Water Use Inventory Report for the Grand River Watershed

February 2011

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Grand River Conservation Authority

Executive Summary

Water quantity issues are growing with increasing population pressures as well as climate change uncertainty. The assessment of current day water demand is the start of understanding how water is used throughout the watershed and gives a basis for water management planning.

This report is a summary of the water demand in the Grand River watershed. Water use is categorized into subgroups of: municipal water supply systems, rural domestic water demand, agricultural water uses and permitted water takings (greater than 50,000 L/day). For the fourth category of almost 700 permitted takings, summaries by each subwatershed give a more detailed breakdown of the demands.

Water demand estimates for this report have vastly improved since the previous report published in 2005. The inclusion of actual water taking records from over half of the almost 1200 sources of water (80% are sourced in groundwater), were submitted by permitted water takers. The remaining uses were estimated using the best available information. Census of Population and Census of Agriculture data were utilized to determine rural domestic and agricultural water use, respectively. Through the assessment of all water takings, using actual takings where available and estimated elsewhere, the analysis has identified the following top 15 water uses within the Grand River watershed on an annual basis:

1. Municipal Water Supply
2. Dewatering
3. Agricultural – Irrigation
4. Aggregate washing
5. Agricultural – Livestock watering
6. Rural Domestic Water Supply
7. Aquaculture
8. Remediation
9. Communal Water Supply
10. Unspecified Industrial Uses
11. Golf Course Irrigation
12. Industrial Cooling Water
13. Food Processing
14. Bottled Water
15. Recreational Uses

The total assessment of all water takings for the Grand River watershed amounts to 152M m^3/year. The municipal demand, comprised entirely from actual reports, accounts for approximately 60% of the total water use and is ten times greater than the next highest water using sector.

While the annual total is necessary for comparison purposes, the seasonal demand and temporal changes in water takings must be considered for a more accurate representation of water takings. Specifically, agricultural water demand for irrigation purposes is at a peak in the summer months but negligible in the winter months. The seasonal demand is highly dependent on climatic factors and can have wide variability from year to year.

Finally, this report addresses the concept of consumptive use ratios. The relative influence of each type of water taking as well as the source of supply, factors into the consumptive nature of the taking. An assessment of the consumptive nature of each use is provided in brief. The next steps will be to address the cumulative effects of the takings in a localized area, which may have greater impacts than each individual taking alone.

The current water demand as presented here is important for current water management planning. However, the future of water management will need to consider the high uncertainty associated with global climate change and how it will alter the watershed's water demands and supply.

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1.0 Introduction

The Grand River watershed is approximately 6700 km^2 in size, and is home to approximately 920,000 residents (2006 Census). Population projections anticipate much growth for the watershed due to the Places to Grow and Greenbelt legislations introduced in the Province of Ontario. The influx of population, coupled with the industrial growth potential, will put increasing strain on the watershed's water supplies. With the introduction of the Clean Water Act in 2006 (Ontario Regulation 287/07) and the update to the Grand River watershed Water Management Plan, an understanding of current water uses was requested to better understand the demands on our water resources.

This report builds upon the report entitled "Water Use in the Grand River Watershed" (2005), as better information has become available, including actual water taking records from permit holders. This report identifies the major water use sectors and reports on actual water takings and sources, wherever possible. The major water use groups have been identified as: municipal supply, unserviced domestic demand, agricultural water use and other permitted water takings. The permitted water takings sector is derived from the Ontario Permit to Take Water Database, and is further broken down into water use categories.

This report is interested in characterizing only sources from within watershed as water budgets including both demand and supply will require information within this boundary. In the Grand River watershed, water supply sources are from both groundwater and surface water sources such as rivers and ponds. While Lake Erie is considered a surface water source, for the interest of water use within the Grand River watershed, this source is excluded from calculations as it is considered external to the watershed boundaries.

Water use values will be reported on a flow basis for ease of comparison across sectors. For instance, rates or specific volumes will be translated into *Litres per second* to quantify water use. As larger volumes are difficult to conceptualize, a small flow rate can be compared to the flow in the Grand River to understand the magnitude of the taking. The annual average flow rate exiting the Shand Dam into the Grand River, for example, is approximately 8760 L/s.

When flow volumes are reported, for ease, comparisons can be made to Environment Canada (2010) reports that state the average Canadian's water consumption. A unit cubic metre (1 m^3/day) will be consumed in a day by a 3-person household, as the average Canadian is estimated to require 0.329 m^3/day for all water needs in 2004. In the Region of Waterloo, average water demand is lower than the Canadian average, and a 5-person household consumes approximately a cubic metre per day.

2.0 Description of the Watershed

The Grand River watershed is the largest watershed in southwestern Ontario. Located to the west of the Greater Toronto Area, the Grand River begins its 310 km long journey near the village of Dundalk, in the Dundalk Highlands, which is also the headwaters for such other rivers as the Nottawasaga, Saugeen, and the Sauble Rivers. The Grand River flows south from there and picks up its major tributaries, the Conestogo, the Speed and the Nith Rivers, as it flows by the urban centers of Kitchener, Waterloo, Cambridge, Brantford. The City of Guelph is another urban centre in the Grand River watershed, located at the confluence of the Speed and the Eramosa Rivers. Downstream of Brantford, the Grand River passes by Six Nations, as well as the towns of Caledonia, Cayuga and Dunnville, before flowing into Lake Erie at Port Maitland.

A general map of the watershed is included in Figure 1. The predominant land use in the watershed is agricultural; approximately 5% of the total area is devoted to urban centres (see Figure 2).

2.1.1 Physiography

In a physiographical sense, the Grand River can be divided into three distinct areas, as shown in Figure 3: the northern till plain; the central moraine and sand plains; and the southern clay plain. The northern till plain can be characterized by relatively tight tills, producing significant amounts of runoff, and small amounts of groundwater recharge. This area has smaller communities but no large urban centres, with the dominant land use being agriculture.

The central moraine area contains the watershed's three major moraines: the Waterloo, Galt/Paris and the Orangeville Moraines, which are shown in Figure 3. Also included in this area is a portion of the Norfolk Sand Plain, which is located just to the west of Brantford. Numerous sand and gravel deposits are located in this area, allowing significant amounts of groundwater recharge to be produced. It is within this central moraine area that the majority of the watershed's population is located, in the cities of Kitchener, Waterloo, Cambridge, and Guelph.

The southern clay plain is the remnants of a previous lakebed. The heavy clays left behind when the lake receded, produce very high amounts of runoff, and do not allow significant water infiltration to produce groundwater recharge. The City of Brantford is located just on the northwestern edge of this area.

