Water Use in the Kettle Creek Watershed

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DRAFT

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Executive Summary

As the Kettle Creek 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 Kettle Creek watershed.

This report is an initial summary of the present-day water uses within the Kettle Creek 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 62.5% response rate. The analysis of all water use data identified the following water uses within the basin:

1. Municipal Water Supply
2. Rural Domestic
3. Agricultural Irrigation
4. Agriculture
5. Golf Course Irrigation
6. Dewatering
7. Commercial Mall/Business
8. 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 third largest water user on an annual basis, their water takings are concentrated during the months of June to August. Agricultural irrigation is actually the second highest water taking and is more than the combined total of all non-municipal water takings 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 the municipalities on the Elgin Area Water Treatment Supply System gather further information on serviced populations along the pipeline and taking amounts in the watershed.

3. That information gathered from the municipal sector be separated into industrial, commercial, institutional and residential components of water use.

4. 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.
5. That consumptive ratios of all major water sectors be determined, as well as the occurrence of water diversions.
6. That the development of a central database of water use in the watershed continue. 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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Acknowledgements

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- The member municipalities in the Kettle Creek watershed for supplying water use information.
- The staff at the Kettle Creek Conservation Authority for reviewing and providing support for the report.
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- The permit holders in the watershed who voluntarily supplied actual water use information for the report.

1.0 INTRODUCTION

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 is divided into 4 groupings: Municipal Supply, Agricultural, Unserviced Population and Other Permitted Takings. The 'Other Permitted Takings' group is further broken down into different user groups using the Permit to Take Water (PTTW) categories, however does not include permits that are considered as part of the other groups of residential or agricultural purposes.

Water use information is divided into subwatersheds within the larger Kettle Creek 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).

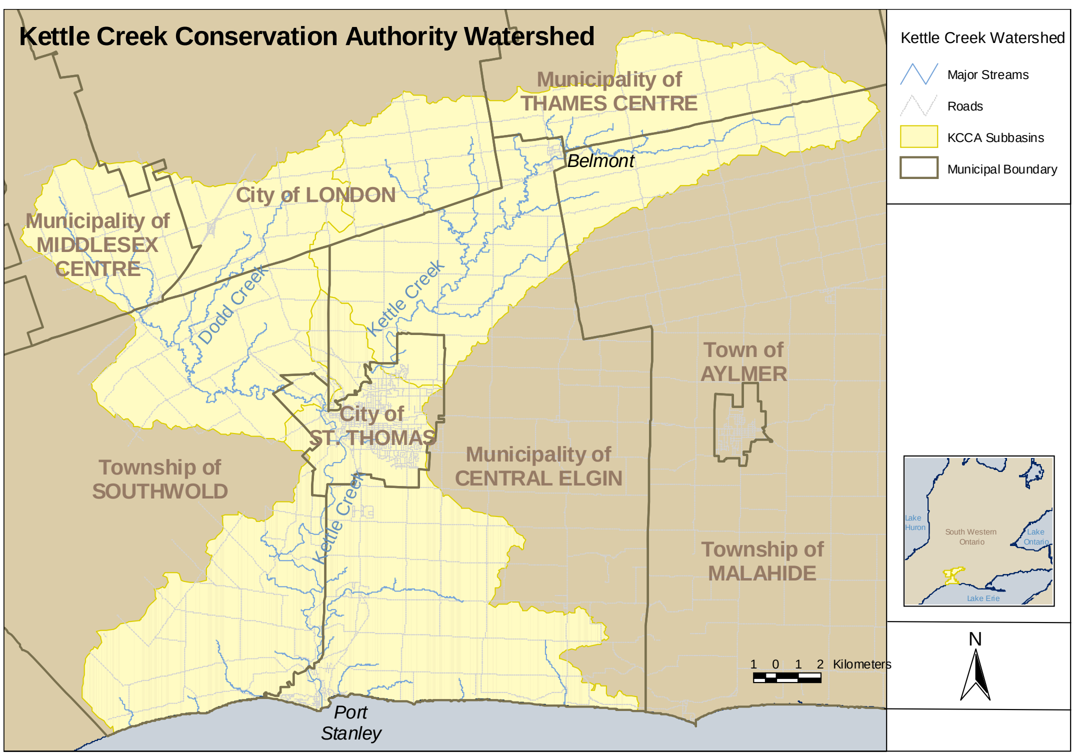

Figure 1. Watershed Overview Map

2.0 DESCRIPTION OF THE WATERSHED

The Kettle Creek Watershed is located in south western Ontario on the northern shore of Lake Erie (see Figure 1). The watershed is situated just south of the city of London, in Elgin County and encompasses the City of St. Thomas. Smaller communities include Port Stanley and Belmont. Kettle Creek and its major tributary of Dodd Creek flow towards St. Thomas and then continue south into Lake Erie at Port Stanley. The watershed area is approximately 520 km^2.

The Kettle Creek watershed has been divided topographically into three subwatersheds for analysis and to highlight geographical differences in water uses across the watershed (see Figure 1). Kettle Creek has been divided into Upper Kettle Creek subwatershed and the Lower Kettle Creek subwatershed, and the Dodd Creek tributary subwatershed. Much of the watershed land is used for agriculture for cash crops, with about 5% in urban land.

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 systems. 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. While per capita values are listed, they should not be used in a comparison between municipal systems, as differing proportions of residential, and Industrial, Commercial and Institutional (ICI) demand may vary widely from municipality to municipality.

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	Belmont	2004	~1800	448.25	0.249	655.75	0.364	1,799	Groundwater	Communication with Municipal Staff
Elgin	St Thomas	2004	~40,000	4339.09	0.108	69319	1.733	68,170	Lake Erie	Communication with Township Staff
Elgin	Southwold and Central Elgin	2004	~5500	6,070.65	1.104				Lake Erie	Communication with Municipal Staff
Elgin	Central Elgin (Port Stanley Secondary Water System)	2004	~3500	891.07	0.255				Lake Erie	Communication with Municipal Staff
	TOTAL		50,800	11,749						

Information for Table 1 was provided by the municipalities in Elgin County. Much of the Kettle Creek watershed area is supplied by the Elgin Area Primary Water Supply System, which pumps water from Lake Erie. The recorded values from the secondary water supply often service two municipalities (for example, Central Elgin and Southwold), which made it difficult to measure the number of residents and per capita water use. The water use information was transferred to subwatersheds based on percentage area within and outside the municipality, as well as within each subwatershed area. It is likely that ICI water uses were included in these water takings, which would elevate the per capita values as seen in Table 1. Also, residents adjacent to the pipeline can tap into it as it runs through the watershed (see Figure 2), making exact serviced population figures difficult to quantify.

Municipal supply sources, as seen in Figure 2, are from groundwater wells, and surfacewater sources such as Lake Erie. The majority of the municipal supply in the Kettle Creek watershed is from Lake Erie, supplied through the Elgin Area Primary Water Supply System. In Figure 2, the entire volume of water taken through the Elgin Area Primary Water Supply System is represented at the point of intake in Lake Erie. This volume of water is distributed via pipelines that run through Elgin County and also supplies approximately 25-30% of the rural and urban districts of the City of London both within and outside of the watershed region.

