Water Use in the Long Point Region Conservation Authority

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DRAFT

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Executive Summary

As the Long Point Region watershed continues to experience both economic and population growth, there will be increased demands on the basin's water resources to supply sufficient water to residential, commercial and industrial consumers. In the context of protecting water supplies for drinking water and other uses, the quantity of water takings in the basin is a step towards a better understanding of the various water needs in the Long Point Region watershed.

This report is an initial summary of the present-day water uses within the Long Point Region watershed. Water use estimates were broken down into four subgroups: Municipal Supply, Agricultural, Unserviced Population and Other Permitted Takings (larger than 50,000 L/day).

Water use estimates were determined using the best available data. Municipalities were contacted directly to establish municipal water use. Census of Population and Census of Agriculture were utilized to determine rural domestic as well as agricultural water use. The Permit to Take Water (PTTW) database was used to quantify any water uses that did not fall into the previous three categories. A phone survey of the permit holders was completed to refine water use estimates based on their records, with a 52% response rate. The analysis of all water use data identified the following top 15 water uses within the basin:

1. Agricultural – Irrigation
2. Municipal Water Supply
3. Aquaculture
4. Rural Domestic
5. Agriculture
6. Remediation
7. Dewatering – Construction
8. Aggregate Washing
9. Golf Course Irrigation
10. Commercial – Other
11. Dewatering – Pits and Quarries
12. Industrial – Other
13. Recreational – Aesthetics
14. Water Supply – Campgrounds
15. Miscellaneous

While annual totals are useful for comparison purposes, seasonal and annual temporal changes in water use must be considered for an accurate representation of water taking. While agricultural irrigation is the largest water user on an annual basis, their water takings are concentrated during the months of June to August. Agricultural irrigation is actually the significantly higher and is more than the combined total of all other water takings annually, during these summer months. During an extreme dry year, which requires more irrigation than an average year, this demand for water is much more pronounced.

This study has identified a number of limitations with water use data available to water managers. In an attempt to address these shortcomings and increase the accuracy of water use estimates, the following recommendations are presented:

1. That the water use estimates generated from this report be combined with estimates of water availability to identify possible water quantity issue areas.

2. That information gathered from the municipal sector be separated into industrial, commercial, institutional and residential components
3. That investigations into more accurate estimates of irrigated land continue, including assessing the use of alternative methodologies such as remote sensing and crop specific water uses.
4. That consumptive ratios of all major water sectors be determined, as well as the occurrence of water diversions.
5. That development of a central database of water use in the watershed continues. This database would house recent information on municipal water systems as well as information gathered from phone surveys of permitted water users.

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Acknowledgments

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- The member municipalities in the Long Point Region watershed for supplying water use information.
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- The permit holders in the watershed who voluntarily supplied actual water use information for the report.

1.0 INTRODUCTION

The Long Point Region watershed is a region with agricultural land comprising a majority of the land use and water use. This region has the highest density of permitted water takings in the province and water use is intense from both groundwater and surfacewater sources. As part of watershed characterization under Source Water Protection Planning initiatives, a water use inventory could better estimate sources and demands for water resources in this region and provides information for water budgets.

This report details the initial estimate of water use for the watershed, and identifies the major water use sectors. For the purposes of this report, water use has been divided into the 4 groupings: Municipal Supply, Agricultural, Unserviced Population and Other Permitted Takings. The last group comprises the Permit to Take Water (PTTW) takings that are not included in the previous three groups, and are further broken down into user groups.

Water use information is divided into subwatersheds within the larger Long Point Region watershed (see Figure 1) to get a spatial representation of where the takings occur or where the taking is being used. At various points throughout this report, cubic metres (m^3) will be used to quantify water use. To put perspective into a cubic metre of water use, a household of 3 people use approximately 1 m^3 per day, as the average daily Canadian water use is 0.340 m^3 (Environment Canada, 2005).

2.0 DESCRIPTION OF THE WATERSHED

The Long Point Region watershed is located in south western Ontario on the northern shore of Lake Erie (see Figure 1). The watershed is a series of creeks that drain into Lake Erie through Haldimand, Norfolk, Oxford, Brant and Elgin Counties, covering an area of approximately 2780 km^2. Major creeks in this watershed include Big Creek, Little and Big Otter Creeks, and Nanticoke Creek. The watershed can actually be divided up into 12 subwatersheds, as seen in Figure 1, for comparison of the various sections of the watershed for this water use report.

Larger urban areas in the watershed include the Town of Tillsonburg and the Town of Simcoe, with smaller towns including Delhi, Waterford and Hagersville, just to name a few. The predominant land use in the region is agriculture.

The watershed can be divided into 2 distinct sections based on the underlying geology of the region. Much of the area is in the Norfolk Sand Plain, which consists of well-drained soils that allow for significant amounts of groundwater recharge and have low runoff potential. The eastern side of the watershed is part of a clay plain, the remnants of a historic lake bed which left behind heavy clays when the lake receeded. This region produces high amounts of runoff and do not allow significant water infiltration to produce groundwater recharge.

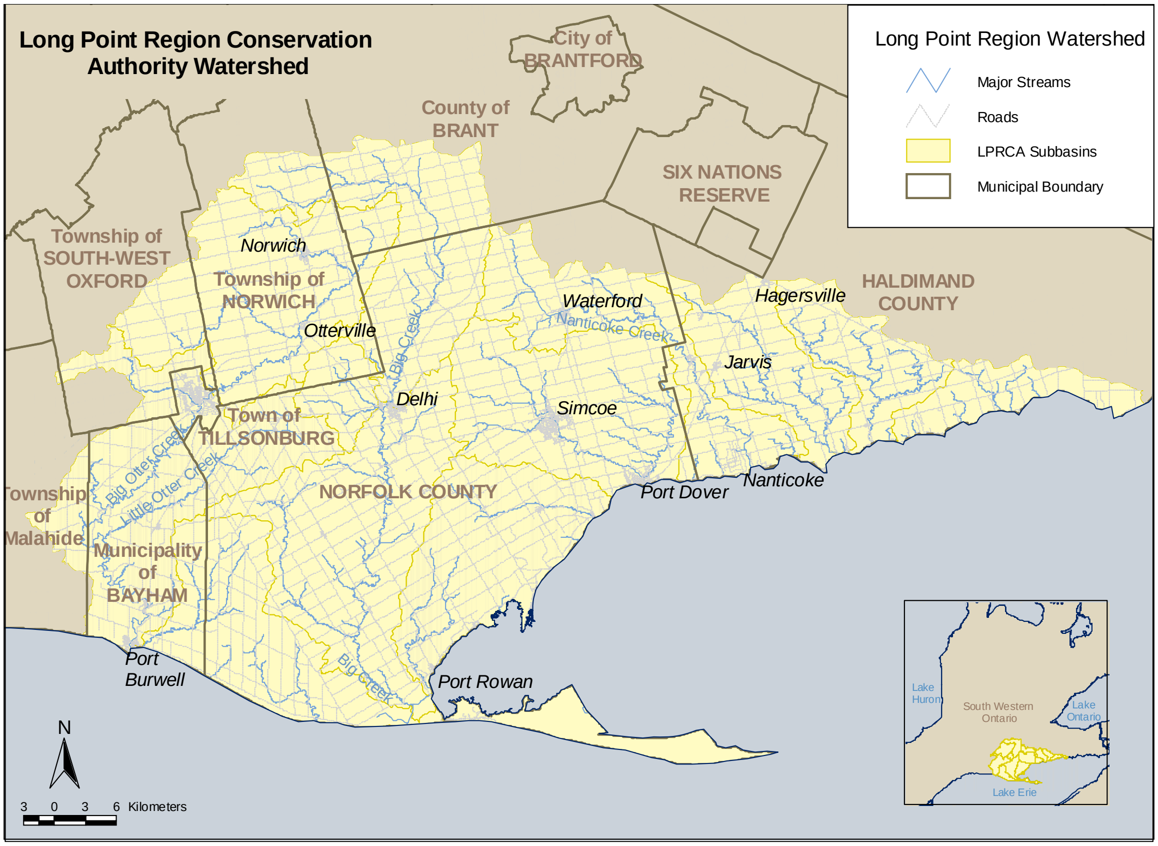

Figure 1. Watershed Overview Map

3.0 MUNICIPAL WATER USE

Municipal water use is the supply of water provided through a central distribution system operated by a municipality. Various methods were employed to determine the amount of water municipalities provide through their distribution. These methods included personal communication with municipal staff, data collected from reports for the Drinking Water regulation requirements (Ontario Regulation 170/03) and information gathered from municipal websites and online documents. Data was collected to obtain a complete picture of municipal water use including serviced population, average daily demand and maximum daily demand, as well as UTM coordinates of the supply wells, river intakes or lake intakes.

It is important to note that municipal water use includes urban domestic use, whether indoor or outdoor, and also includes uses for industrial, commercial, institutional or other uses that rely on municipalities for their water supply.

Each municipal water system in the watershed is listed in Table 1, along with the serviced population, average daily demand, average per capita demand, maximum daily demand and maximum per capita demand, when available. While per capita values are listed, they should not be used to compare between municipal systems, as differing proportions of residential, and Industrial, Commercial and Institutional (ICI) demand may vary widely from municipality to municipality.

The Long Point Region is predominantly in the Norfolk Sand Plain, making groundwater easily accessible for municipal supply, as well as for other uses. Much of this region relies on groundwater, however communities adjacent to Lake Erie utilize this source for municipal water. Communities including Port Rowan and Port Dover in Norfolk County have their own lake intakes from Lake Erie. The western side of Long Point Region watershed is in Elgin County (Municipality of Bayham, Township of Malahide) and some communities are serviced by the Elgin Area Water Supply System, which also pumps from Lake Erie. Supply sources are seen in Figure 2, which include the sources from groundwater wells and surfacewater sources such as rivers and Lake Erie.

