123 m^3/year

On-farm Processing
= 0 L/ha/year x 1.82 ha
= 0 L/year
= 0 m^3/year

Other Water Uses
= 0 L/ha/year x 1.82 ha
= 0 L/year
= 0 m^3/year

Sub-Total Water Use for Irrigation
= 90 m^3/year + 1.23 m^3/year + 0.123 m^3/year + 0 m^3/year + 0 m^3/year
= 91.35 m^3/year

Average Daily Sub-Total
= 91.35 m^3/year / 42 days/year
= 1.305 m^3/day

Total Water Use for Irrigation
= 1.305 m^3/day + 32.96 m^3/day
= 34.26 m^3/day

Example Calculation: Fruit Irrigation

Irrigation Sub-total
= # Applications per Year x Application Rate (m/event) x Farm Area (m^2) x Fraction of Area Irrigated*

Irrigation Total
= Irrigation sub-total (m^3/year) x % of crop under regular irrigation + Irrigation sub-total (m^3/year) x % of crop under drip irrigation x 0.85

Herbicide Spraying
= # Sprays per Year under cover x Application Amount (L/ha) x Farm Area (ha) x 0.15 + # Sprays per Year not under cover x Application Amount (L/ha) x Farm Area (ha) x 0.85 / 1000 (L/m^3)

Fungicide Spraying
= # Sprays per Year for fruit bearing trees x Application Amount (L/ha) x Farm Area (ha) x % of trees bearing fruit + # Sprays per Year for non-bearing trees x Application Amount (L/ha) x Farm Area (ha) x % of trees bearing fruit / 1000 (L/m^3)

Sanitation Washing
= Application Rate (L/bushel) x Productivity (bushels/ha) x Farm Area (ha) / 1000 (L/m^3)

Harvesting/Transport
= Harvesting Rate (L/ha/year) x Farm Area (ha) / 1000 (L/m^3)

On-farm Processing
= Processing Rate (L/ha/year) x Farm Area (ha) / 1000 (L/m^3)

Other Water Uses
= Other Uses Rate (L/ha/year) x Farm Area (ha) / 1000 (L/m^3)

Sub-Total Water Use for Fruit Type
= Irrigation + Herbicide + Fungicide + Washing + Harvesting/Transport + On-Farm Processing + Other Water Uses

Average Daily Sub-Total
= Irrigation Use (m^3/year) / Operating Season (days irrigation/year)

Total Water Use for Irrigation
= Fruit type 1 sub-total + Fruit type 2 sub-total + Fruit type *n* sub-total…

***NB**: Survey data in some cases provided all of the items listed in the calculation for "Irrigation". Where one or more of the items was not available, standard values were substituted from de Loe (2005).

Record: FC2579
Data from Questionnaire:
Area – 11.33 ha

Irrigation Sub-total
= 4 Applications per Year x 0.035 (m/event) x 11 331 m^2 x 0.111
= 176.08 m^3/year

Irrigation Total
= 176.08 m^3/year x 0.8447 + 176.08 m^3/year x 0.1553 x 0.85
= 171.98 m^3/year

Herbicide Spraying
= [0.25 sprays per year under cover x 500 L/ha x 11.33 ha x 0.85 + 2 sprays per year not under cover x 500 L/ha x 11.33 ha x 0.15] / 1000 L/m^3
= 2.90 m^3/year

Fungicide Spraying
= [12 sprays per year for fruit bearing trees x 1000 L/ha x 11.33 ha x 0.86 + 5 sprays per year for non-bearing trees x 1000 L/ha x 11.33 ha x 0.14] / 1000 L/m^3
= 124.87 m^3/year

Sanitation Washing
= 646 L/bushel x 845 bushels/ha x 11.33 ha / 1000 L/m^3
= 6184.71 m^3/year

Harvesting/Transport
= 693 (L/ha/year) x 11.33 (ha) / 1000 L/m^3
= 7.85 m^3/year

On-farm Processing
= 1252 (L/ha/year) x 11.33 (ha) / 1000 L/m^3
= 14.19 m^3/year

Other Water Uses
= 5594 (L/ha/year) x 11.33 (ha) / 1000 L/m^3
= 63.38 m^3/year

Sub-Total Water Use for Fruit Type
= 171.98 m^3/year + 2.904 m^3/year + 124.87 m^3/year + 6184.71 m^3/year + 7.85 m^3/year + 14.19 m^3/year + 63.38 m^3/year
= 6569.88 m^3/year