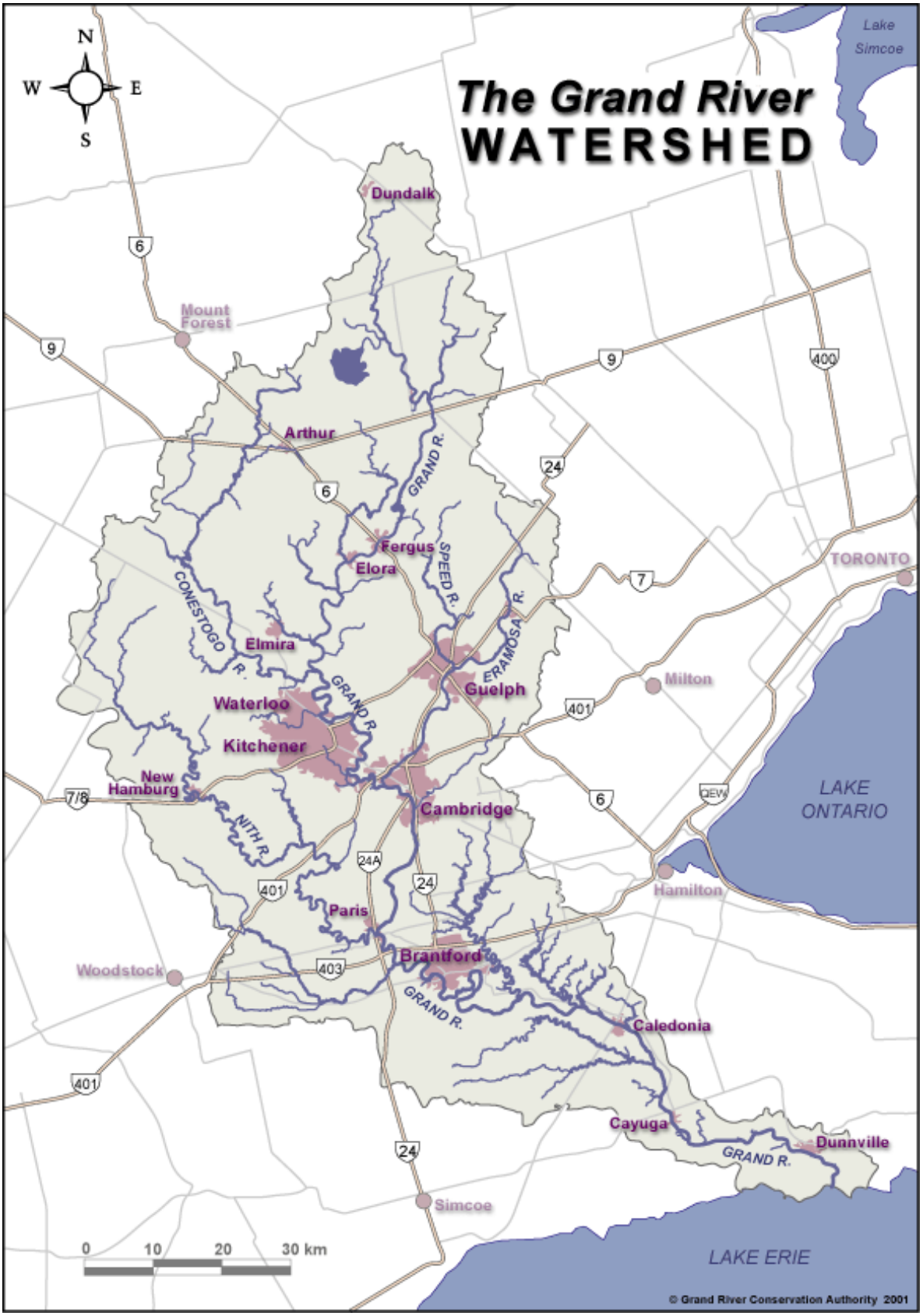

Figure 1. Map of the Grand River Watershed

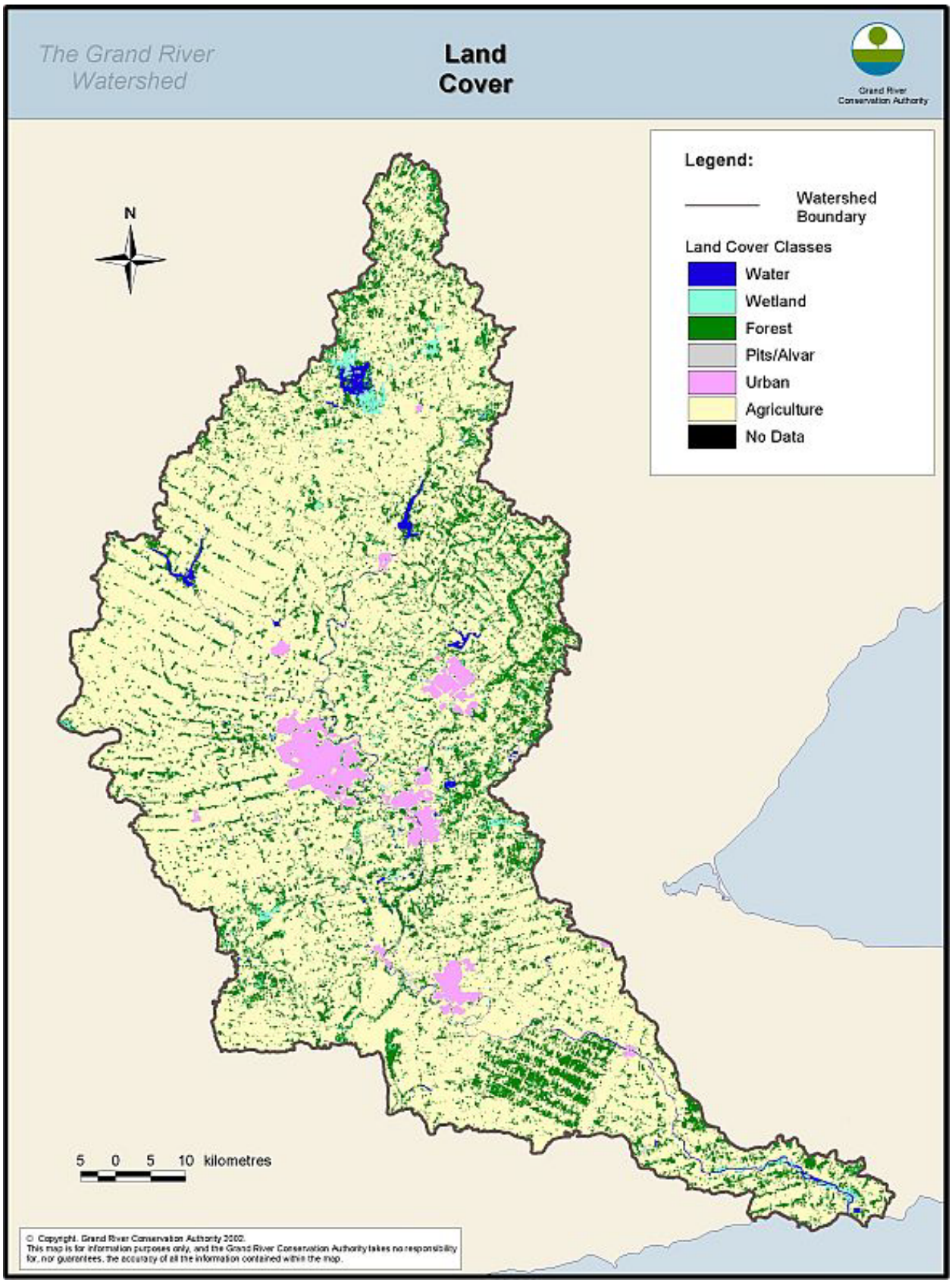

Figure 2. Land cover classification in the Grand River watershed

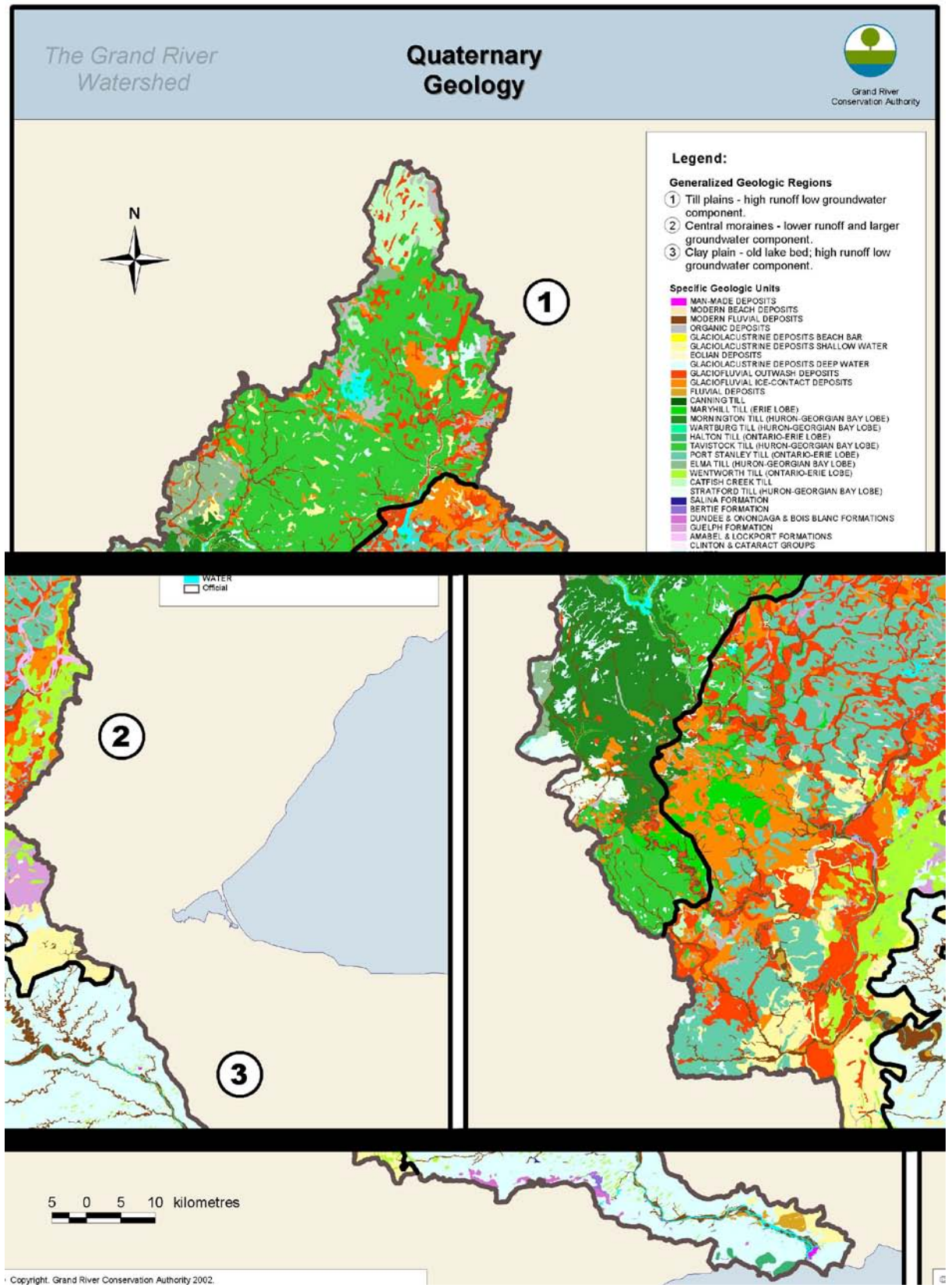

Figure 3. Quaternary geology of the Grand River watershed

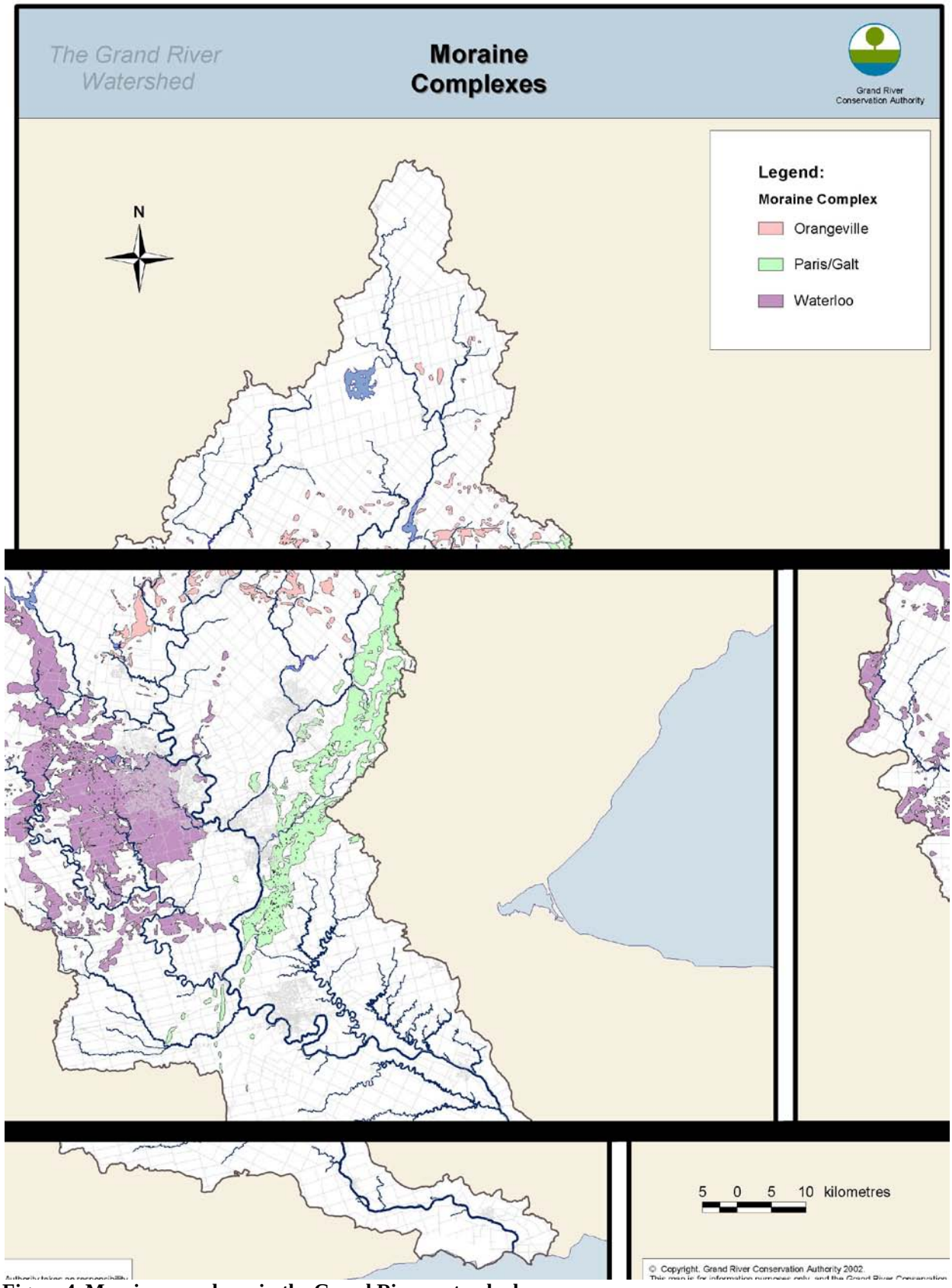

Figure 4. Moraine complexes in the Grand River watershed

3.0 Municipal Water Use

Municipal water use is the supply of water provided through a central distribution system operated by and within the municipality. Various sources and collection methods are employed by the many municipalities within the Grand River watershed, and for a wide range of populated areas. Groundwater sources include shallow, overburden and deep wells, but to differentiate between regional and local aquifers, the sources were broken into two categories of deep overburden/bedrock and overburden wells, respectively. Groundwater is still the largest proportion of municipal supply sources in the Grand River watershed; approximately 65% of all municipal water demand is from groundwater sources. Surface water supplies include the Grand River and its tributaries, reservoirs created along these water courses, and the Great Lakes, mainly Lake Erie. It is possible that surface water takings will become increasingly more important in the future for municipalities to supplement groundwater supplies.

3.1 Municipal Water Supply Data

Water use information from the municipalities is generally available to the public due to drinking water legislations in Ontario (O. Reg. 170/03). Water quality information must be made available to the public and often the water quantity data is provided as well. Water use and infrastructure information is published in reports including monitoring reports, water supply studies and long term supply strategies. Further information for this report was gathered using municipal surveys, communication with municipal staff and records submitted via their Permits to Take Water to the Province. From this information, a complete picture of the municipal water use, including serviced population, average daily demand, maximum daily demand, system capacity and water source was provided.

A map of the supply source locations and their approximate daily volumes from each source can be seen in Figure 5. The summarized information for each municipal system is given in Table 1, giving population size, average daily and maximum daily rates of total water supplied, sources of supply and system capacity. In total, approximately 790,000 residents were serviced from municipal supplies in the Grand River watershed between the years of 2008 and 2009.

There does not appear to be much change in the reliance on the types of water sources since the previous WUI Report (2001-2005 data), they are still evenly distributed between the Grand River, overburden and deep overburden/bedrock wells, with a small proportion from the Great Lakes (see Figure 6). The volume of total municipal water demand is **102.4 Mm^3/year**.