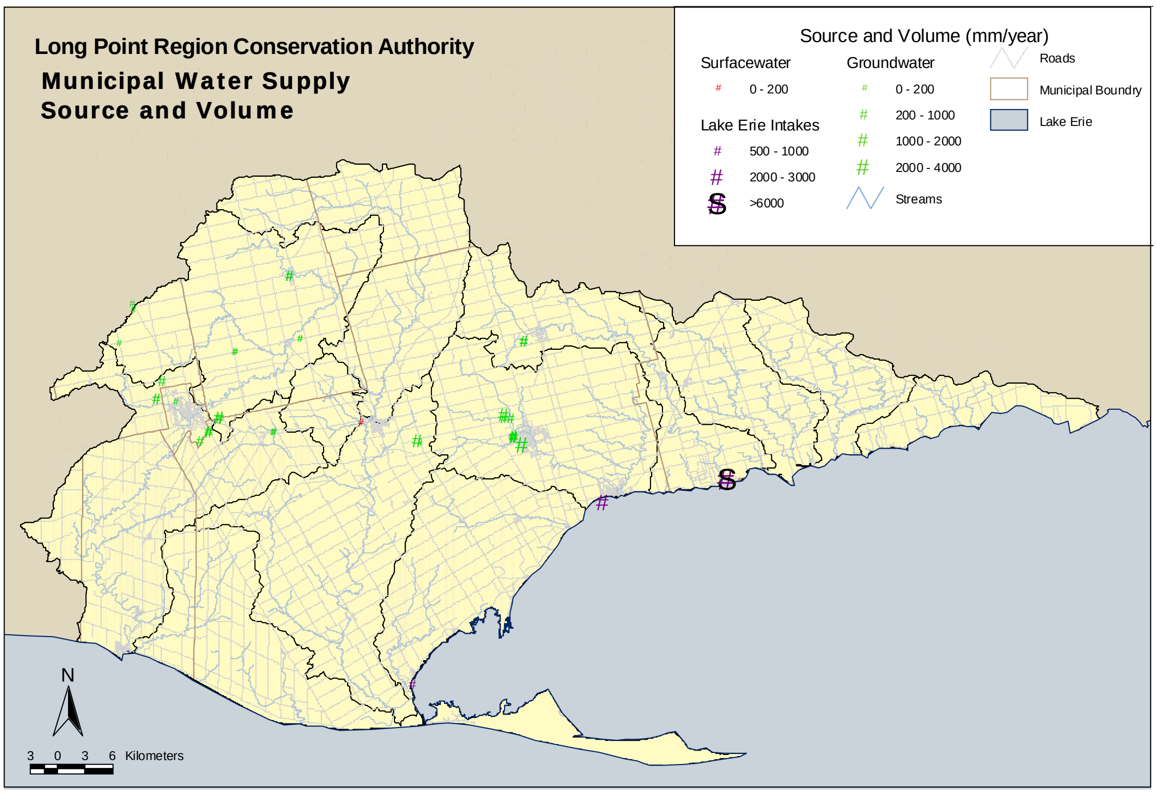

Figure 2. Municipal Water Supply Sources

Table 1.Municipal Water System Information

Municipality	Municipal System	Year of Data	Serviced Popl'n	Average Day		Max Day		System Capacity (approx.)	Water Source	Data Source
				Actual	Per Capita	Actual	Per Capita			
				m^3/d	$m^3/d/capita$	m^3/d	$m^3/d/capita$	m^3/day		
Elgin	Bayham Township (Port Burwell, Vienna, Lake View)	2004	1600	919.8995	0.575				Lake Erie	Communication with Municipal Staff
Norfolk	Courtland	2003	984	258.14	0.262	397.42	0.404	982	Groundwater	Drinking Water Summary Report 2003; Communication with Municipal Staff
Norfolk	Delhi	2003	4706	2923	0.621	4460	0.948	9,143	Groundwater, Surfacewater	Drinking Water Summary Report 2003; Communication with Municipal Staff
Oxford	Dereham Centre	2004	48	9.3	0.194	28.2	0.588	30	Groundwater	Communication with Municipal Staff
Haldimand	Hagersville, Jarvis, Townsend	2004	4970	6605	1.329	8980	1.807	300,000	Lake Erie	Communication with Municipal Staff
Oxford	Mount Elgin	2004	366	82.1	0.224	144.4	0.395	165	Groundwater	Communication with Municipal Staff
Oxford	Norwich	2004	2595	750.8	0.289	1896	0.731	1,637	Groundwater	Communication with Municipal Staff
Oxford	Otterville	2004	954	303.6	0.318	912	0.956	1,832	Groundwater	Communication with Municipal Staff
Norfolk	Port Dover	2003	6083	2869	0.472	4156	0.683	11,400	Lake Erie	Drinking Water Summary Report 2003; Communication with Municipal Staff
Norfolk	Port Rowan	2003	1131	721	0.637	1060	0.937	3,040	Lake Erie	Drinking Water Summary Report 2003; Communication with Municipal Staff
Norfolk	Simcoe	2003	14651	6870	0.469	10025	0.684	19,365	Groundwater	Drinking Water Summary Report 2003; Communication with Municipal Staff
Oxford	Springford	2004	403	109.5	0.272	276	0.685	447	Groundwater	Communication with Municipal Staff
Elgin	Straffordville	2002	750	131	0.175				Groundwater	Norfolk Municipal Groundwater Study
Norfolk	St. Williams	2003	512						Lake Erie	Communication with Municipal Staff
Oxford	Tillsonburg	2004	13972	6428.525	0.460	10038	0.718	14,730	Groundwater	Communication with Municipal Staff
Norfolk	Waterford	2003	3457	1766	0.511	2814	0.814	3,820	Groundwater	Drinking Water Summary Report 2003; Communication with Municipal Staff
	TOTAL		57,182	30,747				366,591		

A portion of the Long Point Region is serviced by the Elgin Area Primary Water Supply System, which pumps water from Lake Erie. The Municipality of Bayham, in the western corner of the LPRCA, is serviced by a secondary water system from an intake off the coast of Port Stanley, which is not shown in Figure 2. Haldimand County also has a large intake for 3 communities to service water supply from Lake Erie. The Nanticoke Water Treatment Plant (WTP) services Hagersville, Jarvis and Townsend, as well as the Lake Erie Industrial Park. The industrial park, which includes Stelco's Lake Erie Works and Imperial Oil's Nanticoke Refinery, is likely a considerable portion of the water demands from the Nanticoke WTP. Further refinement of the values from Haldimand, to exclude the industrial park, is being investigated.

Comparisons between water takings and annual average precipitation are useful for comparing water supply and demand, and are best expressed as a depth over the surfacewater subwatershed. For instance, municipal water takings can be expressed as a depth over the subwatershed from which the taking is located by dividing the total volume of the taking by the area (see Equation 1). The annual average precipitation in this region ranges from 930mm to 1025mm (Delhi is 1010mm/yr; Environment Canada, 2005a), which provides a consistent basis for comparing various water uses. The depth of municipal water takings can be seen in Figure 3. Subsequent maps will utilize this method of displaying water use as a depth across the region.

Equation #1:

$$\text{Depth of Water Taking (m)} = \frac{\text{Volume of Total Taking (m}^3\text{)}}{\text{Subwatershed Area (m}^2\text{)}}$$

For the purposes of water budgeting in watersheds, the Lake Erie water supply is not considered a watershed based water taking and thus the depth of taking from the Lake Erie intake is not included in Figure 3. Thus, municipal taking depths in the Long Point Region watershed are mainly groundwater takings with some surfacewater takings.

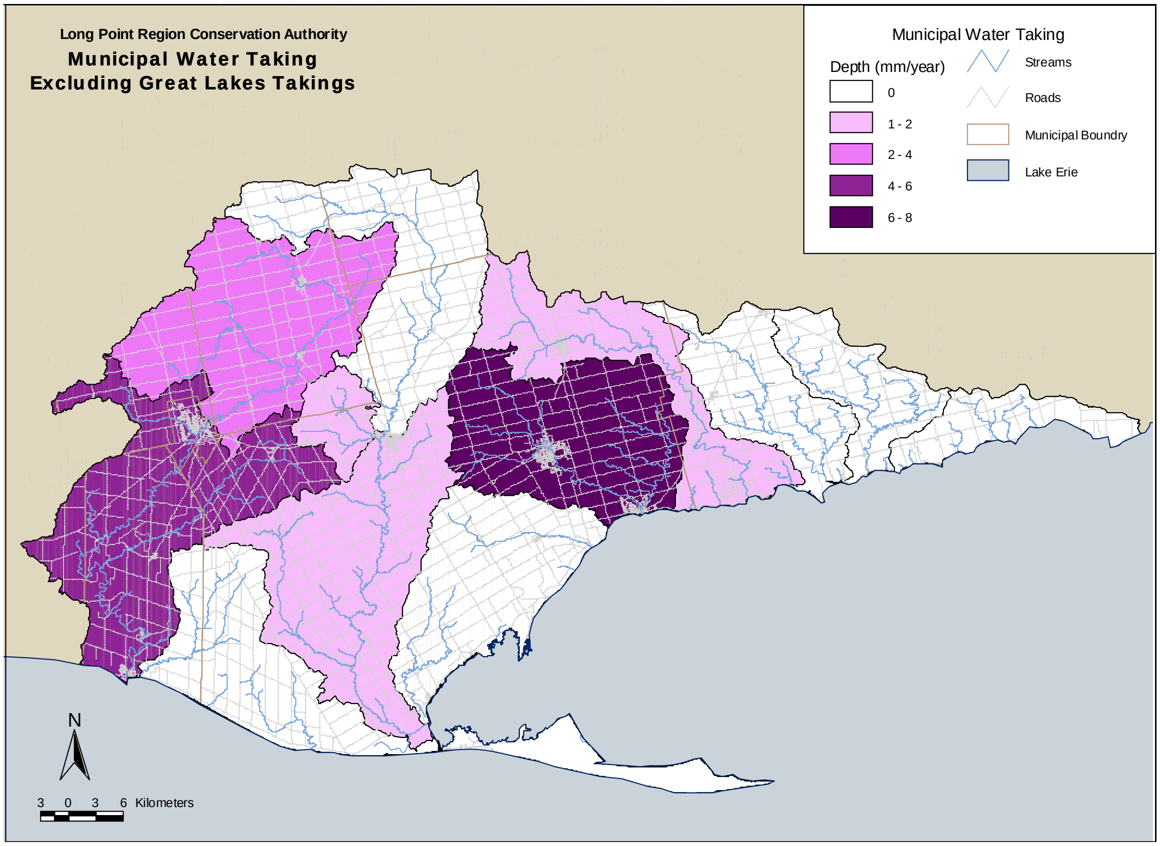

Figure 3. Municipal Water Use

In order to illustrate how municipal supply changes from month to month, information on monthly distributions of municipal water use was required. This information was obtained from the municipality or community, and was often readily available due to the Ontario Regulation 170/03 requirement for all municipalities servicing water to communities to keep records. Table 2 lists the monthly patterns for the serviced municipalities in the LPRCA, when available. This information gives a distribution of water use throughout the year and could be beneficial in understanding water demand trends.

The values in Table 2 show the average monthly water use as 1.00, and departures from that value show either a lower or higher water use by percentage. For instance, a value of 0.95 would indicate that water use in this month is 5% lower than the average monthly water use. Table 2 shows that higher than average water uses in municipalities occurs in the summer months of June to August for most of the Long Point Region watershed. Higher summer water uses may be attributed to outdoor residential water use such as lawn watering.

Table 2. Monthly distribution of average daily municipal water use

Municipal System	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Courtland	0.92	0.85	0.87	0.95	1.00	1.13	1.08	1.03	1.09	1.07	1.00	1.02
Delhi	0.86	0.87	0.97	1.01	1.02	1.07	0.99	1.01	0.97	0.69	1.32	1.22
Dereham Centre	0.79	0.85	0.92	0.90	0.93	0.95	1.27	0.92	1.00	1.08	1.28	1.10
Lake View	0.89	0.84	0.96	0.84	0.87	1.26	1.11	1.07	1.00	1.01	0.93	1.22
Mount Elgin	0.76	0.90	0.99	0.91	0.97	1.06	1.23	1.15	1.08	0.99	0.95	1.01
Norwich	0.96	0.94	0.97	0.99	1.09	1.07	1.07	0.97	1.01	0.97	1.00	0.96
Otterville	0.80	0.84	0.87	0.90	1.05	1.11	1.36	1.14	1.43	1.00	0.75	0.75
Port Burwell	0.85	0.77	0.94	0.86	0.92	1.32	1.21	1.13	0.99	0.99	0.88	1.15
Port Dover	0.98	0.92	0.93	0.93	1.01	1.08	1.16	1.07	1.04	0.95	0.99	0.94
Port Rowan	0.88	1.02	1.06	0.94	1.04	1.20	1.20	1.15	1.00	0.86	0.81	0.84
Simcoe	1.05	1.15	1.09	1.00	1.04	1.07	0.91	1.05	1.02	0.89	0.89	0.84
Springford	0.71	0.69	0.70	0.77	1.11	1.28	1.44	1.24	1.05	1.00	1.00	1.01
Tillsonburg	0.97	0.97	0.95	0.92	0.99	1.06	1.04	1.10	1.16	0.93	0.95	0.96
Vienna	1.03	1.08	1.08	0.86	0.83	1.17	0.97	0.98	0.98	0.99	0.90	1.14
Waterford	0.93	0.83	0.86	0.88	1.04	1.23	1.08	1.02	1.12	0.96	1.02	1.02
Haldimand Communities	0.93	1.02	0.95	0.92	0.97	1.06	1.08	1.04	1.07	1.04	1.02	0.95

The percentages of serviced communities in the Long Point Region that use groundwater or surfacewater sources are seen in Table 3 and Figure 4. The surfacewater values are further broken down into Lake Erie sources and inland surfacewater sources such as the one taking in Delhi from the river. Municipal water use totals 10.4M cubic metres per year for this region.