Total Water Use for Irrigation
= 6569.88 m^3/year / 152 days/year
= 43 m^3/day

Table D1: Standard Rates of Use for Field Crop Irrigation

Crop	Crop Irrigation		Equipment Washing	Other Uses
	# of sprays/yr.	Spraying Rate (L/ha)	% of Crop Irrigation	% of Crop Irrigation
Winter wheat	0.5	225	0.1	0.5
Spring Wheat	0.66	225	0.1	0.5
Oats	0.66	225	0.1	0.5
Barley	0.66	225	0.1	0.5
Mixed grains	0.66	225	0.1	0.5
Corn: for grain	1.5	225	0.1	0.5
Corn: for fodder	1.5	225	0.1	0.5
Rye	0.1	225	0.1	0.5
Alfalfa	0.13	225	0.1	0.5
Hay: other	0.16	225	0.1	0.5
Forage seed for seed	1	225	0.1	0.5
Canola (rapeseed)	1	225	0.1	0.5
Soybeans	1.5	225	0.1	0.5
Dry Field Beans (All)	2	225	0.1	0.5
Flaxseed	1	225	0.1	0.5
Other field crops	0.75	225	0.1	0.5

Table D2: Standard Rates of Water Use for Vegetable Crops

Crop	Irrigation: number of applications	Irrigation: volume applied	Crop spraying: number of sprays	Crop spraying: rate	Main harvest season	Equipment washing	Equipment washing	On-farm processing	Other	Fraction of area irrigated
	# applications/yr.	mm/ha	# sprays/yr.	L/ha	# weeks	% of spray water	L/day/farm	L/ha	L/ha	
Sweet corn	3	30	3	225	10	0.1	0	0	0	0.055
Tomatoes	3	30	5	450	8	0.2	0	0	0	0.089
Cucumbers and gherkins	5	30	3	450	6	0	1820	0	450	0.153
Green peas	5	30	2	225	8	0.2	0	0	20	0.000
Green and wax beans	5	30	3	340	8	0.2	0	0	120	0.000
Cabbage	7	30	5	450	10	0	1820	0	110	0.275
Potatoes	9	25	8.5	375	6	0	2300	0	0.5	0.336
Chinese cabbage	7	30	6	450	10	0	1820	0	75	0.127
Cauliflower	7	30	8	450	8	0	1820	0	0	0.165
Broccoli	7	30	5	450	16	0	1820	2400	0	0.206
Brussel sprouts	7	30	5	450	6	0	1820	0	0	0.140
Carrots	5	30	7	680	6	0	1820	0	3300	0.248
Rutabagas (turnips)	5	30	3	450	6	0	1820	0	2330	0.000
Beets	5	30	2	340	6	0	1820	0	0	0.000
Radishes	7	30	1	560	16	0	1820	240	520	0.626
Dry onions	7	30	7	560	4	0	1820	0	0	0.347
Green onions and shallots	7	30	4	560	22	0	1820	0	0	0.507
Celery	7	30	5	450	6	0	1820	475	75	0.927
Lettuce	7	30	3	680	6	0	1820	0	75	0.212
Spinach	7	30	1	680	9	0	1820	0	75	0.412
Peppers	5	30	6	450	8	0	1820	0	570	0.226
Other vegetables	5	30	3	450	12	0	1820	0	0	0.000
Rhubarb	3	30	1	450	4	0	1820	0	320	0.000
Asparagus	3	30	3	340	6	0	1820	0	135	0.104
Squash, zucchini and pumpkins	5	30	2	450	0	0.2	0	0	0	0.000

Table D3: Standard Water Use Rates for Field Berries

Crop	Irrigation: number of applications	Irrigation: volume applied	Herbicide spray: number of sprays: no cover	Herbicide spray: rate	Insecticide: number of sprays	Insecticide: rate	Fungicide: number of sprays
	# applications/yr.	mm	# of sprays	L/ha	# of sprays	L/ha	# of sprays
Strawberries	8	28	3	300	7	Use fungicide rate	6
Raspberries	8	28	3	300	3	Applied with fungicide	4
Grapes	0	0	2	300	4	445	5
Blueberries	8	28	2	300	5	Applied with fungicide	5
Cranberries	0	0	1	300	3	Applied with fungicide	3
Other berries	0	0	2	300	3	Applied with fungicide	4