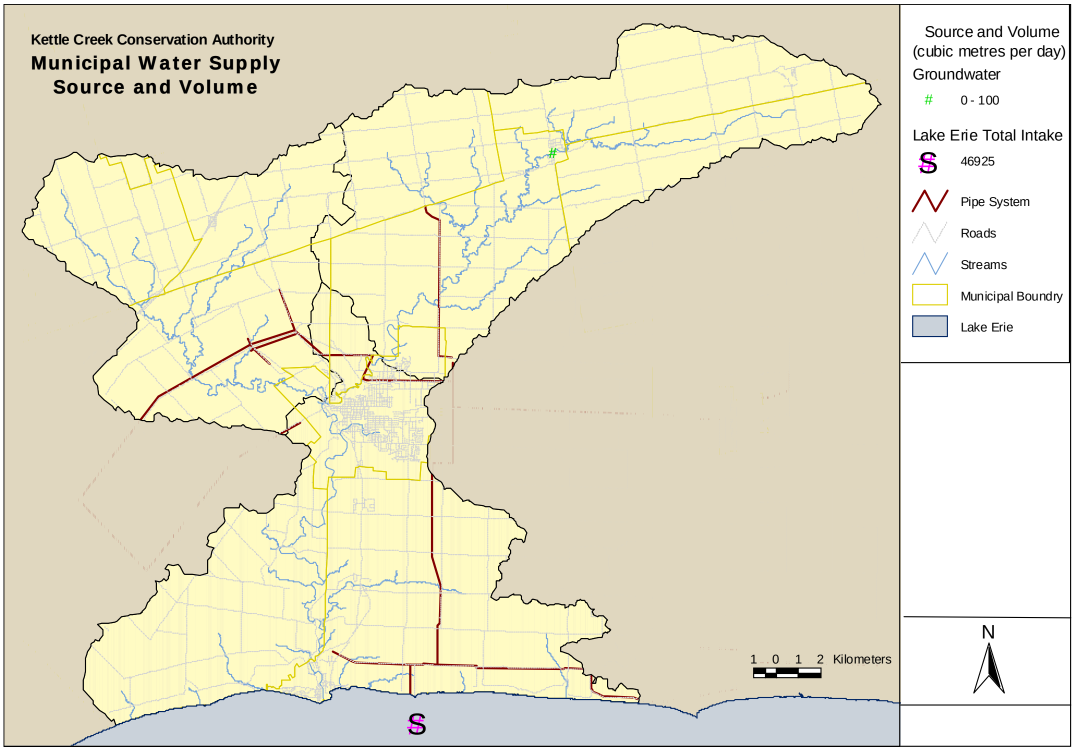

Figure 2. Municipal Supply Sources

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 1010mm to 1040mm (Port Stanley is 1040mm/year; Environment Canada, 2005a), which provides a constant value for comparing to 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 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 Kettle Creek watershed are only seen in the groundwater taking for Belmont, in the northeast corner of the watershed.

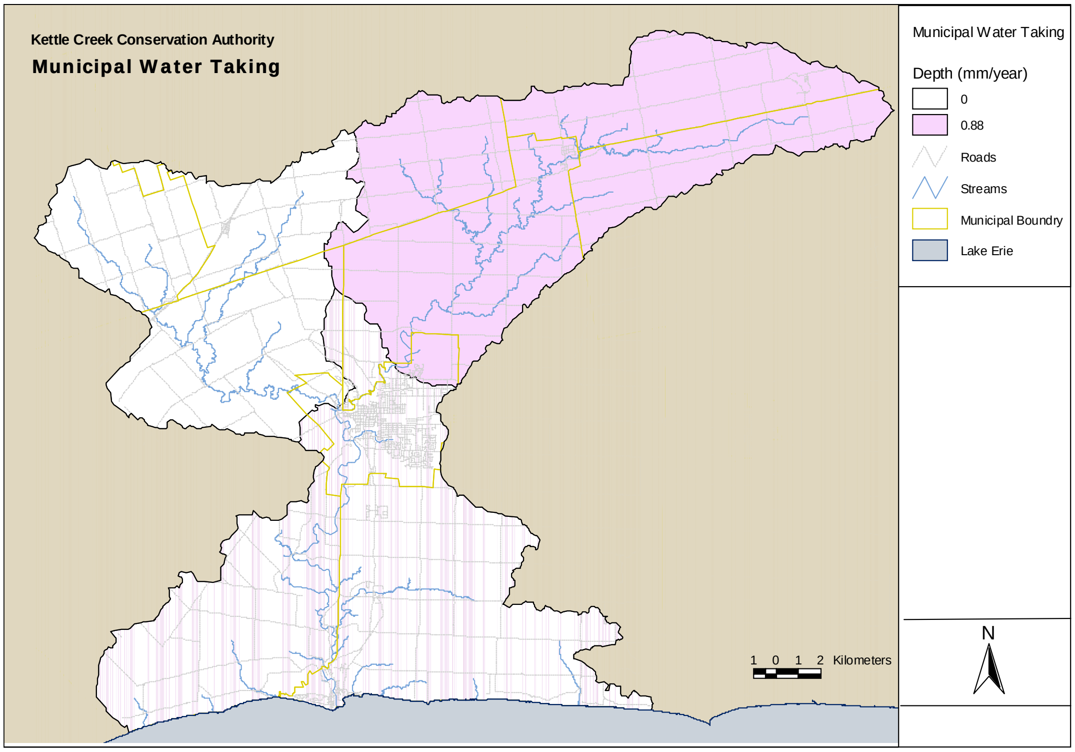

Figure 3. Municipal Water Use

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 that all municipalities servicing water to communities keep records of use. Table 2 lists the monthly patterns for the serviced municipalities in the Kettle Creek watershed, where 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. Monthly Distribution of Average Daily Municipal Water Use.

Municipal System	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Belmont	0.87	0.95	0.96	0.95	1.17	1.35	1.42	1.02	1.00	0.91	0.78	0.62
St Thomas	1.09	1.10	1.00	0.95	1.04	1.37	1.28	0.97	1.18	0.83	0.53	0.67
Southwold and Central Elgin	0.94	1.01	0.97	1.01	1.02	1.10	1.07	0.97	1.04	0.90	0.92	1.04
Central Elgin	1.55	1.48	1.28	1.09	0.68	0.72	0.98	0.71	0.58	0.88	0.91	1.14

Table 2 shows that higher than average water uses in municipalities occurs in the summer months of June and July for most of the Kettle Creek watershed. Higher summer water uses may be attributed to outdoor residential water use such as lawn watering, Central Elgin has much higher water uses in the winter, however.

Table 3 shows the percentages of the serviced communities in the Kettle Creek watershed that use surfacewater from Lake Erie and groundwater for their municipal takings. Belmont has the only groundwater source for municipal water takings in the Kettle Creek watershed. All other municipalities receive their water from Lake Erie from either primary or secondary water systems from an intake in Lake Erie off Port Stanley. Municipal water use totals 6.0M cubic metres per year in this region.

Table 3. Municipal Water Use by Source

Source	Water Use m^3/year	Percent
Groundwater	164,128	2.72%
Surfacewater – Lake Erie	5,880,025	97.28%
Total Municipal Water Use	6,044,153	100.00%

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 the differing water requirements for each use throughout the year.

4.1 Livestock and Year-Round Farming Operations

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.

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 were available for use in this study. Thus, the estimates would have to 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.

The spreadsheet tool created in the study by Kreutzwiser and de Loë (1999) provided the framework 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. 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, results in the total agricultural water use for the specific geographic region could be calculated. The water use coefficients were applied to the 2001 Census of Agriculture (Statistics Canada, 2001) data to generate water use estimates for this report. Figure 4 displays the results of the analysis on a subwatershed basis.