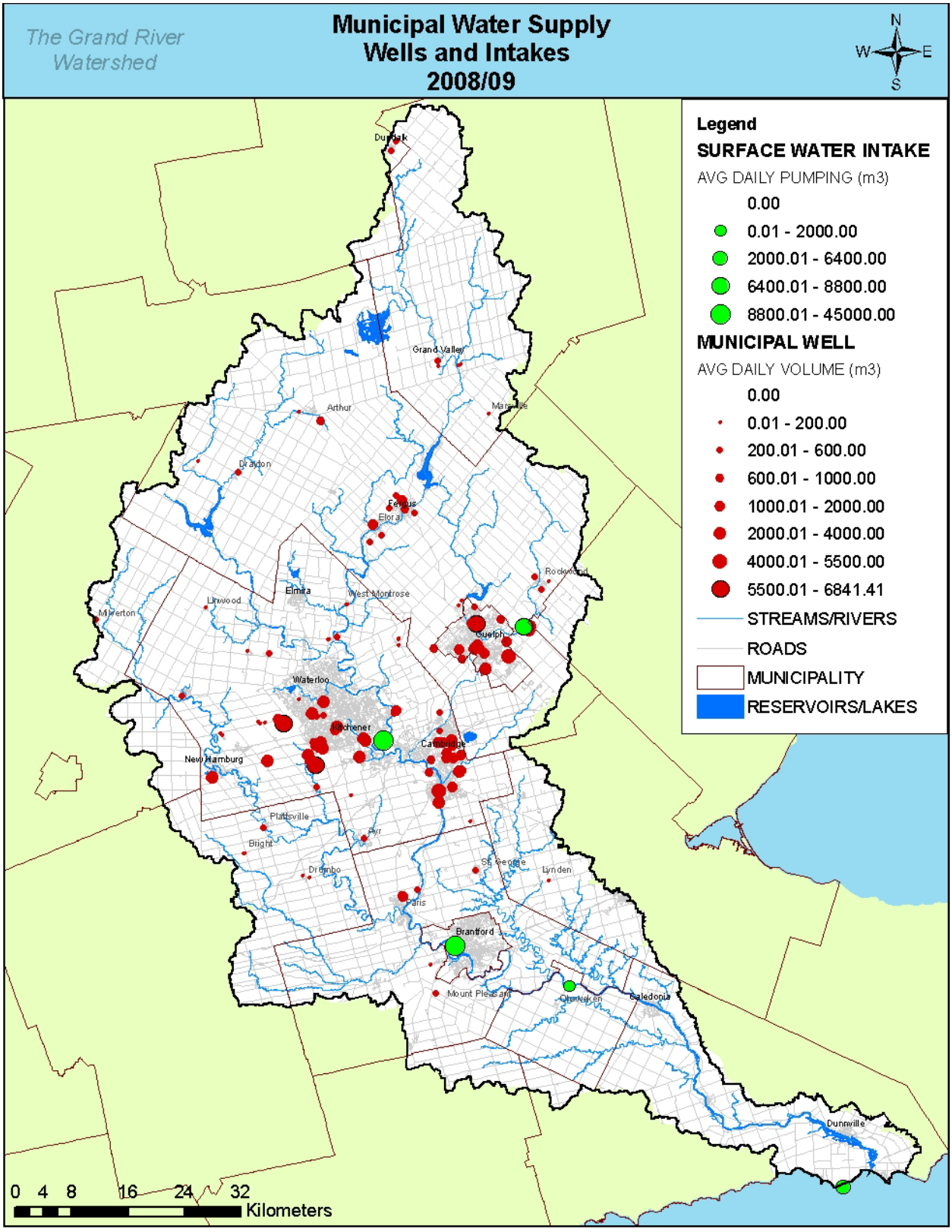

Figure 5. Municipal Water Supply sources, locations and volumes

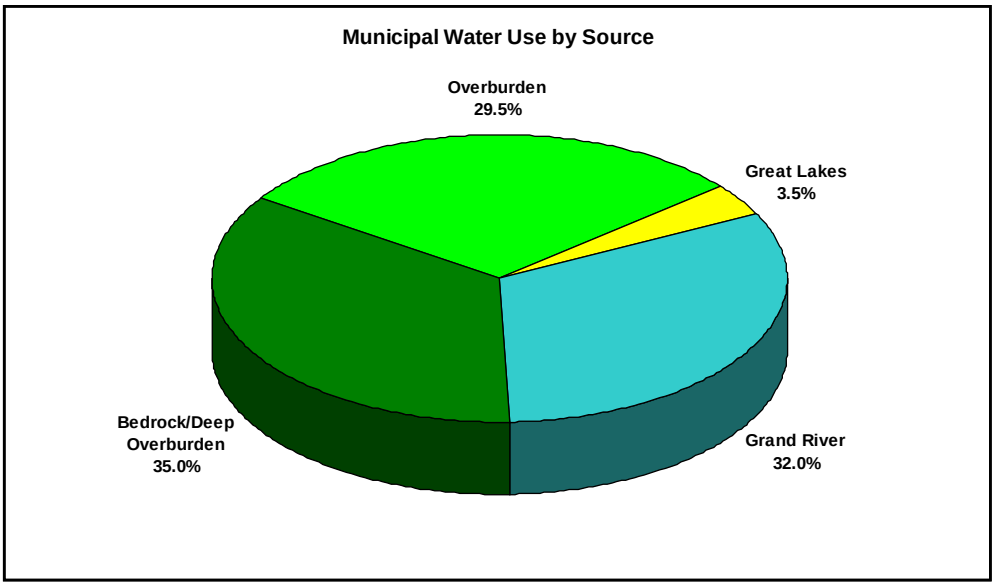

Figure 6. Municipal water use by source

The municipal systems can be described as either a large system (>90,000 residents) or smaller systems (<15,000 residents). There are three major municipal systems, with unique system characteristics from the smaller systems so they will be described in more detail in Section 3.2. Smaller municipal systems are much more abundant and generally range from one to a few supply sources. They are summarized in Section 3.3.

3.2 Large Urban Municipal Systems

There are five major urban cities in the Grand River watershed, namely Brantford, Cambridge, Guelph, Kitchener and Waterloo, comprising 3 municipal supply systems. Each system services a population greater than 90,000 residents and is briefly described here.

City of Brantford

The City of Brantford, situated on the banks of the Grand River, gets all its municipal supply from this surface water source. This is the only large municipal system in the Grand River watershed to use solely surface water for its municipal supply and from only one source. The water is collected from the Grand River into the Holmedale Canal for use by almost 93,000 residents.

City of Guelph

The City of Guelph has an interesting water supply system utilizing both surface water and groundwater sources. The main wellfield is comprised of 23 wells but also includes a series of shallow collection wells. These collection wells are part of the surface water system that pumps water from the Eramosa River into a trench system, accounting for 7.25% of Guelph's total taking. The water then infiltrates and recharges into the ground to be collected by the shallow wells. The entire population of about 120,000 residents in the City of Guelph is supplied by this municipal system.

Integrated Urban System: Cities of Cambridge, Kitchener, Waterloo and Elmira

The Integrated Urban System (IUS) in the Regional Municipality of Waterloo supplies water to the Cities of Cambridge, Kitchener and Waterloo, and also supplies to the

smaller centers of Elmira, Browns and St. Jacobs. The IUS supplies from both groundwater and surface water to approximately 480,000 residents. Groundwater comprises 70% of the supply from numerous wells (over 70), while the Grand River supplements the groundwater through the Mannheim pumping station in Kitchener.

3.3 Small Municipal Water Systems

There are many smaller municipal water systems in the Grand River watershed. The smaller municipal systems service populations from as small as 80 to just over 12,000 residents. Thirty-six municipal operations in the Grand River watershed supply solely from groundwater.