Crop	Fungicide: rate	Frost protection: number of applications	Frost protection: volume	Other	Census data	Fraction of area irrigated	Percentage use of trickle irrigation
	L/ha	# applications	mm/ha	of spray wa	ha		%
Strawberries	445	2	30	0.5	134	0.657	15.53
Raspberries	700	0	0	0.5	91	0.279	15.53
Grapes	445	0	0	0.5	80		0
Blueberries	445	0	0	0.5	158	0.386	15.53
Cranberries	445	0	0	0.5	11		0
Other berries	700	0	0	0.5	6		0

Table D4: Standard Water Use Rates for Fruit Orchards

Crop	Irrigation: number of applications	Irrigation: volume applied	Herbicide spray: number of sprays: no cover	Herbicide spray: number of sprays: cover	Herbicide spray: rate	Insecticide: number of sprays	Insecticide: rate	Fungicide: number of sprays: bearing	Fungicide: number of sprays: non-bearing	Fungicide: rate
	# applications/yr.	mm	# of sprays	# of sprays	L/ha	# of sprays	L/ha	# of sprays		L/ha
Apples	4	35	2	0.25	500	8	Applied with fungicide	12	5	1000
Pears	4	35	2	0.25	500	7	Use fungicide rate	5	0	1000
Plums and prunes			2	0.25	500	6	Use fungicide rate	5	0	1000
Cherries	4	35	2	0.25	500	8	Applied with fungicide	9	0	1000
Peaches	4	35	2	0.25	750	6	Applied with fungicide	8	0	1000
Apricots	4	35	2	0.25	750	6	Applied with fungicide	8	0	1000
Other tree fruits and nuts			2	0.25	500	6	Applied with fungicide	8	0	1000

Crop	Sanitation washing	Harvesting/ transport	On-farm processing	Other	Area	Fraction of fruit bearing trees*	Fraction of area irrigated*	Area irrigated	Percentage use of trickle irrigation
	L/bushel	L/ha	L/ha	L/ha	ha			ha	%
Apples	646	693	1252	5594	2118	0.86	0.111	235	15.53
Pears	0	0	0	0.5	83	0.83	0.032	3	15.53
Plums and prunes	0	0	0	0.5	22	0.87	0.000	0	15.53
Cherries	0	5390	0	0.5	9	0.85	0.079	1	15.53
Peaches	0	0	342	0.5	18	0.87	0.632	11	15.53
Apricots	0	0	0	0.5	0		0.609	0	15.53
Other tree fruits and nuts	0	0	0	0.5			0.000	0	15.53

*Fractions are based on Ontario data

Table D5: Standard water use rates for Greenhouses and Nurseries

Facility	Irrigation: number of applications	Irrigation: volume applied	Irrigation Water Used	Pesticide spraying: number of applications	Pesticide spraying: rate	Equipment washing	Fraction of area irrigated
	# applications/yr	mm/ha	L/year	# applications/yr	L/ha	% of spray water	
Nursery products (pesticide)	0	0	0	9	3000	0.3	0.25
Nursery - New stock	3	25	1.547E+09	0	0	0	0
Nursery - Containers	100	25	1.289E+10	0	0	0	0
Sod-Normal	21	25	0	0	0	0	0.48
Sod -Addnl before harvest	2	25	0	2	300	0.4	0

Facility	Irrigation: number of applications	Irrigation: volume applied	Irrigation: volume applied	Number of applications for pots	Irrigation: Volume applied to non-pot flowers	Number of applications (non-pot)	Pesticide spraying: number of applications	Pesticide spraying: rate	Equipment washing	Census data
	# applications/yr	mm/yr	L/sq.m		L			L/sq.m		m2
Greenhouse Flowers	0	1060	0	1	18	250	36	0.25	0.3	27068
Greenhouse Vegetables	250	0	4.4	0	0	0	5	0.25	0.3	75178
Other greenhouse products	200	0	4	0	0	0	3	0.25	0.3	4890

Table E1 provides a summary of Wastewater Design Flows used for the calculation of consumption by non-agricultural users. Design flows are drawn from Table F3 of the NSE On-Site Sewage Disposal Systems Technical Guideline (2007). Calculations were based on the best available consumption data for each facility type. Previous studies have used broader estimates: (a) CBCL (2003) attempted to map commercial and industrial wells, and estimated that total demand by these source was greater than 114 L/min, and (b)Dillon (2003) added 10% of the total calculated domestic demand to represent commercial uses.