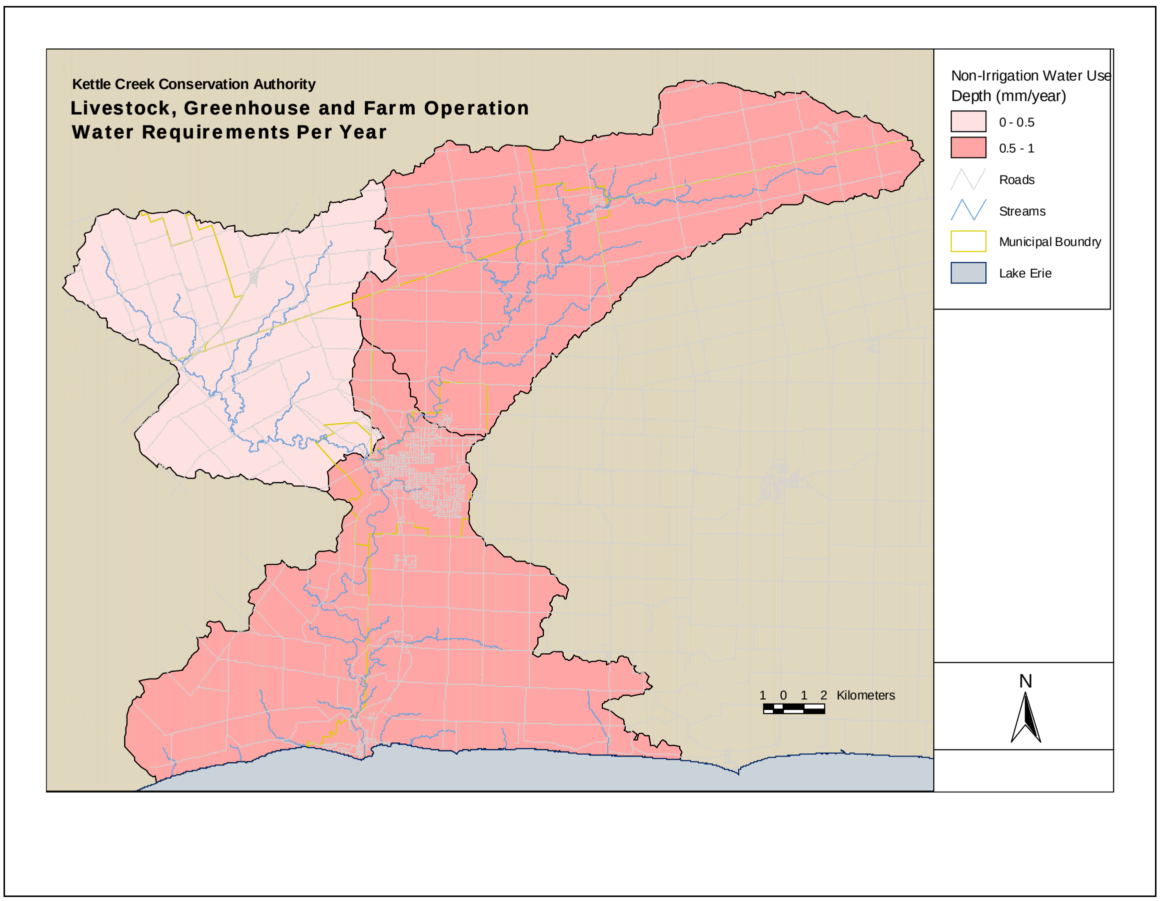

Figure 4. Livestock and Farm Operation Water Requirements.

Census of Agriculture data are generally reported on dissemination areas (DA), which are subsections based on municipal boundaries; however, to keep consistency with other water uses, it was requested that the information be translated to surfacewater subwatersheds for this analysis. Subwatershed 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 171.9 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 three 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. Information was suppressed if there were less than three and greater than zero farm units, but information was also suppressed 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 fewer limitations due to suppression. As a result, information on total values of the generalized farm units (i.e. total cattle in a subwatershed) were the only categories that were able to be resolved, but aided in gaining a better accuracy for the estimate of water use in 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 to a 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 0.4 M 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 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 as 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

Kettle Creek watershed, there were 2 subwatersheds that had suppressed information regarding irrigated land from the 2001 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 Kettle Creek watershed from the 1991, 1996 and 2001 Agricultural Census, as shown in Figure 5, shows that a relatively low portion of the watershed is irrigated. There was a slight increase in irrigated land from 1991 to 1996, however by 2001 the area decreased well below the 1991 levels.

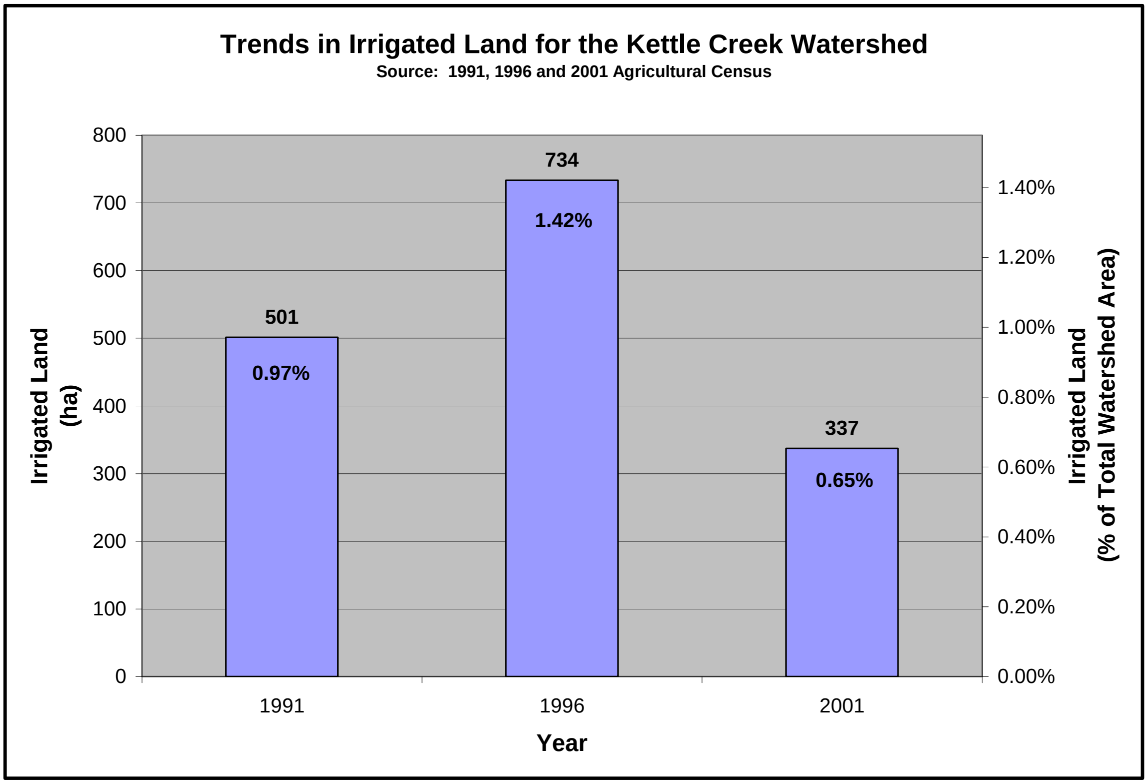

Figure 5. Trends in Irrigated Lands for the Kettle Creek Watershed

Reporting of irrigated land by farmers is retroactive to the year prior to the census year, and thus the data are actually reporting irrigation areas in 1990, 1995 and 2000. The amount of cropped land in the region changed very little from the 1996 census information to the 2000 census information as seen in Table 4. The decrease in irrigation area in 2000 may have been climate-driven, as 2000 was a wetter than normal year.

Table 4. Cropped and Irrigated Land Percentages in the Kettle Creek Watershed

KCCA	1991	1996	2001
Cropped Land in Watershed	66.43%	70.38%	70.12%
Irrigated Land in Watershed	0.97%	1.42%	0.65%
Cropped Land that is Irrigated	1.46%	2.02%	0.93%

4.2.2 Number of Irrigation Events

The estimation of the number of irrigation occurrences utilized an irrigation demand model that was 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% 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. It is assumed that the irrigation season for the Kettle Creek watershed is similar to the Grand River, and falls between June 20 and September 10. Irrigation events can only be triggered in between these dates; 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 6 and 7, 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 7) denoting the soil moisture added by irrigation events.