Table 3. Municipal Water Use by Source

Source	Water Use (m^3/year)	Percent
Groundwater	6,245,640	61%
Surfacewater - Lake Erie	3,893,362	38%
Surfacewater - Rivers	68,282	0.7%
Total Municipal Water Use	**10,378,388**	**100%**

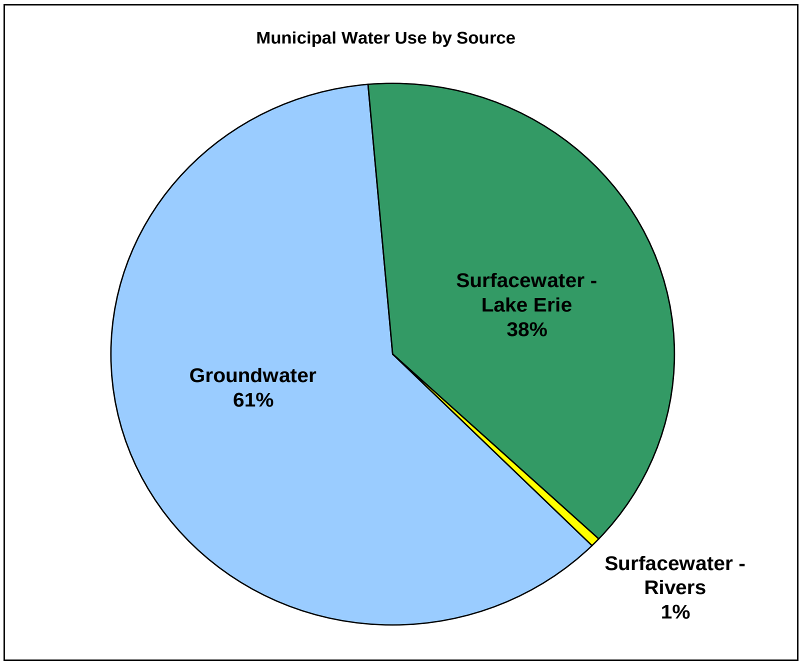

Figure 4. Municipal Water Use by Source

4.0 AGRICULTURAL WATER USE

Agricultural water use was divided into two categories; livestock/farming operation water use and crop irrigation water use. This division was based on the information available for the two categories, as well as their differing water requirements for each use throughout the year.

Water use for livestock and other farming operations are generally year-round takings, as opposed to crop irrigation, which only occurs during the summer growing season. Other farming operations considered in this water use category include greenhouse operations.

4.1 Livestock and Year-Round Farming Operations

Water use estimates for livestock are more difficult to approximate than other water uses, since a Permit to Take Water is not required for animal watering. The exception is water that is taken into a storage facility prior to animal watering, which does require a PTTW. Often, livestock watering needs are not measured by the farmer and very few records are available for use in this study. Thus, the estimates would rely on external information and research on livestock daily water needs and the number of livestock in the watershed.

The National Soil and Water Conservation Program recognized this gap in livestock water use estimates, and contracted research out to the University of Guelph to, among other objectives, verify and update agricultural water use data on a sector-by-sector basis. The study, by Kreutzwiser and de Loë (1999), built upon previous work by refining existing water use coefficients for specific farming practices.

A spreadsheet tool was created in the study (Kreutzwiser and de Loë, 1999), which allowed the user to import Census of Agriculture data and calculate the total agricultural water use for a particular geographic unit. The study generated various water use coefficients for many of the different variables collected within the Census of Agriculture, such as animal populations and farming practices. By multiplying the water use coefficients (i.e. dairy cows consume 90 L/day) by the information given in the Census of Agriculture database, such as the number of animals or crop type and area, the total agricultural water use for the specific geographic region could be calculated. Data from the 2001 Census of Agriculture (Statistics Canada, 2001) were used with the water use coefficients to generate water use estimates for this report. Figure 5 displays the results of the analysis on a subwatershed basis.

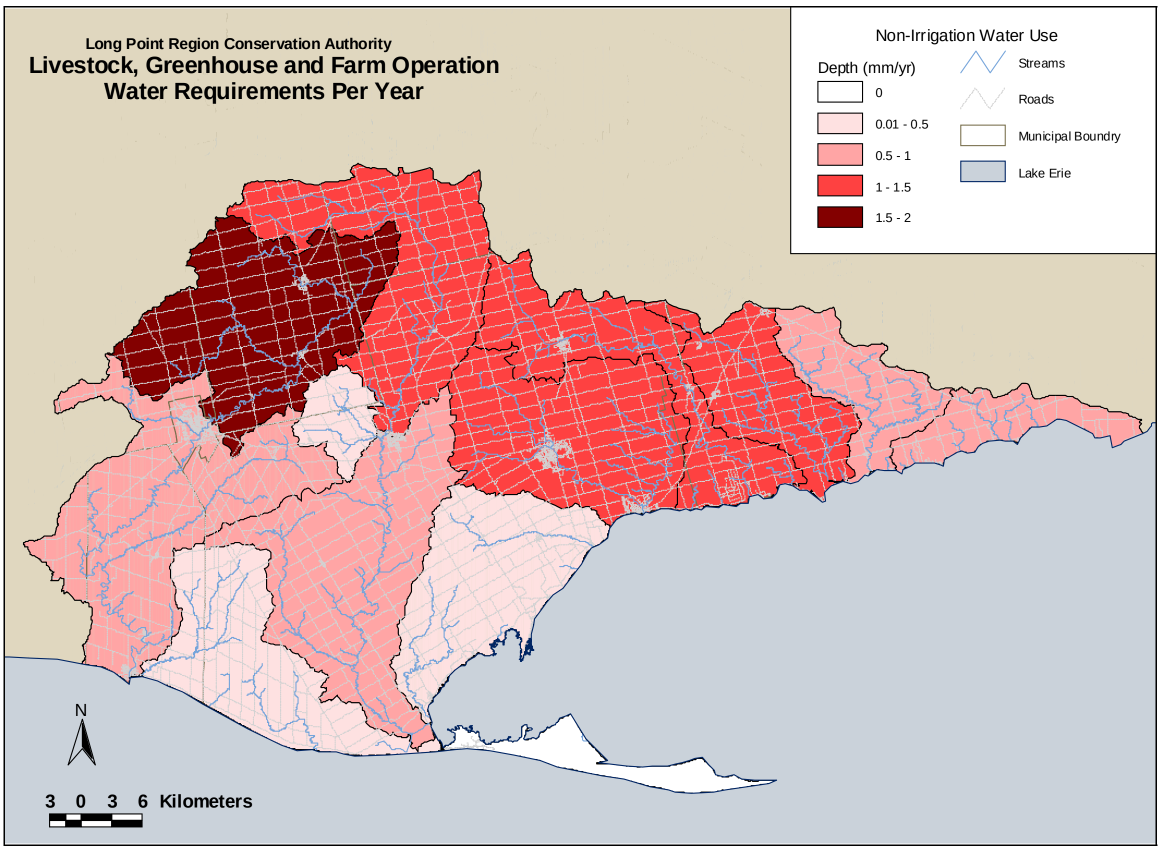

Figure 5. Livestock and Farm Operations Water Requirements

Census of Agriculture data is generally reported on dissemination areas (DA), which are subsections based on municipal boundaries; however, it was requested for this analysis that the information be translated to a surfacewater subwatershed basis for consistency with other water uses. Subsubwatershed basins were provided by the Grand River Conservation Authority based on hand delineation of the topographic surface of the watersheds using the National Topographic System (NTS) and micro-drainage reports (average basin size of 224.2 km^2). Statistics Canada used the subwatershed boundaries to re-cast the information from the original DA divisions. However, privacy issues in census reporting require that no less than 3 farm units of the same type of operation (one type of farming operations may be a sod farm, for example) be available within the basin to release the information concerning that farm type. If there were less than 3 and greater than zero farm units, the information would be suppressed, as well as suppressing information from adjacent basins, to protect the privacy of the owners.

To resolve some of the suppression issues, information was obtained from aggregated Census of Agriculture data, provided from the Ontario Ministry of Agriculture and Food (OMAF). The aggregated data gave more generalized groupings of farm units and thus had less suppression. Thus, only information on total values of generalized farm units (i.e. total cattle in a subwatershed) was able to be resolved, but aided in gaining more accuracy in the estimate of water use for agricultural operations.

The coefficients derived by Kreutzwiser and de Loë (1999) assume that some agricultural water uses such as livestock watering, remains constant throughout the year. Water requirements that are specific for a particular season, such as crop washing, are assigned solely to that particular season.

All water use related to crop irrigation (e.g. for tobacco, vegetables and sod) was not included in this exercise, as crop irrigation was accounted for in a separate calculation and is discussed in the next section.

It is estimated that agricultural water uses, excluding irrigation water, account for 12.3M m^3 per year.

4.2 Crop Irrigation

Crop irrigation is the application of supplemental water onto cropped fields when natural precipitation is insufficient. While it is possible to calculate water use for crop irrigation using the same technique as for livestock/farming operations in the previous section, the need to investigate annual variations in water use required estimation with an irrigation demand model. The water requirements for crop irrigation are seasonal, and are determined by the area of land irrigated and the number of irrigation events per year.

4.2.1 Area of Irrigated Land

The area of irrigated land reported in the Census of Agriculture was used for this study to quantify the extent of irrigated land in the watershed. Statistics Canada re-cast the information on irrigated land for the subwatershed basins, as previously described. In the Long Point Region, there were 2 subwatersheds that had suppressed information regarding irrigated land from the Census of Agriculture data.

By investigating the reported amount of irrigated land in the Census of Agriculture, one can identify certain trends. A summarization of the total irrigated land in the Long Point Region watershed from the 1991, 1996 and 2001 Agricultural Census reporting years, as shown in Figure 6, shows that a relatively large portion of the watershed is irrigated. There was an increase in irrigated land from 1991 to 1996, however by 2001 the area decreased to just under the 1991 levels.