Example Calculation

Average Daily Water Use
= Wastewater Design Flow (L/day/unit) x Number of Units x 0.001 m^3/L

Record FC1254
Apartment Building
Number of Showers (from survey): 42 ***(assume 42 apartment units)***

Average Daily Water Use
= 1000 L/day/apartment unit x 40 x 0.001 m^3/L
= 42 m^3/day

Appendix E

Waste Water Design Flows and Example Calculations for Non-Agricultural Users

Table E1: Wastewater Design Flows and Assumed Unit Quantities

Use	Unit	Rate (L/day)	Assumed Units	Total (m3/day)
Apartment Building	unit	1000	35	35
Automotive	pump island	1893	2	3.8
Church	seat	26	50	1.3
Community Centre	person	9	30	0.27
Day Care	person	73	20	1.46
Elementary School	student	26	120	3.12
Government building	employee	57	25	1.43
High School	student	60	800	48
Hospital	bed employee	550 23	200 40	110.92
Inns/Motels	unit staff	318 40	30 4	9.7
Junior School	student	34	250	8.5
Long term care facility	resident employee	136 45	40 8	5.8
Museum	person	23	20	0.46
nursery school	person	73	30	2.19
Restaurants	seat dishwasher kitchen and toilet/seat	31 23 113	30 1 30	4.34
Serviced Campground	site	227	50	11.35
Shopping Centres	employee toilet room (each)	40 1665	50 2	5.33
Summer camp	person	189	50	9.45
Trailer Park	site	284	80	22.72
Variety Stores	store	500	1	0.5
Arena	seat	11	1000	11
Business Office	employee	50	40	2
College/University	student	60	200	12
Correctional Facility	inmate employee	136 23	200 10	27.43
Day use Park	person	18	80	1.44
Fire Station	person	19	10	0.19
Grocery Stores	L/sq metre	5	3800	19
Police Station	person	19	25	0.48

Appendix F

Civic Unit Data and Example Calculations for Domestic Supply

Table F1 provides civic unit data used to calculate water use by non-serviced domestic users. The method employed most closely resembles the calculation used in Dillon (2003). In that study the "average dwelling density" was calculated based on a weighted average of the dwelling density for a given sub-watershed. The domestic demand was then calculated assuming 2.5 people per dwelling and a domestic demand of 220 L/person/day. The current study used the number of residential civic units in a given secondary watershed (serviced users were subtracted from the dataset). The population density for Kings and Annapolis was calculated to be 2.1 persons per dwelling based on census data and civic unit data. Domestic demand was set at 320 L/person/day as indicated by Natural Resources Canada (1999) for the Annapolis Valley Region. AMEC (2002) assumed a standard consumption rate of 100 US gallons/day/person. AGRA (2000) introduced the concept of "Water Entitlement" which assumed that all potential users consumed 22,999 L/day, the maximum permitted rate of withdrawal not requiring a water withdrawal permit.

<u>Example Calculation</u>
Total Population of Kings and Annapolis Counties (2006) = 81 473
Total Residential Units in Kings and Annapolis Counties = 38 215

Population Density = 81 473 persons / 38 215 homes
= 2.132 persons / home

Domestic Consumption Rate = 320 L/person/day

Residential Units in Cornwallis Watershed – Residential Units within Service Boundaries
= 5239 homes

Average Daily Domestic Water Use in Cornwallis Watershed
= 2.132 persons/home x 5239 homes x 320 L/person/day x 0.001 m^3/L
= 3574 m^3/day