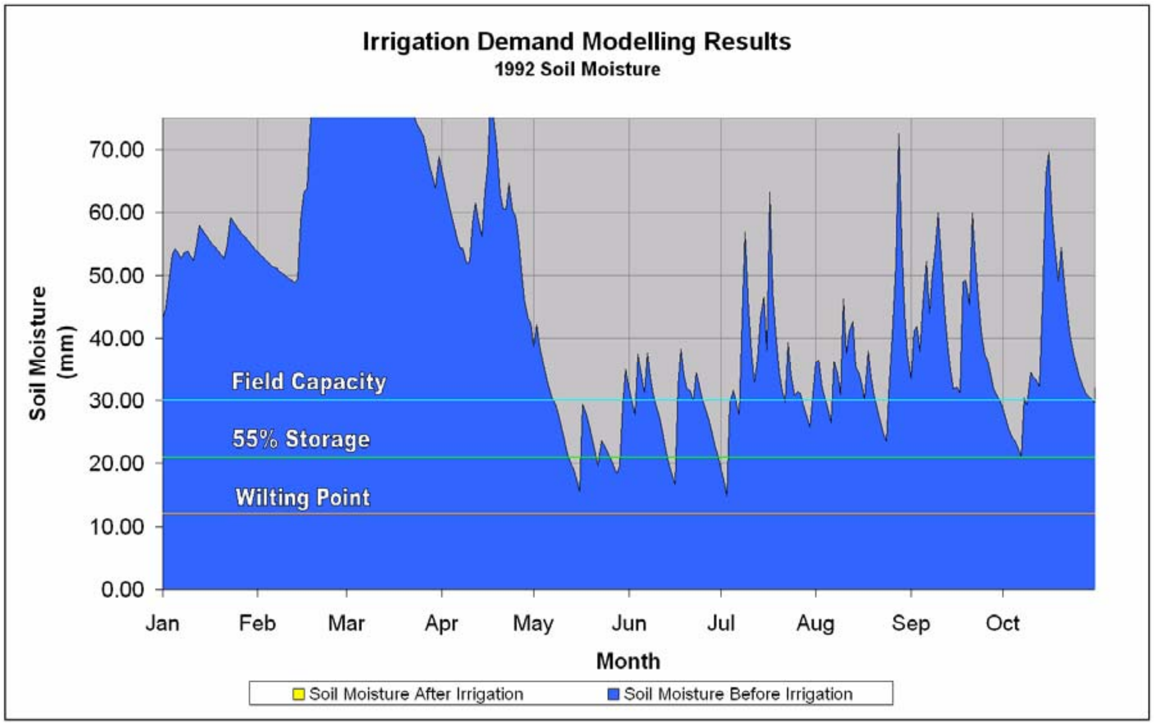

Figure 6. Irrigation Demand Modelling – Wet Year

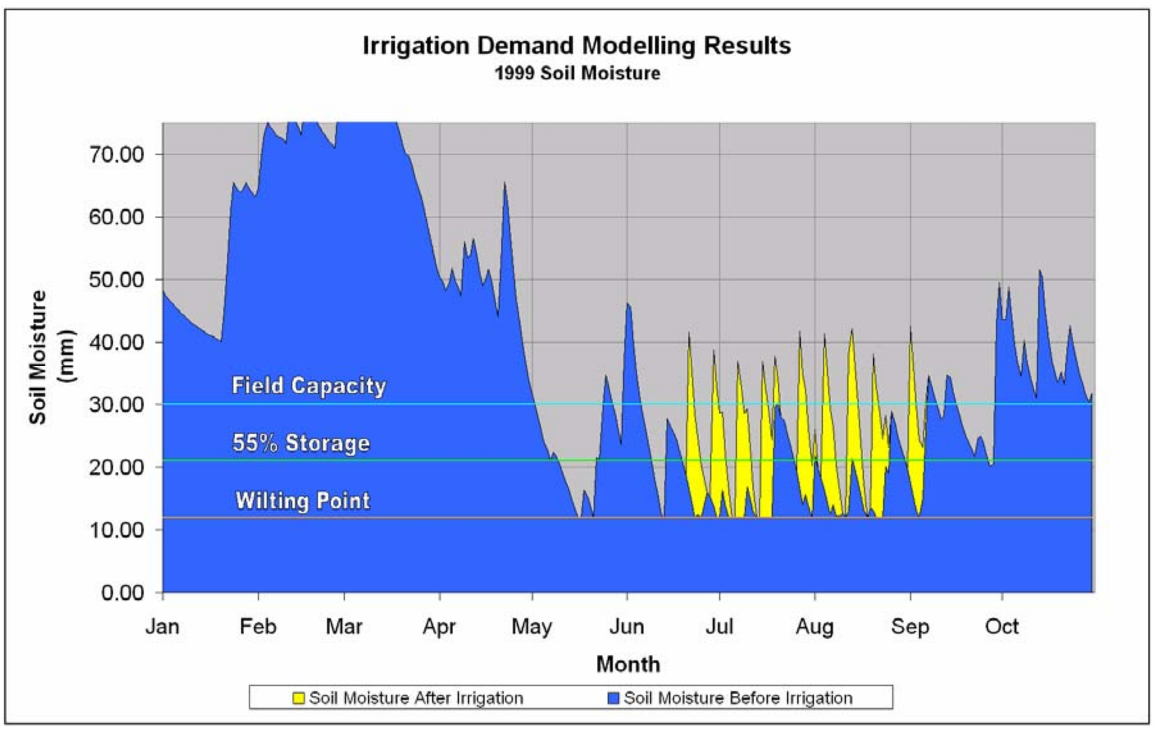

Figure 7. Irrigation Demand Modelling – Dry Year

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 8.

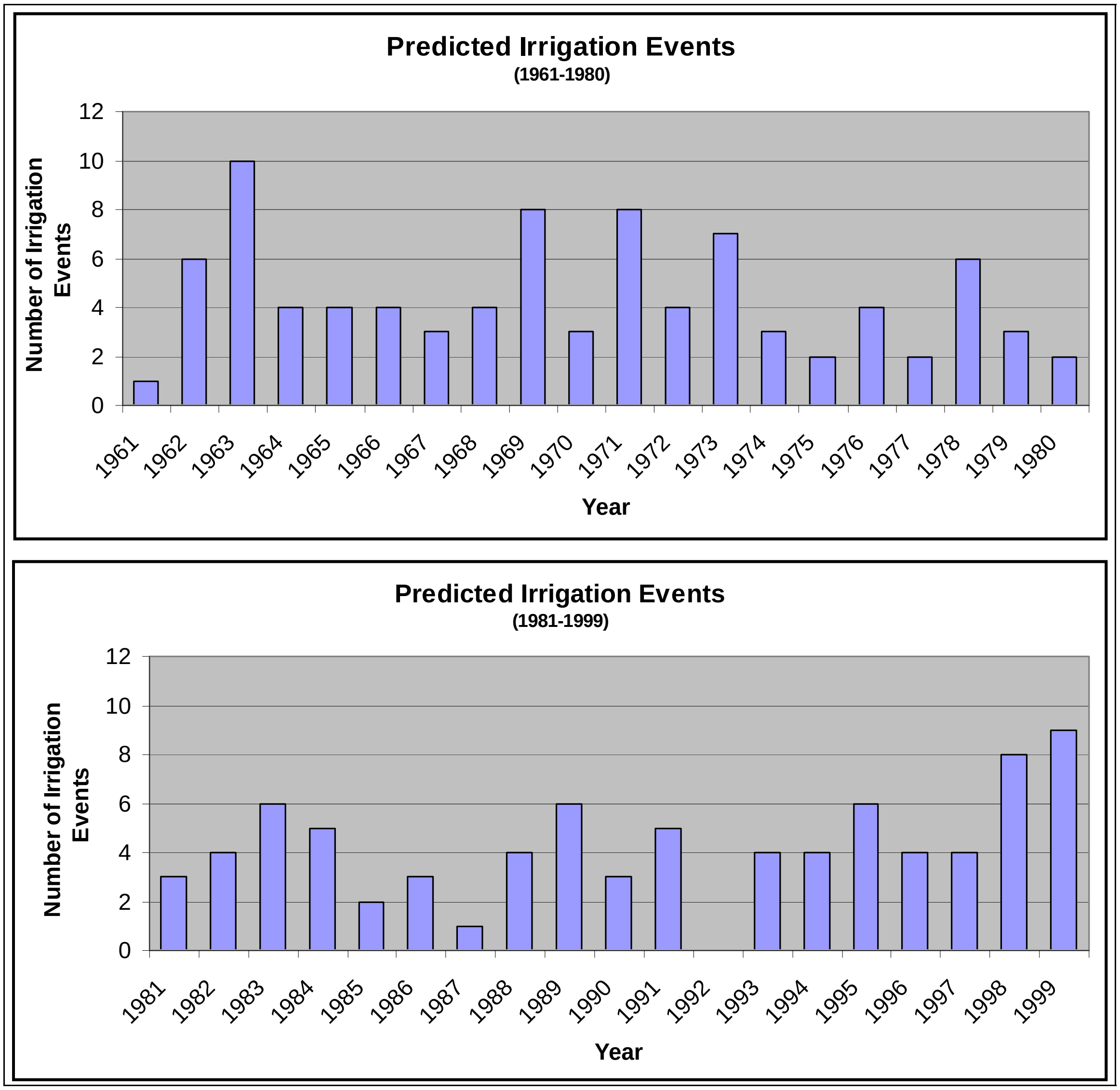

Figure 8. Irrigation Events Predicted 1961-1999

The average (4) and maximum number (10) of irrigation events during the modelling exercise was used to determine the irrigation demand in the Kettle Creek watershed. Table 5 lists the variability of irrigation events as well as the associated water requirement.