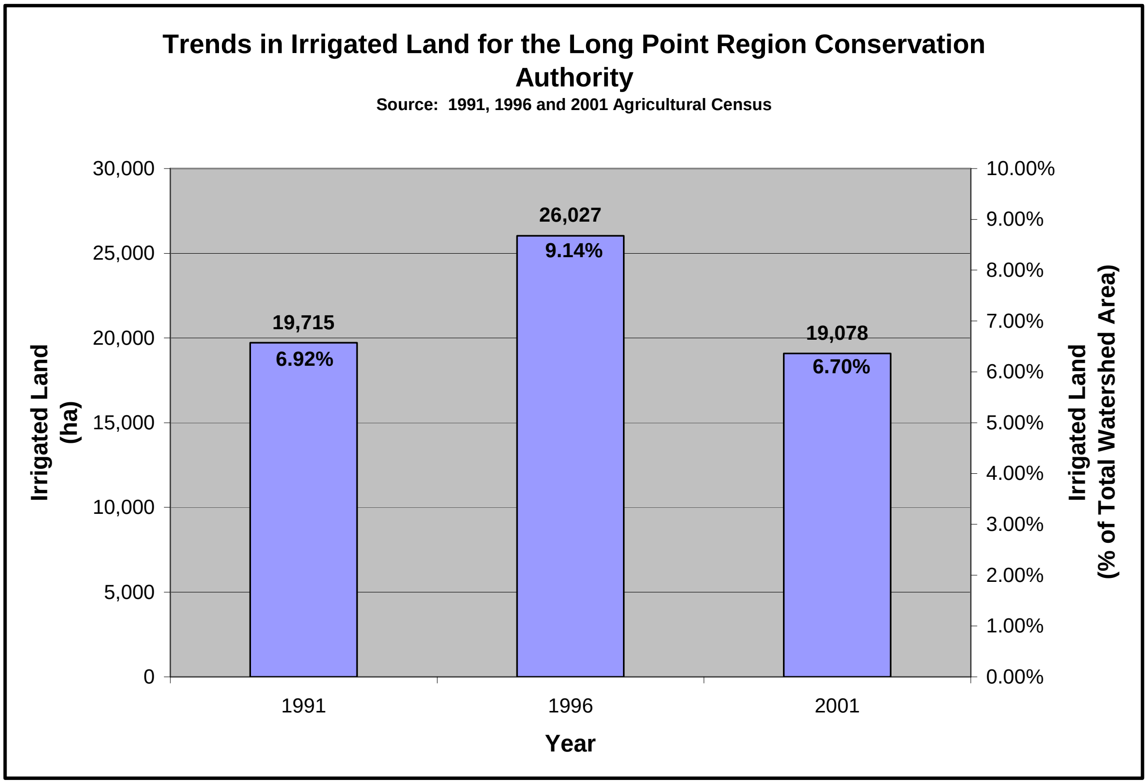

Figure 6. Trends in Irrigated Lands for the Long Point Region Watershed

Reporting of irrigated land by farmers is retroactive to the year prior to the census year, and thus the data is actually reporting irrigation areas in 1990, 1995 and 2000. The decrease in irrigation area in 2000 might have been climate-driven, since the amount of cropped land in the region steadily increased over the decade, as seen in Table 4. Other speculations on a decrease in irrigation may be a change in crop types in the watershed.

Table 4. Cropped and Irrigated Land Percentages in the Long Point Region Watershed

Long Point Region Watershed	1991	1996	2001
Cropped Land in Watershed	55.24%	58.32%	60.57%
Irrigated Land in Watershed	6.92%	9.14%	6.70%
Cropped Land that is Irrigated	12.53%	15.67%	11.06%

4.2.2 Number of Irrigation Events

The estimation of the number of irrigation occurrences utilized an irrigation demand model, developed to predict the number of times farmers would be required to irrigate their crops. This model used synthetic daily soil moisture from the **G**uelph **A**ll-**W**eather **S**equential **E**vents **R**unoff (GAWSER) model. Further information on the GAWSER model and its applications as a water management tool can be found in GAWSER: A Versatile Tool for Water Management Planning (Schroeter *et al*., 2000).

The GAWSER model uses a combination of quaternary geology, land cover, hummocky topography and precipitation to estimate the water cycle at all points in the watershed. The number of irrigation events is calculated based on soil moisture content in which the crop is grown. It is generally accepted that vegetation becomes stressed when the soil moisture content drops below 55% of the water storage ability of the soil (Schwab *et al*., 1981), or halfway between field capacity and wilting point. It is assumed that crops would require irrigation at this point.

The GAWSER model requires that the soil moisture remain under 55% soil moisture for an extended period of time (average soil moisture over a few days) to trigger an event, in order to reduce the number of irrigation events that occur just before a large increase in soil moisture (for example, a large rainfall event). The depth of soil that is assumed to be within the active root zone for measuring for soil moisture is 300 mm (AAFC OMAF, 1995). The irrigation demand model tracks soil moisture in the root zone, and when it reaches the critical level, an irrigation event is triggered applying 25 mm or 1 inch of water with a 65% efficiency rating (Keller and Bliesner, 1990; Allen, 1991).

Irrigation modelling was completed for the years between 1961 and 1999 in a subwatershed of the Grand River watershed. The Whitemans Creek watershed is a part of the Norfolk Sand Plain, which is the predominant geology in the Long Point Region watershed, and thus suitable for application here. It is assumed that the irrigation season for this region is similar to the Grand River, and falls between June 20 and September 10. Irrigation events can only be triggered in between these dates so if the soil moisture falls below the critical soil moisture level outside of these dates, no irrigation event is triggered. The applied water is included to the soil moisture time series and is evaporated as time moves on. When the soil moisture reaches the critical level again, another irrigation event is triggered.

With this irrigation demand model running continuously from 1961 to 1999, one can determine how irrigation demand changes from year to year. Included below are Figures 7 and 8, which illustrate the irrigation demand model output, for two different years, 1992 and 1999, a wet and dry year respectively. The blue area represents soil moisture, with the yellow areas (Figure 8) denoting the soil moisture added by irrigation events.

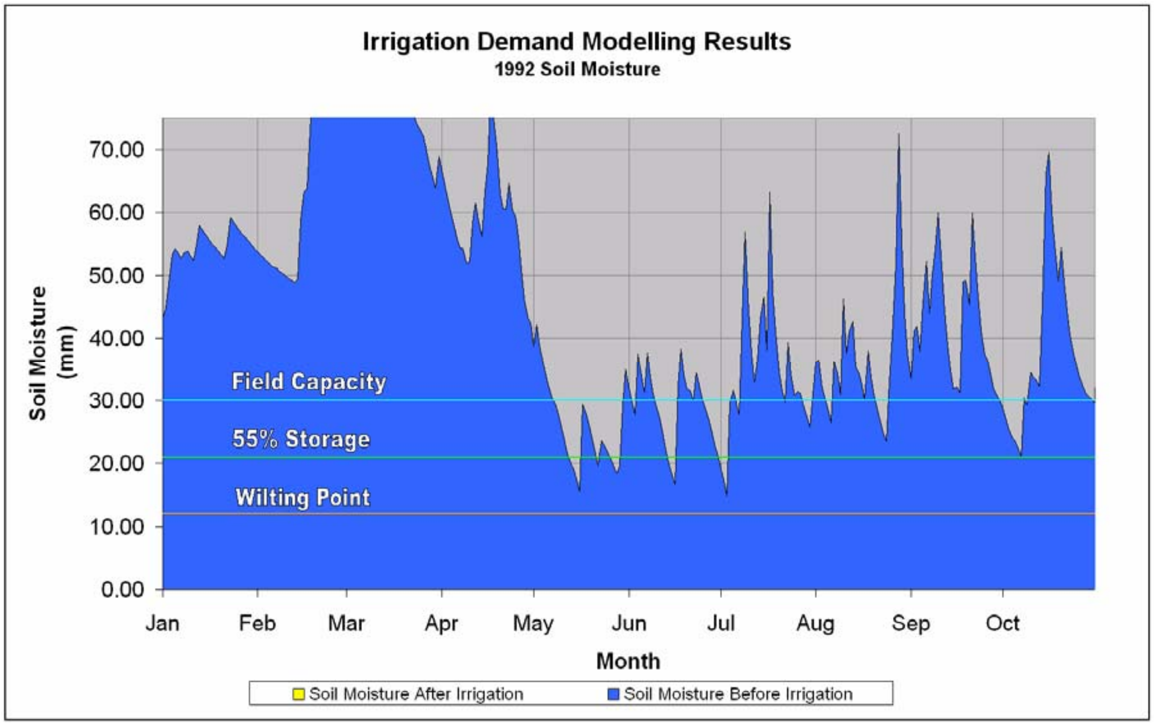

Figure 7. Irrigation Demand Modelling – Wet Year

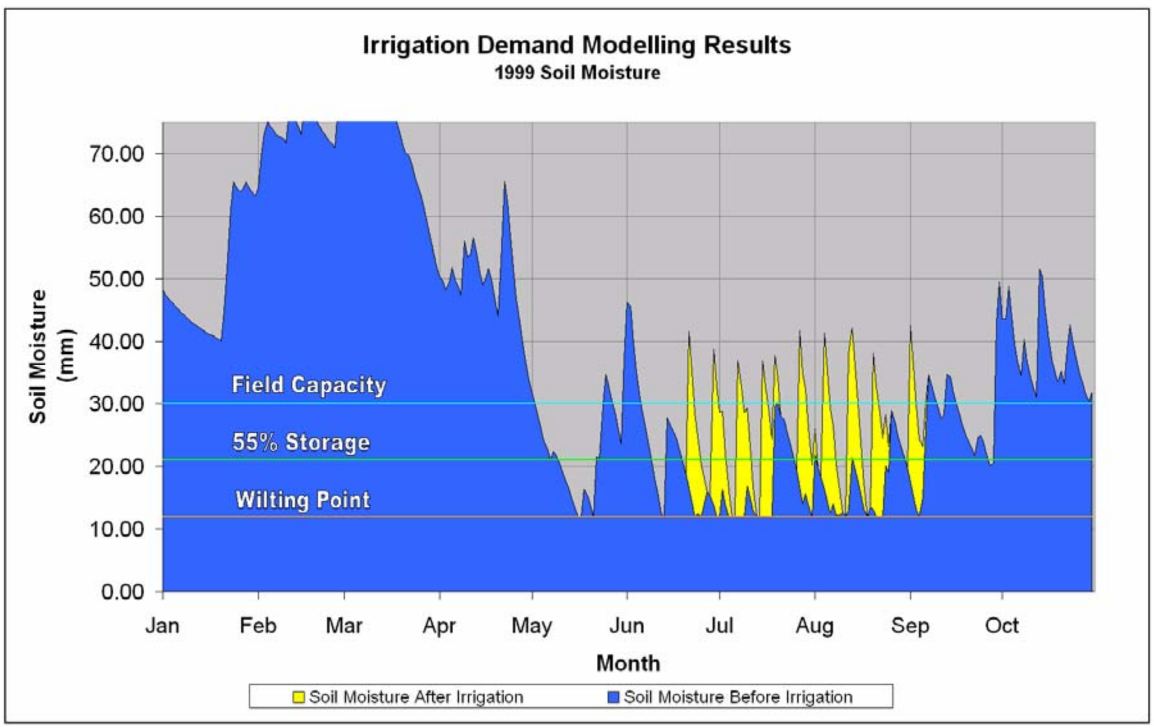

Figure 8. Irrigation Demand Modelling – Drought Year

This type of analysis is useful in determining the temporal variability of irrigation events and ultimately, water demand. Establishing how water use can change with precipitation patterns can be an integral component of water management. The number of irrigation events predicted for each year is included in Figure 9.