Table F1: Civic Unit Data from Provincial Mapping

Secondary Watershed	Building Use Code						
	Unknown	Agriculture	Fishery	In Transition	Manufacturing	Mining	Protected and Limited Use
Allains River	6	0	1	5	3	0	0
Annapolis	208	13	2	137	31	3	1
Canard	42	6	0	21	6	1	0
Coastal	139	20	2	95	14	1	1
Cornwallis	185	22	4	126	21	3	1
Gaspereau	57	7	1	42	12	0	0
Habitant	24	4	2	14	4	0	0
Moose River	11	1	0	6	2	0	0
Pereau	4	0	0	5	0	0	0
Secondary Watershed	**Building Use Code**						
	Recreation, Culture and Entertainment	**Residential**	**Sales**	**Services**	**Storage**	**Transportation, Transmission and Storage**	
Allains River	0	266	2	12	0	2	
Annapolis	98	6749	87	371	5	52	
Canard	13	1149	11	62	0	5	
Coastal	56	4434	65	232	7	34	
Cornwallis	64	5239	90	310	2	42	
Gaspereau	30	1662	20	93	2	19	
Habitant	8	725	7	47	0	3	
Moose River	0	339	3	17	1	6	
Pereau	0	102	3	5	0	0	
Secondary Watershed	**Summary**						
	Residential	**Non-Residential**	**Agricultural**	**Industrial**	**Commercial**	**Total**	
Allains River	266	31	1	5	2	297	
Annapolis	6749	1008	15	91	185	7757	
Canard	1149	167	6	12	24	1316	
Coastal	4434	666	22	56	121	5100	
Cornwallis	5239	870	26	68	154	6109	
Gaspereau	1662	283	8	33	50	1945	
Habitant	725	113	6	7	15	838	
Moose River	339	47	1	9	3	386	
Pereau	102	17	0	0	3	119	

Appendix G

Consumptive Use Coefficients

Table G1: Consumption Coefficients

Sector	Facility Type	Facility Sub-Type	Consumption Coefficient
Supply	Municipal		0.20
	Parks	Day use	0.20
		Serviced campground	0.20
		Summer camp	0.20
	Communal	Water Groups	0.20
		Apartment Building	0.20
		Trailer Park	0.20
	Institutional	College/University	0.25
		Correctional Facility	0.25
		Day Care	0.25
		Elementary School	0.25
		Fire Station	0.25
		Government Building	0.25
		High School	0.25
		Hospital	0.25
		Junior School	0.25
		Long term care facility	0.25
		Police Station	0.25
	Public	Arena	0.20
		Community Centre	0.20
		Church	0.20
		Museum	0.20
	Other		0.25
Agricultural	Livestock	Dairy Cattle	0.90
		Beef Cattle	0.90
		Poultry and other fowl	0.90
		Swine	0.90
		Other	0.90
	Aquaculture		0.10
	Cranberry Farm		0.10
	Domestic		0.20
	Field and Pasture		0.80
	Fruit Orchard		0.80
	Greenhouse		0.90
	Livestock		0.90
	Mink Farm		0.90
	Non-Irrigation		0.10
	Nursery		0.90
	Peat Farm		0.10
	Poultry and other Fowl		0.90
	Vineyard		0.90
	Washing		0.90
	Other		0.25
Commercial	Automotive		0.25
	Business Office		0.25
	Gas Retailers		0.25
	Golf Course Irrigation		0.70
	Grocery Stores		0.25
	Inns/Motels		0.25
	Restaurants		0.25
	Shopping Centres		0.25
	Variety Stores		0.25
	Other		0.25
Industrial	Aggregate Washing		0.25
	Bottled Water		1.00
	Brewing and Soft Drinks		1.00
	Dewatering		0.25
	Food Processing		1.00
	Manufacturing		0.25
Miscellaneous	Recreational		0.10
	EES	Discharge to GW	0.10
		Discharge to SW	1.00
	(Other)		0.25

Consumption Coeffcients were drawn from Ontario MOE (2006), and Shaffer and Runkle (2007)