Table 5. Range of Irrigation Events and Irrigation Water Demand

	Irrigation Events	Water Demand (m^3)
Minimum	0	0
1st Quartile	3	424,000
Median	4	565,000
3rd Quartile	6	848,000
Maximum	10	1,413,000

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 Permit to Take Water database was analyzed to determine a possible breakdown of irrigation water sources. It was determined that from the 25 agricultural irrigation sources, 10 were supplied by groundwater and 15 were supplied from surfacewater, producing a 40%, 60% split, respectively.

Total annual water demand for crop irrigation (for an average year) is displayed in Figure 9.

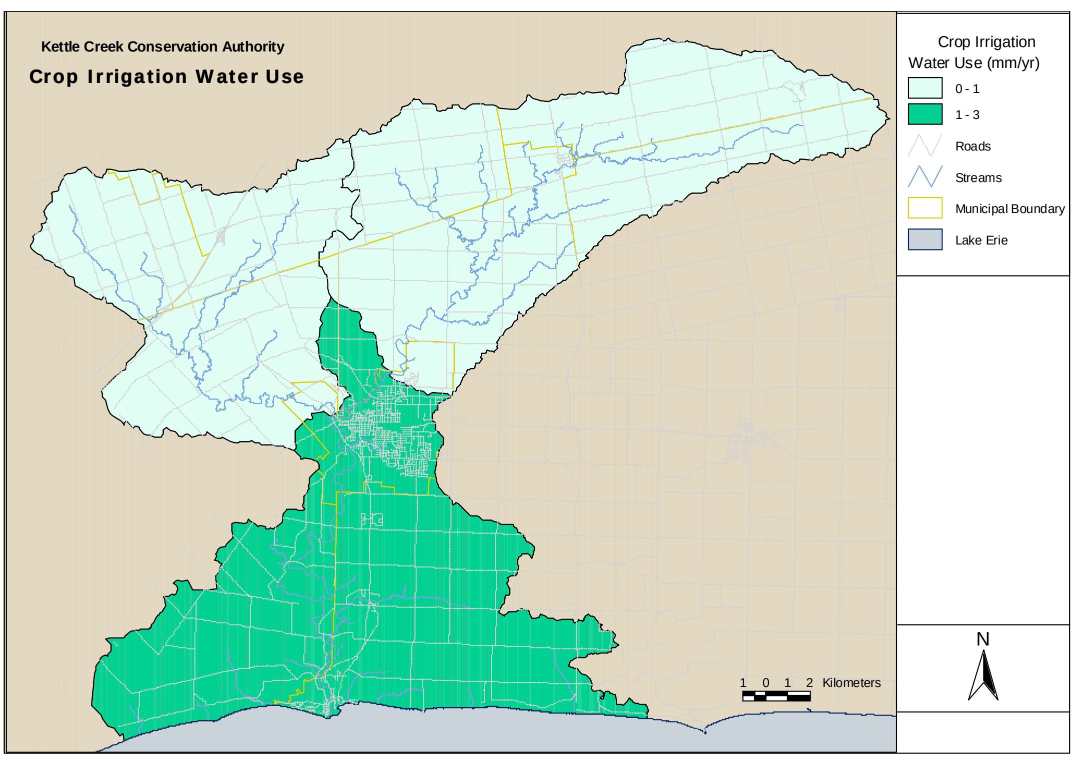

Figure 9. Average Crop Irrigation Water Demand.

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, the total 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 Kettle Creek watershed is estimated to be 13,000 and draw 760,000 cubic metres of water per year. The water use by subwatersheds is shown in Figure 10.

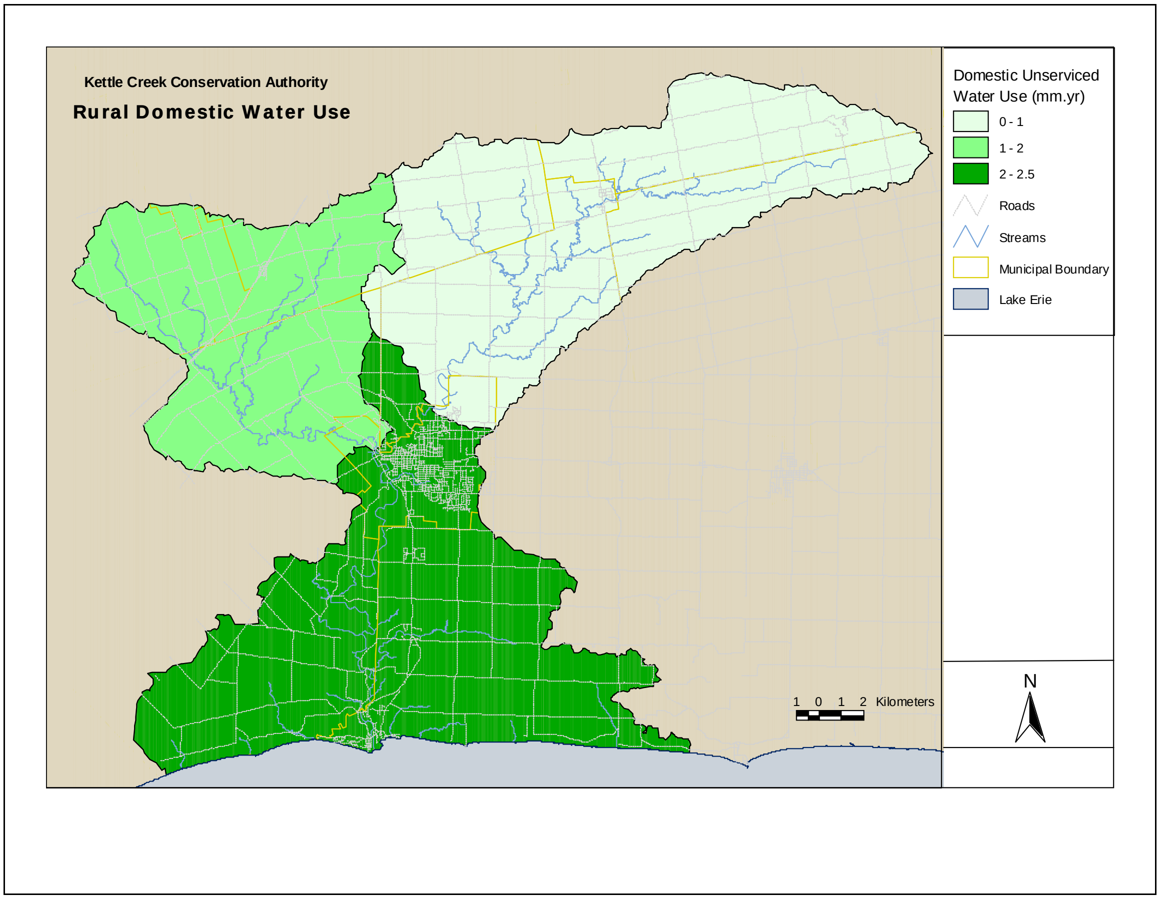

Figure 10. Rural Domestic Water Use

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 permits that have been expired for longer than 10 years, as well as cancelled permits or temporary permits. Permit categories previously discussed were dropped from consideration (e.g. municipal, agricultural, and rural domestic uses) along with permits which did not represent true water takings.