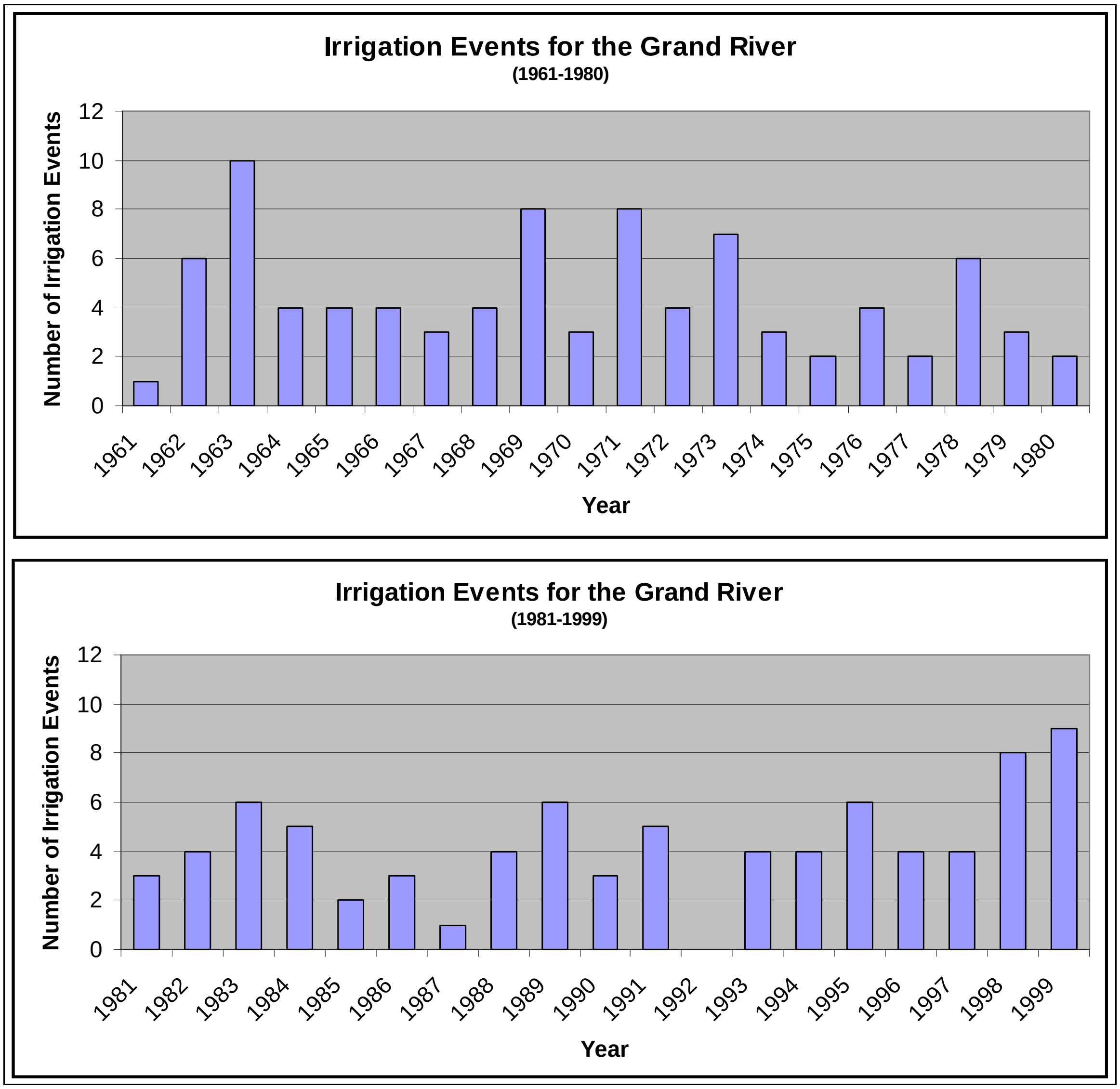

Figure 9. Irrigation Events Predicted 1961-1999

The average (4) and maximum number (10) of irrigation events during the modeling exercise was used to determine the irrigation demand in the Long Point Region. Table 5 lists the variability of irrigation events as well as the associated water requirement.

Table 5. Range of Irrigation Events and Water Demands from the GAWSER Model

	Irrigation Events	Irrigation Water Demand (m^3)
Minimum	0	0
1st Quartile	3	23,988,000
Median	4	31,983,000
3rd Quartile	6	47,975,000
Maximum	10	79,958,000

The irrigation demand model only considers irrigation events meant for maintaining soil moisture at adequate levels for plant growth. Irrigating for climate control, such as spring irrigation to protect against frost, was not considered in this exercise.

The water use for irrigation from the GAWSER model was compared to maximum permitted amounts of all permits in the LPRCA to determine whether there are differences in estimation of water demand. The total amount of water permitted to be taken from all sources (both groundwater and surfacewater) amounts to 3.37M m^3/day for all the agricultural permits in the LPRCA. A range of the varying demands during the months of July and August is given by the total number days that the maximum amount of water that could be taken (see Table 6). Although the GAWSER model was able to estimate the number of irrigation events that occur in a season, it would be very difficult to estimate the number of days that the irrigation pumps were actually running, since an irrigation event could span several days to cover the entire area owned by a farmer.

Table 6. Range of Irrigation Water Demand from PTTWs.

Water Demand for July and August (m^3)	
Daily Maximum Demand	3,372,742
Irrigation Scheduling	**Seasonal Water Demand**
Biweekly	16,863,710
Once a week	30,354,678
1 week per month	47,218,389
Twice a week	60,709,357
Every other day	104,555,004
Daily	209,110,007

From Table 6, if this maximum permitted taking occurred every other day in the months of July and August, the water use would total 104.6M m^3, or if takings occurred daily the total water demand would be 209.1M m^3 during those 2 months. This daily value is substantially higher than the maximum water demand as estimated by the GAWSER model, which is 80M m^3, but other estimates are similar to the demand calculated by the GAWSER model.

The Permit to Take Water database was analyzed to determine a possible breakdown of the source of irrigation water. It was determined that from the 2720 agricultural irrigation sources, 1761 were supplied by groundwater and 959 were supplied from surfacewater, producing a 65%, 35% split, respectively.

Total annual water demand for crop irrigation (for an average year), estimated by the GAWSER modeling exercise, is displayed in Figure 10. The majority of irrigation takes place in the central portion of the watershed, but has high amounts of irrigation across the watershed. This is due to the extensive cash cropping taking place in the Norfolk Sand Plain.

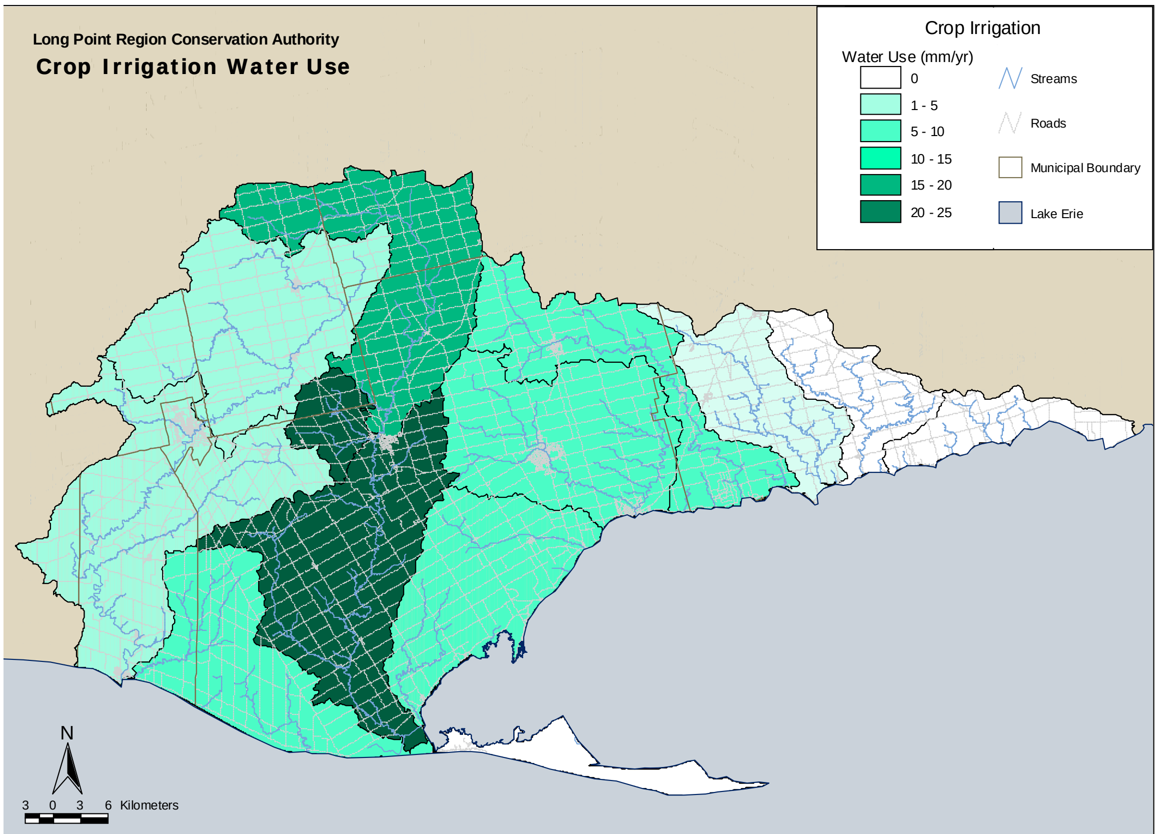

Figure 10. Average Crop Irrigation Water Demand.

5.0 UNSERVICED DOMESTIC WATER USE

Unserviced domestic water use is all water uses for domestic (indoor and outdoor residential water use) use that are not on a municipal distribution system. Generally, these are rural communities and water could be taken from private wells. The estimation of unserviced domestic water use was based on population estimates and per capita water use rates for rural residents.

Rural domestic per capita water use has traditionally been much lower than urban domestic use. While the actual rate varies depending on a large number of factors, 160L/day was assumed to be the rural domestic per capita water use rate

(Vandierendonck and Mitchell, 1997). It should be noted that a large percentage of this water is likely returned to the shallow groundwater system via septic systems. This water use is assumed to be relatively constant throughout the year.

Census of Population from Statistics Canada provides human population on a Dissemination Area (DA) basis. By removing the dissemination areas that are within municipally serviced communities, as given by the information in Section 3.0, a total of the unserviced population can be determined. The rural populations from the DA's were summed and the water use determined was assumed to be evenly distributed across the subwatersheds.

The rural population in the Long Point Region is estimated to be 58,600 and draw 3,400,000 cubic metres of water per year. The water use by subwatersheds is shown in Figure 11.