Surface water sources include the Great Lakes (Erie and Ontario) and the Grand River. There are two communities, Cayuga and Caledonia, which rely on Lake Ontario through a pipeline owned by the City of Hamilton, and one community – Dunnville – that relies on Lake Erie for their water supply. Ohsweken, on the Six Nations reserve just south of Brantford, is the only smaller community that relies on the Grand River for its municipal supply.

There have been some changes to some smaller systems in the watershed since the previous report. There is a new system is in Moorefield which began its municipal distribution system in the summer of 2006, while Baden and New Hamburg combined their system into one. The Towns of Fergus and Elora have also combined their municipal distribution systems into one, but are still reported separately here as data is available to separate their demands.

Table 1. Municipal Water System Information

Municipal System	Year of Data	Serviced Population	Average Day		Max Day		System Capacity (approx)		Water Source
			Actual	per capita	Actual	per capita	C of A	PTTW	
			m^3/d	$m^3/d/cap$	m^3/d	$m^3/d/cap$	m^3/day	m^3/day	
CITY OF BRANTFORD									
Brantford	2008	93,000	41,025	0.4411	58,000	0.6237	100,000	260,000	Grand River
CITY OF GUELPH									
Guelph*	2009	120,000	46,607	0.3884	55,337	0.4611	75,000	140,000	GW, SW (Eramosa River)
COUNTY OF BRANT									
Airport	2008	601	192	0.3203	636	1.0582	2,290	2,290	GW
Mount Pleasant	2008	1,427	630	0.4414			2,298	2,290	GW
Paris	2008	11,358	5,344	0.4705			19,672	15,188	GW
St. George	2008	3,239	1,232	0.3803	2,611	0.8061	6,030	7,855	GW
COUNTY OF DUFFERIN									
Grand Valley	2009	1,600	404	0.2525	711	0.4444	4,645	3,337	GW
Marsville	2009	90	23	0.2539	55	0.6111	182	182	GW
Waldemar	2009	537	87	0.1613	519	0.9665	1,342	1,538	GW
COUNTY OF GREY									
Dundalk	2008	1,700	699	0.4114	1,206	0.7094	2,819	2,817	GW
HALDIMAND COUNTY									
Caledonia	2009	9,740	2,638	0.2708	5,634	0.5784	13,000	---	Lake Ontario
Cayuga	2009	1,575	701	0.4451	1,354	0.8597	2,333	---	Lake Ontario
Dunnville	2009	5,729	6,405	1.1181	11,570	2.0196	14,500	30,500	Lake Erie
CITY OF HAMILTON									
Lynden	2009	480	103	0.2146	235	0.4896	327	327	GW
COUNTY OF OXFORD									
Bright	2009	409	87	0.2127	173	0.4230	589	567	GW
Drumbo	2009	803	167	0.2080	367	0.4570	1,054	952	GW
Plattsville	2009	1,168	435	0.3724	1305	1.1173	2,290	2,290	GW
COUNTY OF PERTH									
Milverton	2008	1,750	437	0.2495	1002	0.5726	182	1,426	GW
SIX NATIONS RESERVE									
Ohsweken	2008	2,000	1,089	0.5443	1123.2	0.5616	1,040		Grand River
REGIONAL MUNICIPALITY OF WATERLOO									
Integrated Urban System*	2008	480,806	151,800	0.3157	189,600	0.3943	261,656	270,000	GW, SW Grand River
Ayr	2008	4,099	1,051	0.2564	1,978	0.4826	2,473	5,480	GW
Baden/New Hamburg	2008	11,056	2,772	0.2507	4,569	0.4133	12,110	4,625	GW
Branchton Meadows	2008	122	36	0.2951	92	0.7541	130	130	GW
Conestogo Golf Course	2008	484	266	0.5496	585	1.2087	601	932	GW
Conestogo Plains	2008	380	78	0.2053	182	0.4789	786	786	GW