Appendix H
Municipal Data

Table H1: Municipal Data

Facility Code	Group Code	Utility	Well ID	Easting	Northing	Average Daily Water Use (m3/day)	Maximum Daily Water Use (m3/day)	Maximum Pumping Rate (L/min)	Geologic Unit	Depth	Depth to Bedrock	Static Water Level
FC1541	FC1541	Village of Lawrencetown	PW1	329746	4970291	136.8	333.2	231	WO	58.5		
FC2559	FC1541	Village of Lawrencetown	PW2	329296	4971203	91.2	195.7	136	WO	67.0	17.7	6.1
FC1561	FC1561	Town of Annapolis Royal-Granville Ferry	NE Well	299500	4959200	436.3	1008.0	700	WO	76.2	9.1	26.7
FC2561	FC1561	Town of Annapolis Royal-Granville Ferry	NW Well	299990	4958056	436.3	1008.0	700	WO	118.3	4.0	31.6
FC1563	FC1563	Village of Margaretsville	Production Well	337416	4990062	60.0	149.0	103	NO	91.4		36.8
FC1564	FC1564	Town of Middleton	PW1	337921	4978854	432.6	888.3	617	WO	94.5		15.2
FC2564	FC1564	Town of Middleton	PW2	337750	4978807	432.6	205.0	142	WO	76.2		5.1
FC2565	FC1564	Town of Middleton	PW3	337655	4978641	432.6	273.3	190	WO	76.2		4.9
FC1570	FC1570	Village of Canning	Well 5A	388267	5002041	72.0	195.8	136	BL	63.4	18.3	15.6
FC1572	FC1572	Village of Greenwood	GW8	348091	4979744	231.2	1151.0	799	Q	23.8		6.1
FC2667	FC2667	Village of Greenwood	GW13	347984	4979665	308.2	1013.0	703	Q			
FC2583	FC1574	Town of Kentville	Well 2000 East 1	378073	4992441	989.9	1301.1	904	Q	33.5		3.7
FC2584	FC1574	Town of Kentville	Well 2000 East 2	378077	4992444	1342.5	1866.7	1296	WO	128.0		0.0
FC2586	FC1574	Town of Kentville	West End No.1 Well	377245	4992298	707.3	998.2	693	Q	34.4	42.0	3.8
FC2587	FC1574	Town of Kentville	West End No.2 Well	377247	4992300	1308.0	1794.5	1246	WO	118.9		3.4
FC2683	FC1574	Town of Kentville	Bonvista Well	377556	4992366	545.4	938.2	652	WO			
FC2684	FC1574	Town of Kentville	Mitchell Ave Pump 1A	377796	4992330	554.5	745.3	518	WO			
FC2685	FC1574	Town of Kentville	Mitchell Ave Pump 1C	377796	4992330	440.5	524.4	364	WO			
FC1576	FC1576	Village of New Minas	Cornwallis Ave Pump 1	386106	4991995	1228.4	2323.9	1614	WO			
FC2597	FC1576	Village of New Minas	Tower Well	386279	4992129	916.6	1112.9	773	WO	99.1		4.9
FC2598	FC1576	Village of New Minas	Cornwallis Ave Pump 2	386096	4992144	671.2	1636.6	1137	Q	17.4		5.0
FC2599	FC1576	Village of New Minas	Jones Rd East Pump 1	386279	4992129	570.8	1642.0	1140	WO			4.1
FC2600	FC1576	Village of New Minas	Jones Rd East Pump 2	385851	4991932	401.8	1636.6	1137	Q	15.9		4.9
FC2601	FC1576	Village of New Minas	Jones Road West Well	385450	4991811	528.2	810.6	563	WO	97.5		10.7
FC2603	FC1576	Village of New Minas	Civic Centre Well	385712	4991336	276.6	523.7	364	WO	52.4	22.8	
FC2672	FC1576	Village of New Minas	Cornwallsi Extension Well	386096	4992144	51.4	451.9	314	WO			
FC1577	FC1577	Village of Port Williams	Well No. 1	388515	4995650	132.6	690.0	479	WO	73.2		9.9
FC2632	FC1577	Village of Port Williams	Well No. 2	388983	4995975	17.7	85.0	59	WO	198.1		16.8
FC2634	FC1577	Village of Port Williams	Well No. 4	388766	4995896	44.2	225.0	156	WO	167.6		7.3
FC2635	FC1577	Village of Port Williams	Well No. 5A	381221	4995195	119.3	597.0	415	WO	97.5		2.0
FC2668	FC1577	Village of Port Williams	Well No. 6	389329	4995194	128.1	583.0	405	WO			
FC1579	FC1579	Town of Wolfville	Wickwire (back-up)	391927	4993772	405.9	1625.8	1129	Q	30.5	42.6	4.3
FC2639	FC1579	Town of Wolfville	Cherry Lane (primary)	391655	4993765	2300.1	3247.2	2255	Q	50.0	42.6	6.9
FC2562	FC2562	Village of Sandy Court - Aylesford	Production Well	355161	4987723	7.2	20.2	29	Q	21.9		6.5