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, agricultural or municipal water supply permits, 8 Permits to Take Water remain in the Kettle Creek watershed. These 8 permits have a total of 15 sources associated with them. It is worthwhile to note that there may be more than one source associated with a particular permit. Of the 15 sources, 12 rely on groundwater, and 3 draw from surfacewater bodies, relating to 80% and 20%, respectively. Figure 11 shows the locations, sources and proportional volume of the maximum permitted water takings of these permits.

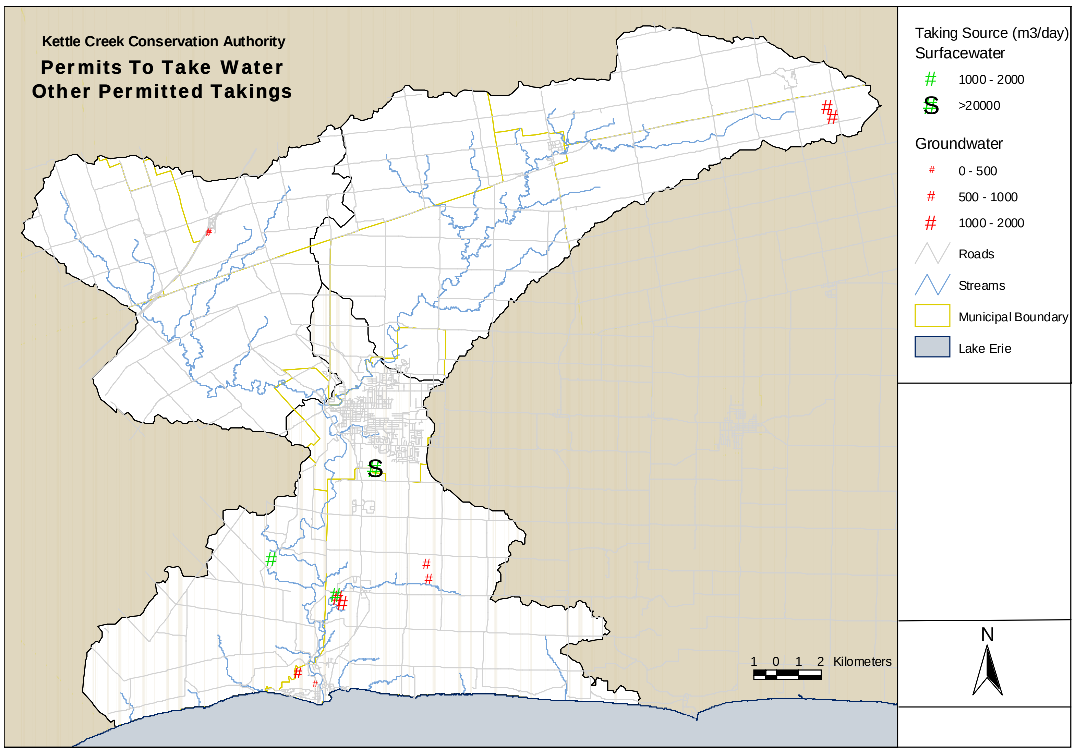

Figure 11. Other Permitted Water Takings: Source, Location and Maximum Amount

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 this drawback with the database information collection, monthly adjustment factors were applied to permitted volumes to more accurately reflect actual water usage, as shown in Table 6. 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 most part, these adjustment factors simply determine when the taking is active. 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 6: Permit To Take Water Adjustment Factors

General Purpose	Specific Purpose	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Commercial	Golf Course Irrigation	0	0	0	0	1	1	1	1	1	1	0	0
Miscellaneous	Other - Miscellaneous	1	1	1	1	1	1	1	1	1	1	1	1
Commercial	Mall / Business	1	1	1	1	1	1	1	1	1	1	1	1
Dewatering	Other - Dewatering	1	1	1	1	1	1	1	1	1	1	1	1

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 of all major water users identified in the watershed was done to gain insight into actual water takings as well as taking characteristics. While Figure 11 shows the maximum amount permitted by each taking, some adjustments were made to display the depths of water takings as seen in Figure 12. A phone survey of the water takers in the Kettle Creek watershed 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 source of the taking, purpose and timing (seasonality and duration during the day) that they were taking water for their use. From this information, a better estimate than the permitted maximum could be used for the estimate of water use by subwatersheds, as seen in Figure 12. The survey generated responses from 5 of the 8 permits (62.5% 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 6 for monthly water uses.

Figure 12 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.

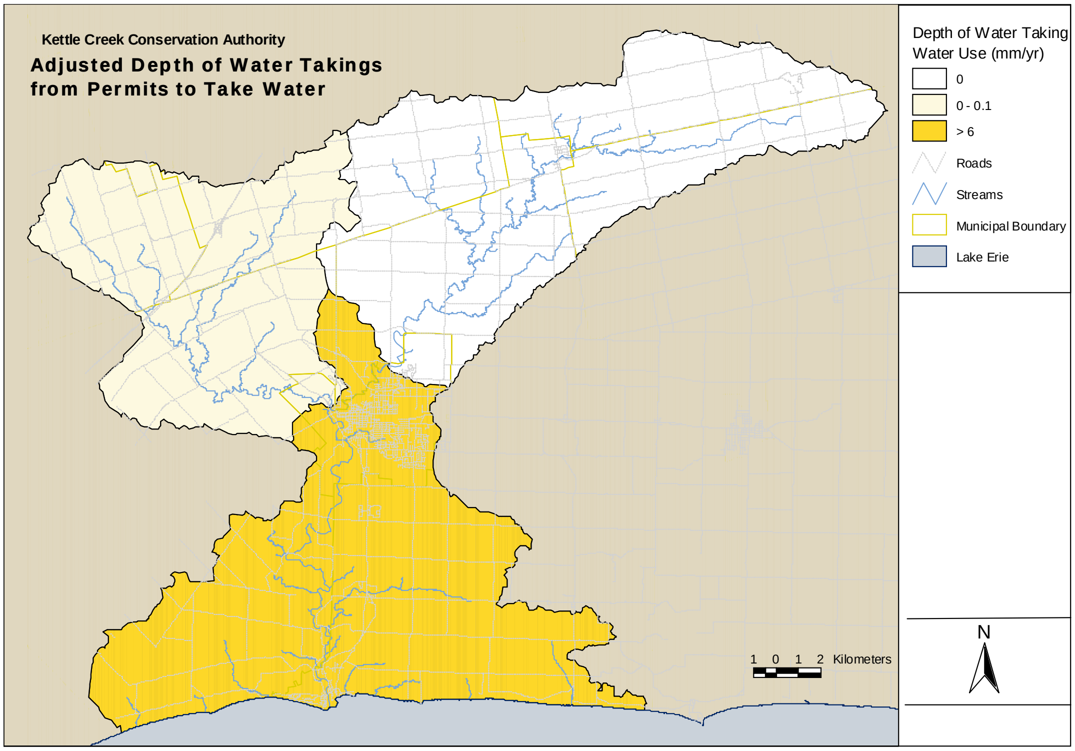

Figure 12. Adjusted Depth of Water Takings from Permits to Take Water

The estimated annual water use for each category listed with the PTTW database is quantified in Table 7. It should be noted that this analysis uses the amount either refined by the survey or monthly adjustment factors, or when not available, the amount included in the database. Permits that are described as "Miscellaneous" make it extremely difficult to understand the true purpose or characteristic of the particular water taking.