Municipal System	Year of Data	Serviced Population	Average Day		Max Day		System Capacity (approx)		Water Source
			Actual	per capita	Actual	per capita	C of A	PTTW	
			m^3/d	$m^3/d/cap$	m^3/d	$m^3/d/cap$	m^3/day	m^3/day	
Foxboro Green	2008	400	102	0.2550	156	0.3900	527	482	GW
Heidelburg	2008	1,102	304	0.2759	603	0.5472	829	1,375	GW
Linwood	2008	814	171	0.2101	325	0.3993	605	1,047	GW
Maryhill	2008	168	71	0.4226	120	0.7143	157	157	GW
Maryhill Village Heights	2008	155	31	0.2000	120	0.7742	820	815	GW
New Dundee	2008	1,136	222	0.1954	389	0.3424	983	983	GW
Roseville	2008	294	78	0.2653	149	0.5068	358	358	GW
St. Agatha	2008	83	20	0.2410	58	0.6988	518	8,756	GW
St. Clements	2008	1,415	241	0.1703	441	0.3117	1,770	1,771	GW
Wellesley	2008	2,536	513	0.2023	768	0.3028	1,500	3,006	GW
West Montrose	2008	193	76	0.3938	138	0.7150	238	238	GW
COUNTY OF WELLINGTON									
Arthur	2008	2,770	864	0.3117	2368	0.8548	4,225	4,226	GW
Drayton	2008	1,550	429	0.2769	841	0.5423	3,928	3,927	GW
Elora	2008	5,202	1,434	0.2757	2,494.2	0.4795		16,506	GW
Fergus	2008	12,893	3,387	0.2627			13,334	12,060	GW
Hamilton Drive	2008	487	178	0.3655	438	0.8994	1,728	1,728	GW
Moorefield	2008	550	61	0.1117	131	0.2378	895	1,310	GW
Rockwood	2007	3,620	947	0.2617	3369	0.9307	3,274	3,275	GW
TOTAL		789,137							* Winter population used

3.3.1 Breakdown of Municipal Water Uses

While per capita values are listed in Table 1, they should not be used to compare between municipal systems, as each municipality has differing proportions of residential use to industrial, commercial and institutional (ICI) demands. It is important to note that municipal water use not only includes urban domestic use, whether for indoor or outdoor, but also includes industries, institutions, commercial ventures and other operations that rely on the municipality for their water supply.

Many municipal systems have capabilities in breaking down the water supply information into specific user groups. These systems have information detailing residential use aside from the ICI proportions, allowing for a better estimate of per capita demands. Often municipal tracking systems will also record 'revenue water', or the water they have sold to consumers, and 'total water supplied', which is revenue water plus any water lost to leakages, meter errors and maintenance uses for more accurate water usages of the system. The difference is called 'unaccounted' for water uses.

Information on the residential per capita demands and the percentage of unaccounted water (total water supplied minus the revenue water), was provided by several communities in the watershed, and the information is seen in Table 2 and Figure 6 for large and smaller systems.