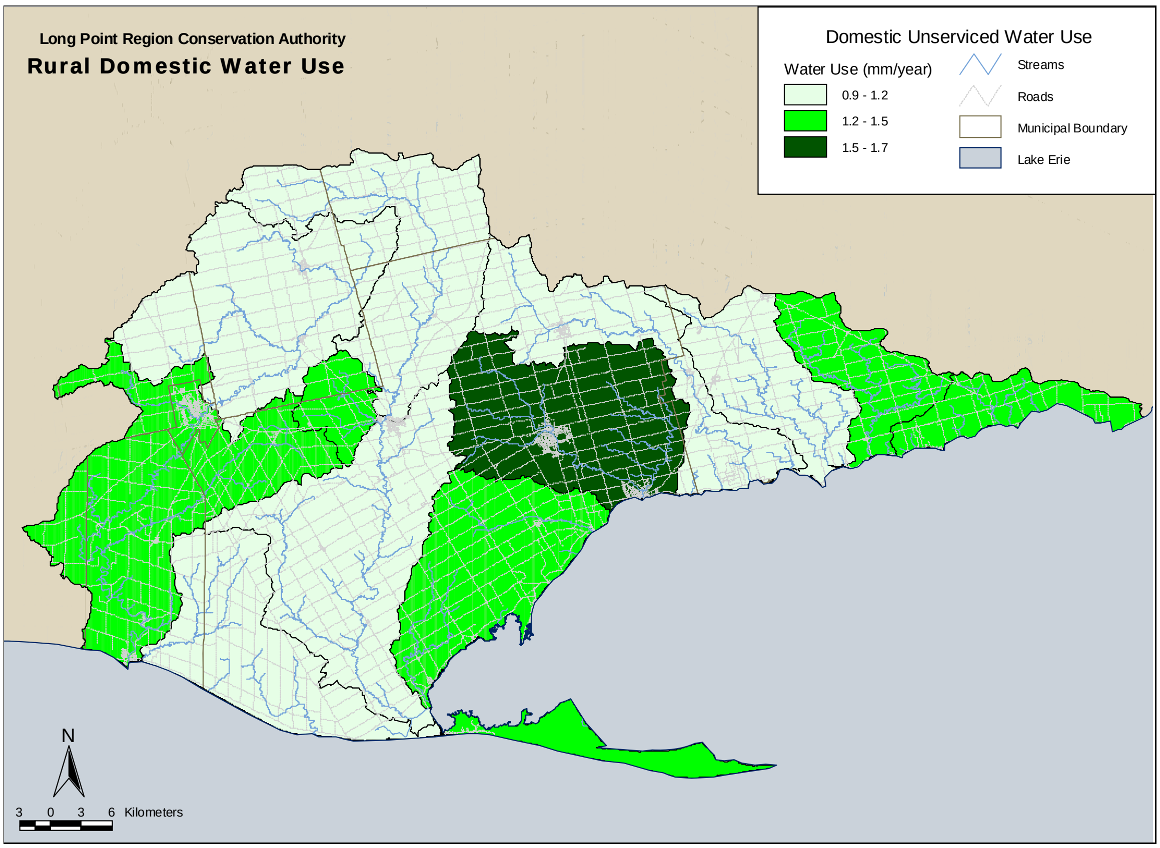

Figure 11. Rural Domestic Water Use

6.0 OTHER PERMITTED WATER TAKINGS

For water uses in the watershed that did not fall into the 3 previously mentioned categories (municipal, agricultural and rural unserviced), the Ministry of the Environment (MOE) Permit to Take Water database was used. The MOE requires any person taking greater than 50,000 litres of water on any day of the year (animal watering, domestic usage and firefighting excluded) to apply for a PTTW. This generally includes many industrial and larger commercial operations, as well as many agricultural water requirements, such as irrigation.

6.1 Active Permitted Water Takings

The PTTW database was queried to remove any permit that has been expired for longer than 10 years, as well as cancelled permits or temporary permits. Any permits from the database that represent water uses that have been previously discussed categories were also dropped from consideration (e.g. municipal, agricultural and rural domestic uses).

Furthermore, permits that were felt not to represent true water takings were also removed from consideration. The most common type that was excluded were those permits representing Ducks Unlimited wetlands for wildlife conservation. These constructed wetlands are built to capture runoff during the spring period, and can therefore have high water taking volumes associated with them. Since these structures will only utilize their full water taking during the initial filling, they were assumed not to be sustained water takings, and were therefore dropped from consideration.

It is recognized that within certain water use sectors, compliance with the PTTW program may be an issue. This raises more issues with the accuracy of water use estimates. The MOE has held a number of PTTW clinics attempting to increase compliance with the program.

Excluding the permits that have been expired for over 10 years, cancelled, temporary, Great Lake sources, agricultural or municipal water supply permits, 50 Permits to Take Water remain in the Long Point Region watershed. These 50 permits have a total of 75 sources associated with them. It is worthwhile to note that there may be more than one source associated with a particular Permit. Of the 75 sources, 61 rely on groundwater, and 14 draw from surfacewater bodies, relating to 81% and 19%, respectively. Figure 12 shows the locations, sources and proportional volume of the maximum permitted water takings of these permits.

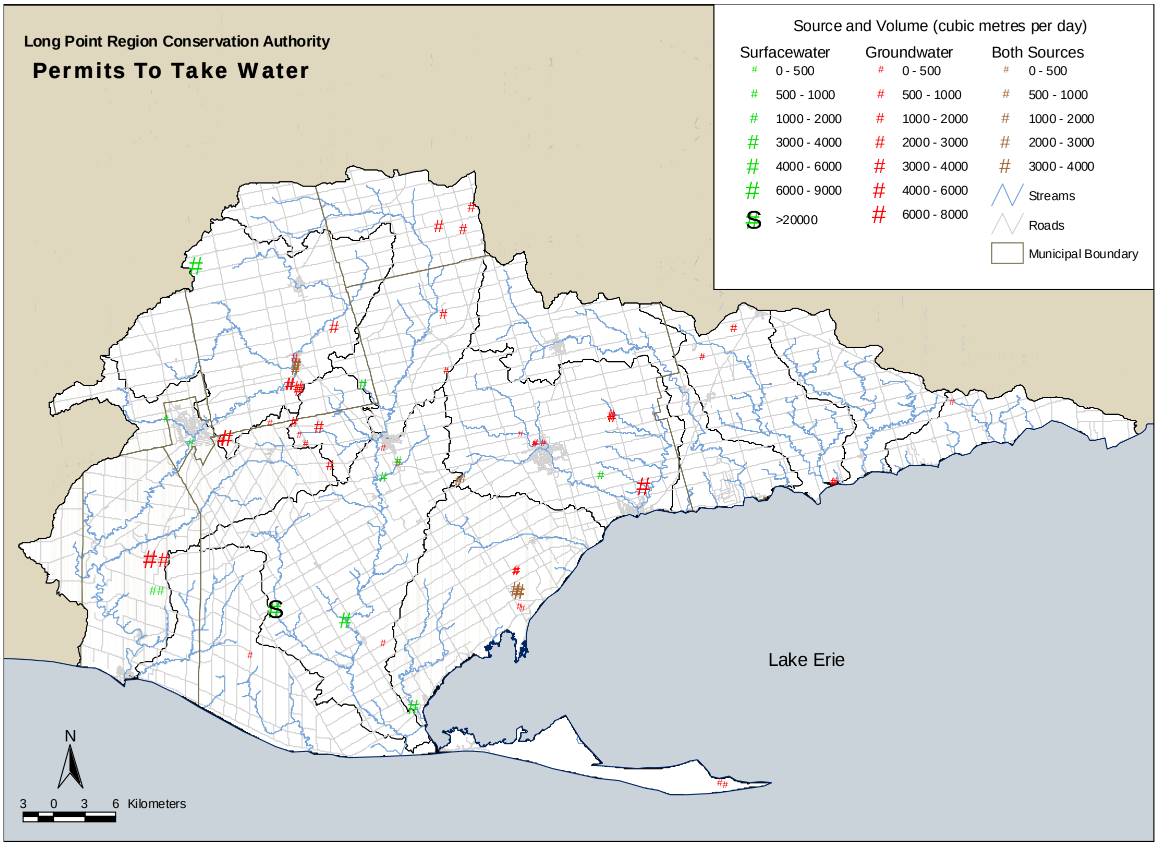

Figure 12. Non-Domestic and Non-agricultural Permits to Take Water: Source, Location and Maximum Amount

6.2 Adjustments to the PTTW Database

When applying for a PTTW, the applicant must declare the maximum volume of water they may take. Reporting maximum permitted, but not actual water taking, is a shortcoming of the PTTW program, when used for estimating actual water use. In many cases, the applicant applies for a quantity much greater than they would actually use. In addition, it is not known how many days the permit holder is actively taking water, or even during which season. It should be noted that MOE has recognized this issue with the PTTW program, and is currently implementing amendments which would require permit holders to submit actual water use statistics to the MOE.

In order to address the deficiency in the database information collection, monthly adjustment factors were applied to permitted volumes to more accurately reflect actual water usage, as shown in Table 7. For the most part, these adjustment factors simply determine when the taking is active. Months when the permit was assumed to be active were given a value of 1, while inactive months were given a 0 value. For the water supply permits (not including campgrounds), monthly patterns were assumed to be the same as the Regional Municipality of Waterloo's pattern for smaller communities, as described in Section 1.0, with the maximum permitted flowrate being the August monthly water use.

Table 7: Permit To Take Water Adjustment Factors

General Purpose	Specific Purpose	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Commercial	Aquaculture	1	1	1	1	1	1	1	1	1	1	1	1
Commercial	Golf Course Irrigation	0	0	0	0	1	1	1	1	1	1	0	0
Commercial	Other - Commercial	1	1	1	1	1	1	1	1	1	1	1	1
Dewatering	Construction	1	1	1	1	1	1	1	1	1	1	1	1
Dewatering	Pits and Quarries	1	1	1	1	1	1	1	1	1	1	1	1
Industrial	Aggregate Washing	0	0	0	0	1	1	1	1	1	1	1	0
Industrial	Food Processing	1	1	1	1	1	1	1	1	1	1	1	1
Industrial	Manufacturing	1	1	1	1	1	1	1	1	1	1	1	1
Industrial	Other - Industrial	1	1	1	1	1	1	1	1	1	1	1	1
Institutional	Schools	1	1	1	1	1	1	1	1	1	1	1	1
Miscellaneous	Other - Miscellaneous	1	1	1	1	1	1	1	1	1	1	1	1
Recreational	Aesthetics	0	0	0	0	1	1	1	1	1	1	0	0
Remediation	Other - Remediation	1	1	1	1	1	1	1	1	1	1	1	1
Water Supply	Campgrounds	0	0	0	0	1	1	1	1	1	0	0	0
Water Supply	Other - Water Supply	0.80	0.75	0.82	0.82	0.89	0.86	0.97	1.00	0.95	0.95	0.87	0.84

There are still known issues with the accuracy of the estimates when using the outlined adjustment factors to gain a better estimate of water use throughout the year. For instance, during the months that a permit is assumed to be active, the taking is assumed to be occurring continuously. While it is unlikely that most water takings will be continuously active during the entire month, there are no data available to support an analysis to determine the period of taking for each purpose.

Water use estimates for some categories will be elevated due to the assumption of continually active water takings, the maximum permitted takings and the multiples of some permits. The water use estimates for these categories will be the absolute maximum and do not represent actual conditions.

A survey all major water users identified in the watershed was done to gain insight into actual water takings as well as taking characteristics. While Figure 12 shows the maximum amount permitted by each taking, some adjustments were made to display the depths of water takings as seen in Figure 13. A phone survey of the 50 water takers in the Long Point Region was completed in the summer of 2005 (June to August), to get better estimates or actual volumes of water use by each user.

Each water user was asked to describe the timing during the year and duration of the day that they were taking water for their use, the source of the taking, and purpose. From this information, a better estimate than the permitted maximum could be used for the estimate of water use by subwatersheds. The survey generated responses from 26 of the 50 permits (52% response rate) to refine the estimates of their water uses. Where no data could be obtained from the user, adjustments were made based on the adjustment factors as seen in Table 8 for monthly water uses.

Figure 13 shows the depth of water use on a surfacewater subwatershed, with the adjustments made to refine the depths from the survey and the adjustment factors.