Table 7. Adjusted Permit to Take Water Taking Volumes in Cubic Metres – By Source

Purpose	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Golf Course Irrigation					33,160	33,160	33,160	33,160	33,160	33,160			**198,960**
Other - Dewatering	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140	**61,680**
Mall / Business	102	92	102	99	102	99	102	102	99	102	99	102	**1,200**
Other - Miscellaneous	2	2	2	2	2	2	2	2	2	2	2	2	**25**
TOTAL	**5,240**	**5,230**	**5,240**	**5,240**	**38,400**	**38,400**	**38,400**	**38,400**	**38,400**	**38,400**	**5,240**	**5,240**	**261,870**

The adjusted water takings are considerably less than the permitted maximums provided by the database, at an average of 11% of the value given in the database. The most drastic changes in volume were seen in the 'Miscellaneous – Other' category, where there was feedback from the only permit in this category, resulting in <0.001% of database value. The Dewatering category showed the least change in volume, as there was no feedback given by this permit holder (36.5% of permitted volume). 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 major water use sectors in the Kettle Creek watershed will be the focus of this section. The final summation of all the water uses in each of the subwatersheds is shown in Figure 13. 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.

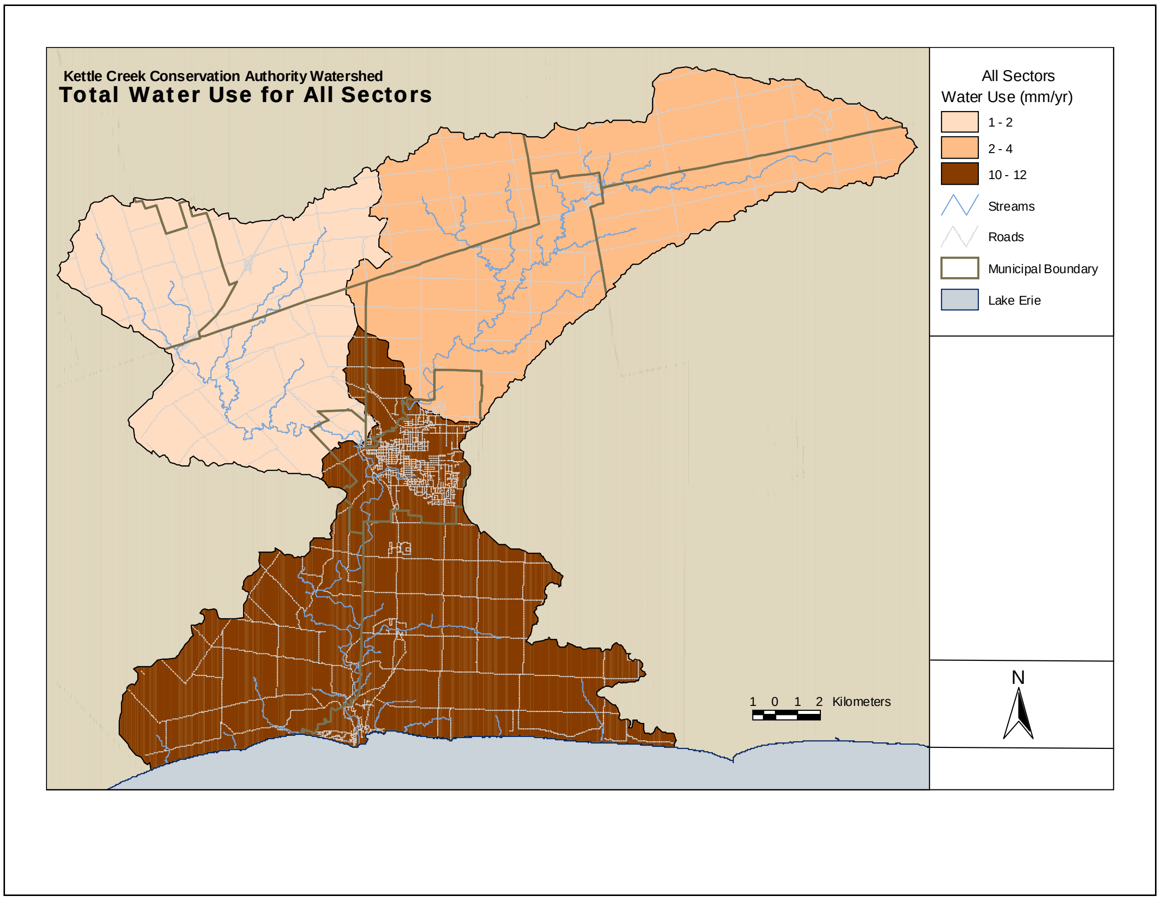

Figure 13. Total Water Use Depths For All Sectors

As seen in Figure 13, the majority of water takings in the Kettle Creek watershed occur in the Lower Kettle Creek subwatershed, while the Dodd Creek subwatershed has the lowest water uses. From the previous sections describing water uses, there are many demand factors attributing to the differences in water takings among the subwatersheds, but there could also be factors linked to the availability of supply in these subwatersheds. For instance, both the Dodd Creek and Upper Kettle Creek subwatersheds have baseflow supply issues; however the Upper Kettle Creek has more groundwater availability than the Dodd Creek subwatershed. The Lower Kettle Creek has both better groundwater and baseflow availability. These differences in supply availability could indicate to potential water takers where suitable supplies are to meet their demands, which may have caused more of them to concentrate in the Lower Kettle Creek subwatershed. Hence, the demand for water could result from the differences in location of water supplies in the watershed.

Table 8 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 8. Total Water Use Comparison (in cubic metres)

	Use Category	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
1	Municipal	518,250	492,320	511,650	495,070	520,290	573,430	580,580	491,370	524,250	452,620	403,890	480,420	6,044,150
2	Rural Domestic	64,530	58,285	64,530	62,448	64,530	62,448	64,530	64,530	62,448	64,530	62,448	64,530	759,784
3	Agricultural - Irrigation						141,250	282,500	141,250					565,000
4	Agricultural	21,520	19,440	21,520	20,830	21,520	20,830	58,340	58,340	57,640	21,520	20,830	21,520	363,840
5	Golf Course Irrigation	-	-	-	-	33,160	33,160	33,160	33,160	33,160	33,160	-	-	198,960
6	Other - Dewatering	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140	61,680
7	Mall / Business	102	92	102	99	102	99	102	102	99	102	99	102	1,200
8	Other - Miscellaneous	2	2	2	2	2	2	2	2	2	2	2	2	25
	TOTAL	609,540	575,280	602,940	583,590	644,740	836,360	1,024,350	793,890	682,740	577,070	492,410	571,710	7,994,640