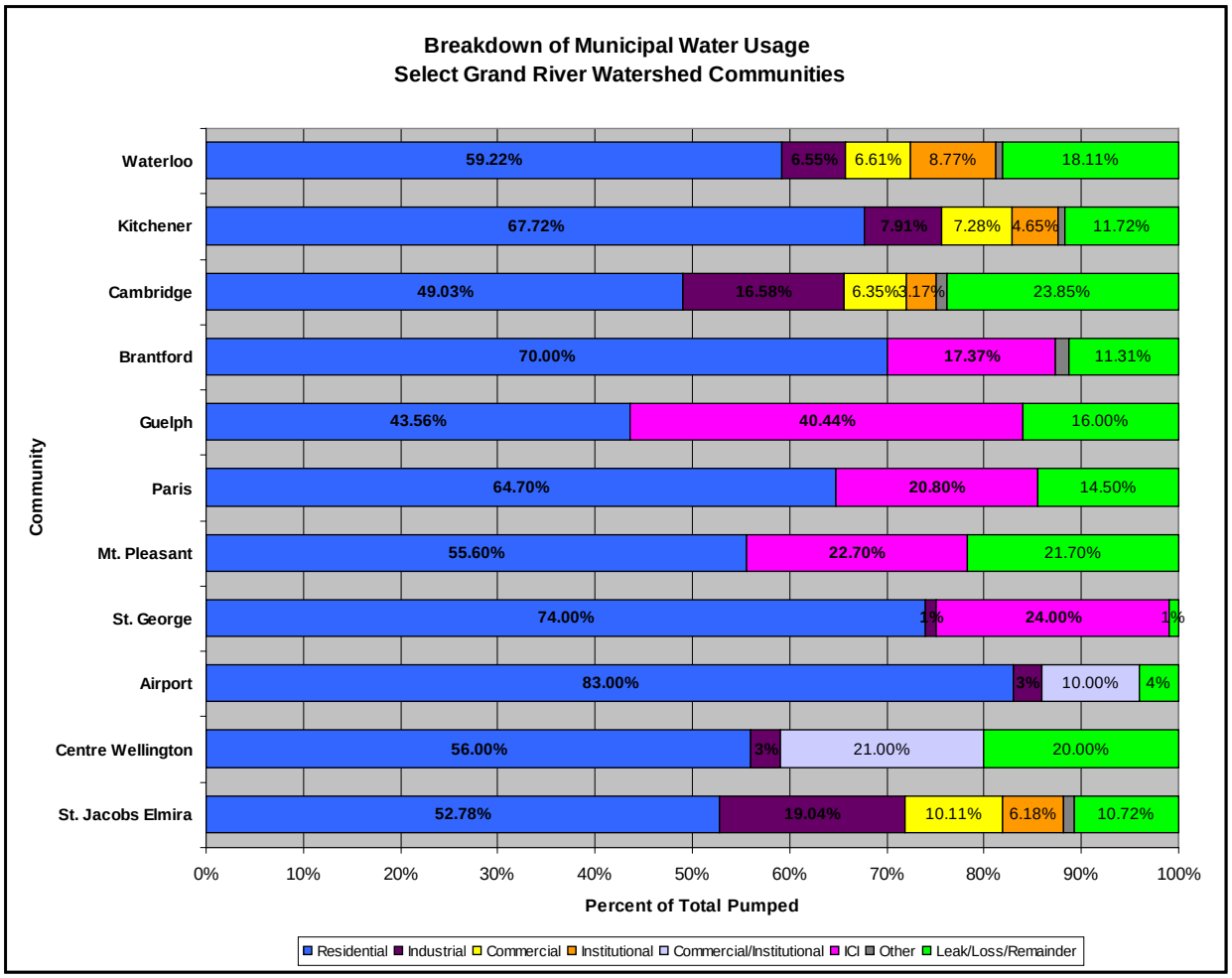

Figure 7. Breakdown of municipal water uses in select municipal systems

Table 2. Residential per capita rates for selected watershed communities

Community	Residential Per Capita Demand (L/cap/day)	Community	Residential Per Capita Demand (L/cap/day)
Brantford	211.35	Airport	247.80
Guelph	169.18	Mount Pleasant	260.36
RMOW IUS	187.88	Paris	300.75
Fergus	186.49	St. George	228.83
Elora	234.19		

3.3.2 Monthly Pattern of Water Use and Conservation By-laws

Monthly patterns of water use by the municipalities are useful in understanding when demands for water are changing throughout the year. For instance, outdoor watering of lawns and gardens has been known increase the demands for water in the summer months in the past, which can be problematic during seasonal drought issues. However, many municipalities have been initiating outdoor water conservation programs, with a goal to see declines in the peak demand during the summer months.

The larger municipality monthly distributions, which are show in Table 3, are only slightly different from the small municipal systems average, as seen in Figure 7.

Table 3. Monthly distributions of average daily water use by large municipalities

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RMOW IUS	0.97	1.02	1.01	1.03	1.01	1.04	1.09	1.06	1.01	0.93	0.93	0.91
Guelph	0.96	0.95	0.95	0.96	1.04	1.02	1.05	1.02	1.04	1.05	1.03	0.91
Brantford	0.95	0.93	0.94	0.96	1.02	1.08	1.21	1.05	1.05	0.96	0.91	0.91
AVERAGE	**0.96**	**0.97**	**0.97**	**0.98**	**1.02**	**1.05**	**1.12**	**1.04**	**1.03**	**0.98**	**0.96**	**0.91**

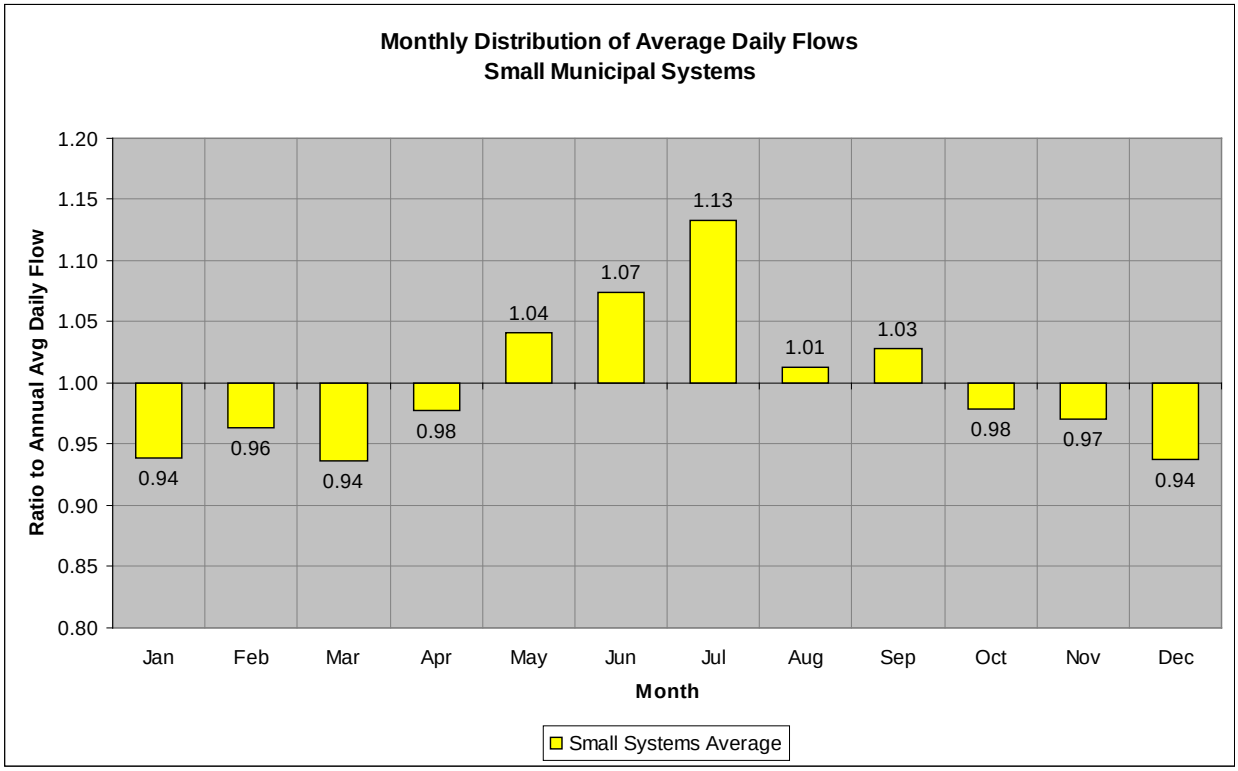

Figure 8. Monthly distribution of average daily water use in small municipal systems

3.3.2.1 Water Conservation Initiatives: Seasonal Outdoor Use

Monthly distributions of water use peaks in the summer months and much of this can be attributed to seasonal outdoor water use, such as lawn watering and car washing. Many municipalities have initiated water conservation by-laws for outdoor water use to reduce this water demand in the summer months (see Table 4). Most by-laws are allow watering on alternate days, where odd numbered houses can water on odd numbered days (and similarly for even-numbered houses). A few by-laws are more restrictive and only allow once a week, such as the Region of Waterloo and Guelph-Eramosa.