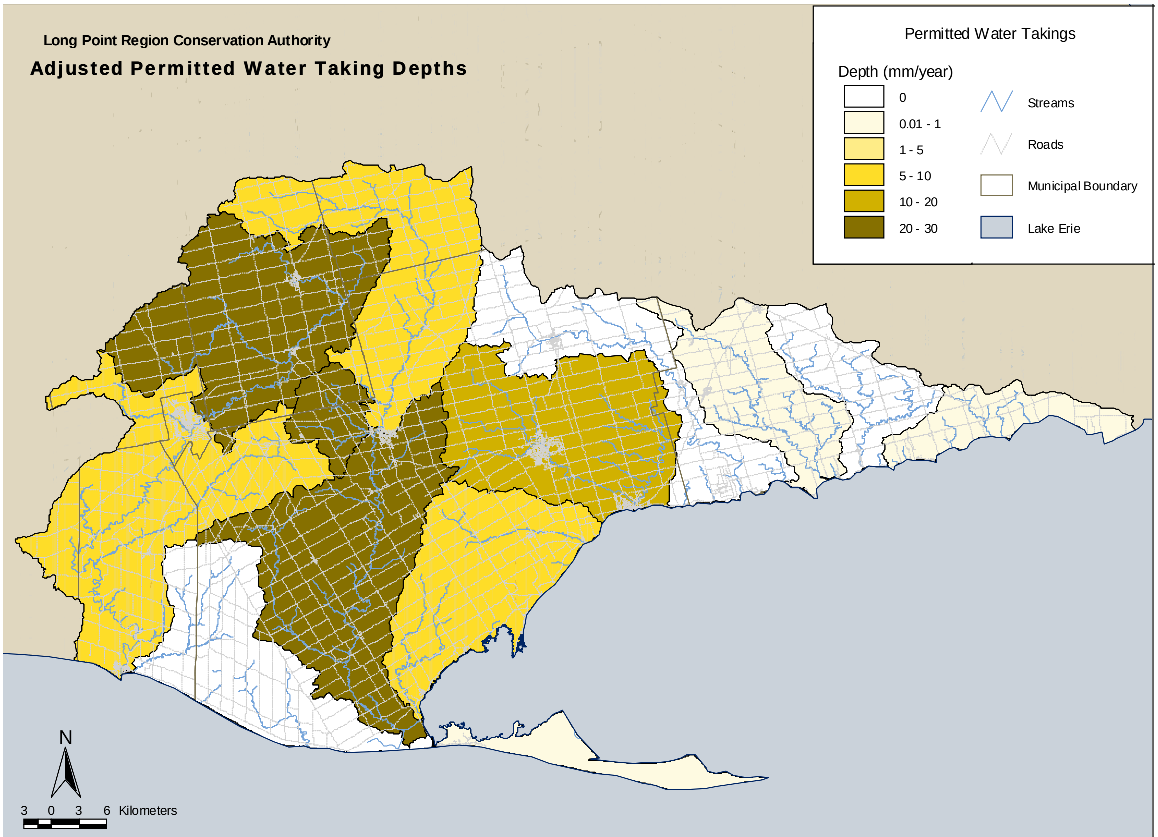

Figure 13. Adjusted Depth of Water Takings from Non-Domestic and Non-Agricultural Permits to Take Water

The estimated annual water use for each category listed with the PTTW database is quantified in Table 8. It should be noted that this analysis uses the amount either refined by the survey or monthly adjustment factors, or when not available, is the amount included in the database. Permits that are described as "Industrial – Other" or "Miscellaneous" make it extremely difficult to understand the true purpose or characteristic of the particular water taking.

Table 8. Adjusted Permit To Take Water Volumes in cubic metres – By Source

	Water Use Category	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
1	Aquaculture	557,340	503,410	557,340	539,370	557,340	539,370	557,340	557,340	539,370	557,340	539,370	557,340	6,562,280
2	Other - Remediation	83,700	75,600	83,700	81,000	83,700	81,000	83,700	83,700	81,000	83,700	81,000	83,700	985,500
3	Construction	44,700	40,370	44,700	43,260	44,700	43,260	44,700	44,700	43,260	44,700	43,260	44,700	526,300
4	Aggregate Washing					74,680	72,270	74,680	74,680	72,270	74,680	72,270		515,520
5	Golf Course Irrigation					67,420	65,250	67,420	67,420	65,250	67,420			400,180
6	Other - Commercial	22,550	20,370	22,550	21,820	22,550	21,820	22,550	22,550	21,820	22,550	21,820	22,550	265,480
7	Pits and Quarries	20,890	18,870	20,890	20,210	20,890	20,210	20,890	20,890	20,210	20,890	20,210	20,890	245,940
8	Other - Industrial	11,250	10,160	11,250	10,880	11,250	10,880	11,250	11,250	10,880	11,250	10,880	11,250	132,410
9	Aesthetics					2,250	2,180	2,250	2,250	2,180	2,250			13,350
10	Campgrounds					1,690	1,640	1,690	1,690	1,640				8,350
11	Other - Miscellaneous	680	610	680	660	680	660	680	680	660	680	660	680	7,990
12	Manufacturing	230	210	230	230	230	230	230	230	230	230	230	230	2,760
13	Schools	40	40	40	40	40	40	40	40	40	40	40	40	500
14	Food Processing	17	16	17	17	17	17	17	17	17	17	17	17	203
	TOTAL	**741,400**	**669,650**	**741,400**	**717,480**	**887,440**	**858,810**	**887,440**	**887,440**	**858,810**	**885,750**	**789,750**	**741,400**	**9,666,770**

The adjusted water takings are considerably less than the permitted maximums provided by the database, at an average of 15% of the value given in the database. The most drastic changes in volume were seen (0% of database value for 'Water Supply – Other' category) where there was the most feedback in the surveys and the least in categories (36.5% in Miscellaneous and 34% in Other – Commercial categories) where there were no responses. The benefits of the survey were also to clarify the information in the database, as there were sometimes errors found in the purpose category or termination of the water use.

7.0 ANALYSIS

The final summation of all the water uses in each of the Long Point Region subwatersheds is shown in Figure 16. This shows the sum total of all the water uses including municipal, livestock and greenhouse, crop irrigation, rural domestic and PTTW adjusted takings, on an annual basis. Due to the large volumes estimated for crop irrigation in this watershed, as well as other permitted takings, the central portion of the watershed in the Norfolk Sand Plain shows the highest water use and lessens towards the outer ends of the watershed.

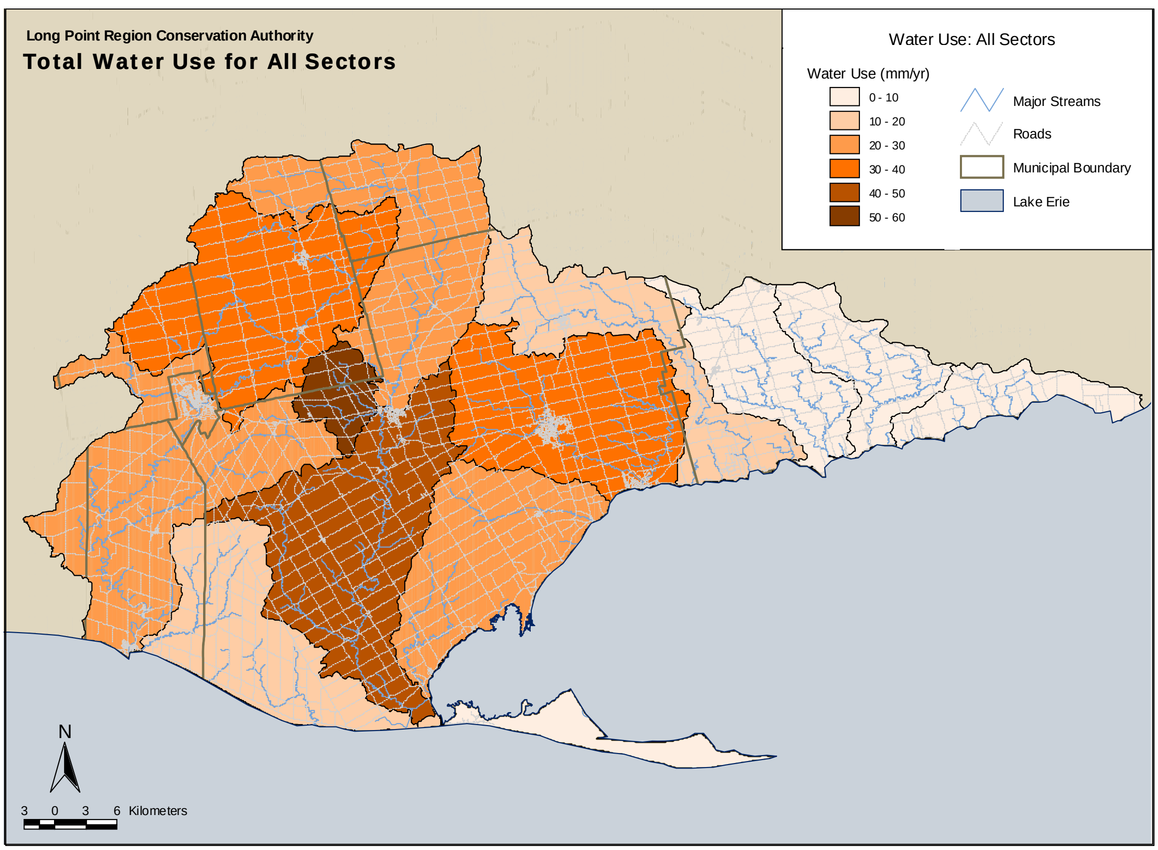

Figure 16. Total Subwatershed Water Depths For All Sectors

Table 9 lists all the water uses described in the previous sections and compares them against each other, as well as illustrates the monthly and annual variation of water use. Figure 14 shows the percentages of water use on an annual basis.

Table 9. Total Water Use Comparison (in cubic metres)

	Water Use	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
1	Agricultural - Irrigation	-	-	-	-	-	7,995,750	15,991,500	7,995,750	-	-	-	-	31,983,000
2	Municipal	843,040	810,460	854,000	803,610	888,210	923,680	959,060	935,850	917,910	832,830	801,730	807,980	10,378,390
3	Aquaculture	557,340	503,410	557,340	539,370	557,340	539,370	557,340	557,340	539,370	557,340	539,370	557,340	6,562,280
4	Rural Domestic	297,700	268,900	297,700	288,100	297,700	288,100	297,700	297,700	288,100	297,700	288,100	297,700	3,505,300
5	Agricultural	174,660	157,760	174,660	169,030	174,660	169,030	524,930	524,930	519,300	174,660	169,030	174,660	3,107,350
6	Other - Remediation	83,700	75,600	83,700	81,000	83,700	81,000	83,700	83,700	81,000	83,700	81,000	83,700	985,500
7	Dewatering - Construction	44,700	40,370	44,700	43,260	44,700	43,260	44,700	44,700	43,260	44,700	43,260	44,700	526,300
8	Aggregate Washing	-	-	-	-	74,680	72,270	74,680	74,680	72,270	74,680	72,270	-	515,520
9	Golf Course Irrigation	-	-	-	-	67,420	65,250	67,420	67,420	65,250	67,420	-	-	400,180
10	Other - Commercial	22,550	20,370	22,550	21,820	22,550	21,820	22,550	22,550	21,820	22,550	21,820	22,550	265,480
11	Dewatering - Pits and Quarries	20,890	18,870	20,890	20,210	20,890	20,210	20,890	20,890	20,210	20,890	20,210	20,890	245,940
12	Other - Industrial	11,250	10,160	11,250	10,880	11,250	10,880	11,250	11,250	10,880	11,250	10,880	11,250	132,410
13	Aesthetics	-	-	-	-	2,250	2,180	2,250	2,250	2,180	2,250	-	-	13,350
14	Campgrounds	-	-	-	-	1,690	1,640	1,690	1,690	1,640	-	-	-	8,350
15	Other - Miscellaneous	680	610	680	660	680	660	680	680	660	680	660	680	7,990
16	Manufacturing	230	210	230	230	230	230	230	230	230	230	230	230	2,760
17	Schools	40	40	40	40	40	40	40	40	40	40	40	40	500
18	Food Processing	17	16	17	17	17	17	17	17	17	17	17	17	203
	TOTAL	2,056,797	1,906,775	2,067,757	1,978,227	2,248,007	10,235,387	18,660,627	10,641,667	2,584,137	2,190,937	2,048,617	2,021,737	58,640,803