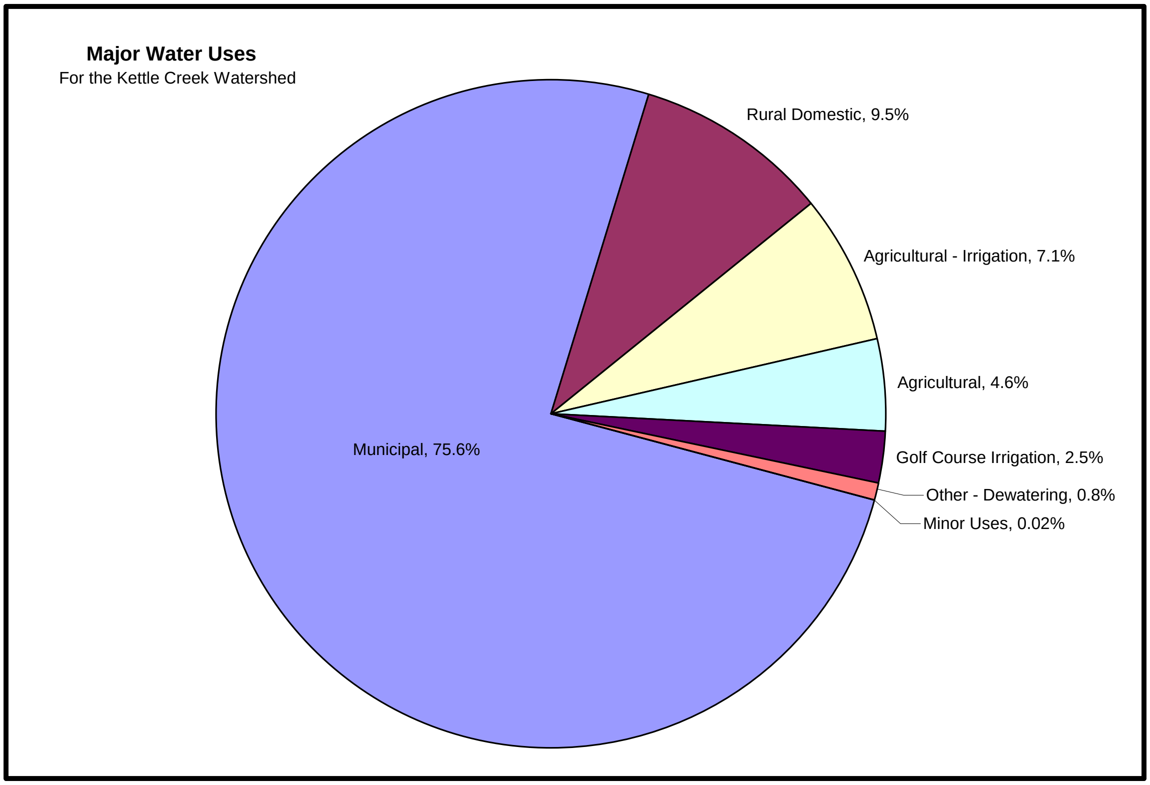

Figure 14. Major Water Uses – Annual Basis

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 third highest annual water taking, but this volume is spread over only 3 months of actual water use, coming second only to municipal water takings and much higher than all the other water uses in the watershed.

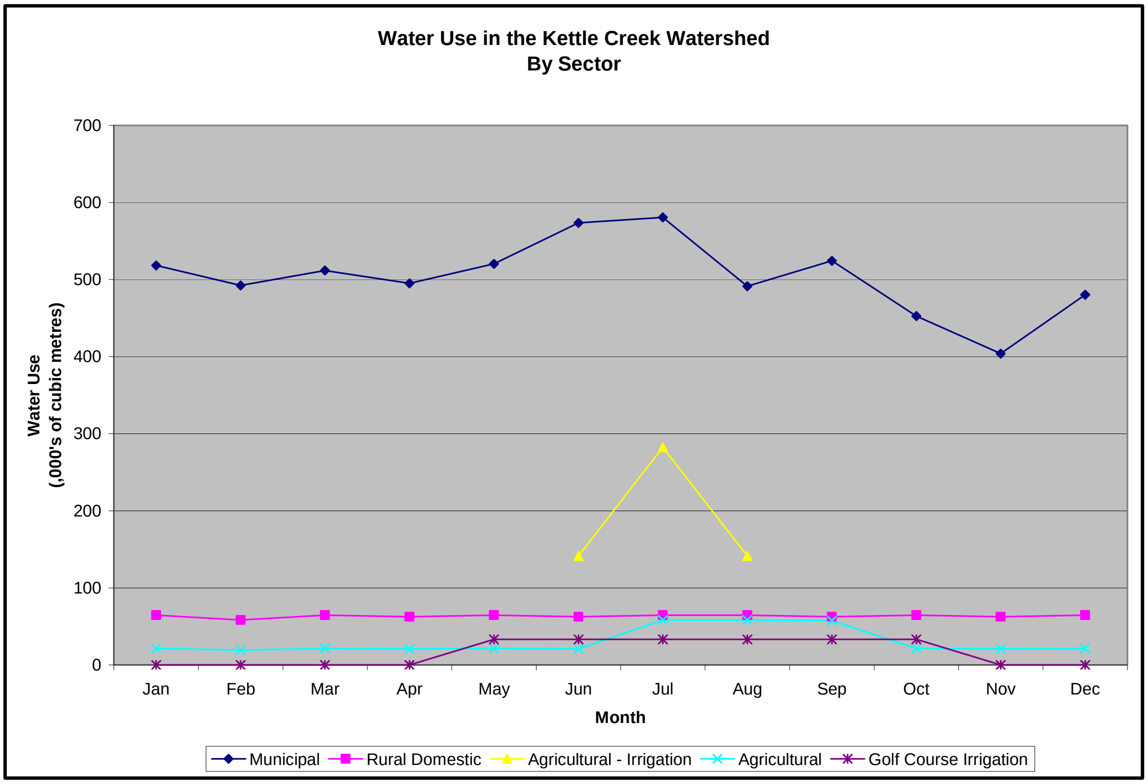

Figure 15. Monthly Variation of Major Water Uses

It should be noted that with regard to crop irrigation, the actual water use may be more intense than 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 non-municipal 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. Climate variation plays 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 8, one can qualitatively divide water users into climate-dependent and climate-independent subgroups, as seen in Table 9.

Table 9. Climate-Sensitive Water Uses

Category	Climate Sensitive	Climate Insensitive
Agricultural	X	
Agricultural Irrigation, Average	X	
Dewatering	X	
Golf Course Irrigation	X	
Mall/Business		X
Municipal Supply	X	
Other - Commercial	X	
Other - Industrial		X
Rural Domestic	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. It should be noted that when investigating water takings at an individual source scale (such as an aquifer), these diversions, while not consumptive, 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 Kettle Creek watershed was the focus of this report. The following water use sectors were identified as being important in a watershed-wide context:

1. Municipal Water Supply
2. Rural Domestic
3. Agricultural – Irrigation
4. Agriculture
5. Golf Course Irrigation
6. Dewatering
7. Commercial Mall/Business
8. Miscellaneous

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.

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, 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 the municipalities on the Elgin Area Water Treatment Supply System gather further information on serviced populations along the pipeline and taking amounts in the watershed.
3. That information gathered from the municipal sector be separated into industrial, commercial, institutional and residential components of water use.

4. 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.
5. That consumptive ratios of all major water sectors be determined, as well as the occurrence of water diversions.
6. That the development of a central database of water use in the watershed continue. This database would house recent information on municipal water systems as well as information gathered from phone surveys of permitted water users.

9.0 REFERENCES

Agriculture and Agri-Food Canada, and Ontario Minsistry of Agriculture, Food and Rural Affairs. 1995. Best Management Practices – Irrigation Management Booklet.

Allen, R. G. 1991. Irrigation Engineering Principles. Utah State University, Agricultural and Irrigation Engineering Dept., Logan, UT.

Environment Canada. 2003. Freshwater Website: Water Use. http://www.ec.gc.ca/water/en/manage/use/e_use.htm. Accessed: July 10, 2003.

Environment Canada. 2005a. Canadian Climate Normals or Averages 1971-2000. http://www.climate.weatheroffice.ec.gc.ca/climate_normals/index_e.html. Accessed September 12, 2005.

Environment Canada. 2005. Municipal Water Use: 2001 Statistics. Canada: Minister of Public Works and Government Services. http://www.ec.gc.ca/water/en/info/pubs/sss/e_mun2001.htm (also in pdf format). Accessed 13 April, 2005.

Keller, J. and R. D. Bliesner. 1990. Sprinkler and Trickle Irrigation. New York, NY: Van Nostrand Reinhold Pub.

Kreutzwiser, R.D. and R.C. de Loë. 1999. REVISED. Agricultural and Rural Water Use in Ontario. A Report to the National Soil and Water Conservation Program, August 31, 1999. Guelph, Ontario: Rural Water Management Group, Department of Geography, University of Guelph.

Ontario Ministry of Environment. 2003. Permit To Take Water Database.

Schroeter, H.O., Boyd, D.K., Whiteley, H.R. 2001. GAWSER: A Versatile Tool For Water Management Planning.

Schwab, G.O., Frevert R. K., Edminster, T.W., Barnes, K. K. 1998. Soil and Water Conservation Engineering. Third Edition. Toronto.

Statistics Canada. 1991.

Statistics Canada. 1996a. Census of Agriculture – Farm Data. Catalogue No. 93F0035XIE.

Statistics Canada. 1996b. Population and Dwelling Counts. Catalogue No. 93357XPB.

Statistics Canada. 2001a. Census of Agriculture – Farm Data. Catalogue No. 93F0301XIE.

Statistics Canada. 2001b. Population and Dwelling Counts. Catalogue No. 93F0051XIE.

Vandierendonck, M., and B. Mitchell. 1997. Water Use Information for Sustainable Water Management: Building Blocks and the Ontario Situation. Canadian Water Resources Journal, 22(4): 395-415.