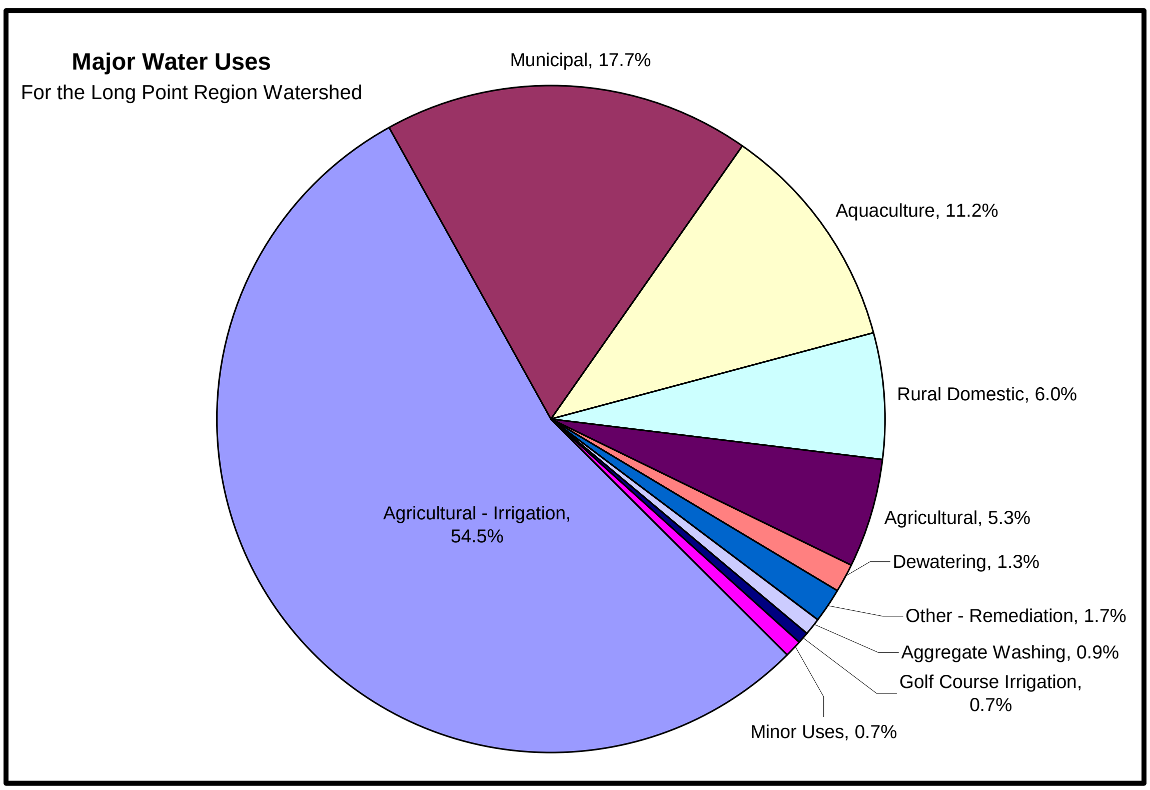

Figure 14. Major Water Uses – Annual Basis

While Figure 14 is useful for comparing totals, this analysis will under-represent the significance of short but intense water uses, such as crop irrigation. A line graph (Figure 15) illustrates the importance of monthly variability. Agricultural irrigation is the second highest annual water taking, but spikes considerably in the month of July and is 3.5 times higher than all the other water uses combined.

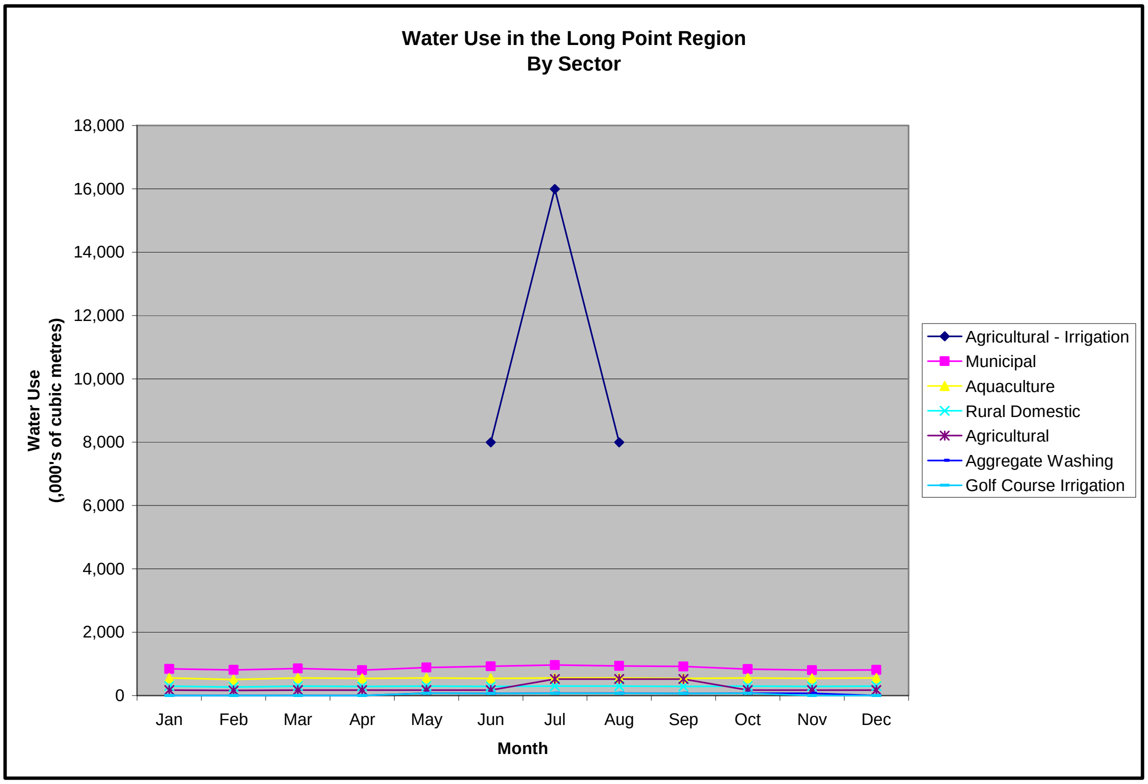

Figure 15. Monthly Variation of Major Water Uses

It should be noted that with regard to crop irrigation, the actual water use may be more intense that what is represented by the monthly analysis. Crop irrigation can be focused into a particular week, depending on climate conditions making it by far, the highest taking in the watershed, albeit for a short duration.

For effective water management, one must consider the intensity of water takings, particularly for surfacewater management. The intensity of water takings is generally less important due to the delayed response associated with groundwater. However, when considering unconfined aquifers, which are well connected to the surfacewater system, the intensity of takings may be more significant.

In addition to monthly variation, water use also varies on an annual basis. Climatic variations play an enormous role in certain types of water use. The longer the watershed goes without receiving rain, the more water is needed to water lawns, or irrigate agricultural crops.

While the amount of water used by many water takers is largely dependent on the climate, some water users operate independently of climate. These may include water bottlers, aggregate producers or aquaculture operations. These users require the same amount of water every year for the industrial or commercial processes that produce the product. While not possible, due to data limitations, to quantify the impact of dry periods on every water user listed in Table 10, one can qualitatively divide water users into climate-dependent and climate-independent subgroups, as seen in Table 10.

Table 10. Climate-Sensitive Water Uses

Category	Climate Sensitive	Climate Insensitive
Aggregate Washing		X
Agricultural	X	
Agricultural Irrigation, Average	X	
Aquaculture		X
Bottled Water		X
Cooling Water		X
Dewatering		X
Food Processing		X
Golf Course Irrigation	X	
Heat Pumps		X
Mall / Business		X
Manufacturing		X
Miscellaneous	**Unknown**	
Municipal Supply	X	
Other - Commercial	X	
Other - Industrial		X
Other - Institutional	X	
Recreational	X	
Remediation		X
Rural Domestic	X	
Schools	X	
Snowmaking	X	
Water Supply, Campgrounds	X	
Water Supply, Communal	X	
Water Supply, Other	X	

Water diversions and consumptive water uses are a consideration for the continuation of water use estimates. For instance, wastewater discharge from aquaculture, dewatering or sewage treatment plants all increase the amount of water available in the surfacewater system. Currently, there is not sufficient information to develop consumptive use ratios for all major water uses.

In addition to consumptive water takings, there is a need to identify those takings which represent a diversion of water from the original source. While not consumptive, a dewatering operation that removes groundwater and discharges it to surfacewater represents a diversion of groundwater to surfacewater. When investigating water takings at an individual source scale (such as an aquifer), these diversions do play a significant role in determining the production capacity of the source.

8.0 CONCLUSIONS AND RECOMMENDATIONS

The identification of the various water uses in the Long Point Region watershed was the focus of this report. The largest water use in the Long Point Region watershed is agricultural irrigation, with estimates derived from irrigation demand modeling. The vast number of agricultural irrigation permits in the region is also an indication of the level of intensity of this water use.

This report has identified the following water use sectors as being important in a watershed-wide context:

1. Agricultural – Irrigation
2. Municipal Water Supply
3. Aquaculture
4. Rural Domestic
5. Agriculture
6. Remediation
7. Dewatering – Construction
8. Aggregate Washing
9. Golf Course Irrigation
10. Commercial – Other
11. Dewatering – Pits and Quarries
12. Industrial – Other
13. Recreational – Aesthetics
14. Water Supply – Campgrounds
15. Miscellaneous
16. Manufacturing
17. Schools – Water Supply
18. Food Processing

The study attempted to use a variety of available information from different sources such as the PTTW database, municipal records, specific water users by phone survey and Statistics Canada information from census results to obtain the best estimates of water use across the sectors. Most municipalities were able to give actual volumes of use for serviced communities in their jurisdiction.

The PTTW database gives a broad understanding of the different types of water uses in a watershed, however accuracy of the information is lacking and poses a problem for water managers who use the PTTW database to quantify the amount of water use within a specific area. The database does not currently contain sufficient detail or reliability to determine the actual amount of water used, or show the annual or seasonal fluctuations of water takings.

Phone surveys of the users in the PTTW database helped to refine these estimates, and wherever possible, other sources of information were used. For example, municipalities were contacted to determine actual rates of consumption, and Census of Agriculture and

Census of Population data were used to determine agricultural and rural domestic water use. An irrigation demand model, using soil moisture data from a continuous hydrological model, coupled with Census of Agriculture data, has made it possible to determine water demand for crop irrigation and the annual variability of water use.

While annual totals are useful for comparison purposes, seasonal and annual variations must be considered to fully understand the water use in a watershed. Some seasonal and annual variation were shown, however they were limited due to limitations with the data sources. The variations are most significant when considering extremely variable and intense water takings, such as crop irrigation.

This study has identified a number of limitations with water use data available to water managers. In an attempt to address these shortcomings and increase the accuracy of water use estimates further, the study has made the following recommendations:

1. That the water use estimates generated from this report be combined with estimates of water availability to identify possible water quantity issue areas.
2. That information gathered from the municipal sector be separated into industrial, commercial, institutional and residential components
3. That investigations into more accurate estimates of irrigated land continue, including assessing the use of alternative methodologies such as remote sensing and crop specific water uses.
4. That consumptive ratios of all major water sectors be determined, as well as the occurrence of water diversions.
5. That development of a central database of water use in the watershed continues. This database would house recent information on municipal water systems as well as information gathered from phone surveys of permitted water users.

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