The effective dates of many of the restrictions are only during times of water shortages, such as when declared by the municipality with recommendations from the Grand River Low Water Response team under the Ontario Low Water Response Plan. However, there are some that are initiated by a calendar day, regardless of water levels in the watershed.

Table 4. Outdoor water Conservation By-laws throughout the Grand River watershed

Municipality	By Law #	Name or Level Description	Lawn Watering		Watering Gardens		Car Washing		Other Outdoor Water Uses	Effective Dates
			Type	Timing	Type	Timing	Type	Timing		
Brant	116-06	Water Use By-law	Alternate* Day	7-9am, 7-9pm	Hand water	All Day	No restrictions			Year-round
Brantford		Outdoor Water Conservation Program	Alternate Day	7-9am, 7-9pm	Allowed	All Day	No restrictions			June-August
Centre Wellington (Fergus, Elora)	99-55	Lawn Watering By-law	Alternate Day	5-7am, 7-10pm	Alternate Day	5-7am, 7-10pm	No restrictions			Year-round
Guelph-Eramosa (Rockwood, Hamilton Drive)	81/2007	Level 0 & 1: Alternate Day with Time Restrictions	Alternate Day	7-9am, 7-9pm	Alternate Day	7-9am, 7-9pm	Alternate Day	7-9am, 7-9pm	Decorative fountains must re-circulate, no ponding water -Cannot direct water onto a paved surface -Need permit to water new lawns	When level is declared
		Level 2: Reduce and stop non-essential uses	Once a week	7-9am, 7-9pm	Alternate Day	7-9am, 7-9pm	Not permitted			
		Level 3: Further reduce & stop non-essential uses	Not permitted		Not permitted		Not permitted			
City of Guelph		Level 0 Blue: Careful use	Alternate Day	7-9am, 7-9pm	No restrictions		Must have shut-off nozzle on hose		Decorative fountains must re-circulate water	When level is declared
		Level 1 Yellow: Reduce outside use	Alternate Day	7-9am, 7-9pm	No restrictions		Must have shut-off nozzle on hose			
		Level 2 Red: Reduce & stop non-essential use	Not permitted		Alternate Day	7-9am, 7-9pm	Alternate Day	7-9am, 7-9pm		
City of Hamilton	R84-026	Wise Water Use	Alternate Day	All Day	Alternate Day	All Day	No restrictions			When level is declared
		Watering Ban	Not permitted		Not permitted		No restrictions			
Mapleton Township (Drayton, Moorefield)	2003-40	Watering Restrictions	Alternate Day	5-7am, 7-10pm	Alternate Day	5-7am, 7-10pm	No restrictions			When level is declared
Oxford	4193-2002	External Use of Water	Alternate Day	6-9am, 6-9pm	Alternate Day	6-9am, 6-9pm	Alternate Day	6-9am, 6-9pm	Also applies to complete filling of swimming pools and ICI users with different times of day	May 1 - Sep 30
Region of Waterloo	07-069	Water Conservation By-law	Once a week	5:30-10am, 7-11pm	Alternate Day	5:30-10am, 7-11pm	Alternate Day	5:30-10am, 7-11pm	Pools on alternate days within time restrictions	May 31 - Sep 30
Wellington North (Arthur)	21-06	Outdoor Water Usage	Alternate Day	6-9am, 7-10pm	Alternate Day	6-9am, 7-10pm	Stage 2: not permitted	----	No spray washing, decorative fountains must re-circulate	When level is declared

*Alternate Day means: Even/odd numbered addresses water on even/odd numbered calendar days

In comparing the municipalities with and without outdoor water use by-laws, Figure 8 shows the differences in the monthly distributions compared to the average of all small communities.

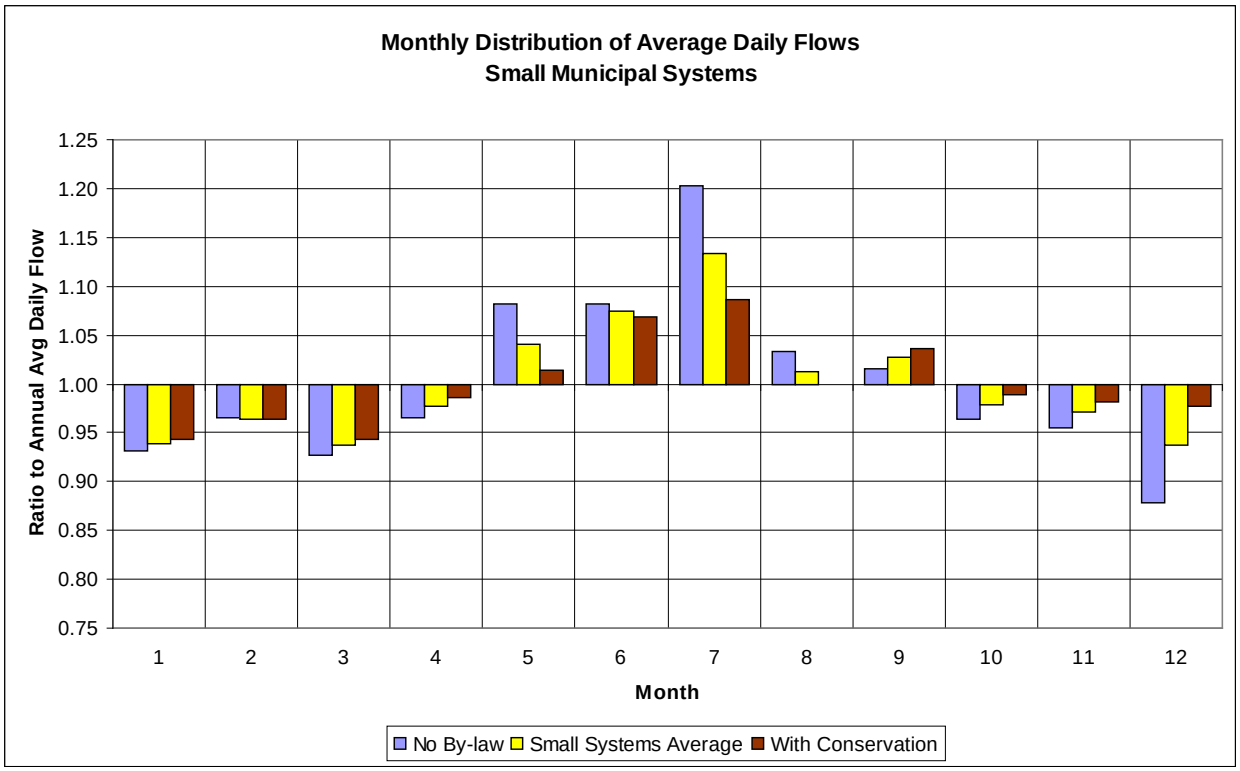

Figure 9. Monthly water demand with and without outdoor use conservation by-laws

For this graph, data was calculated with 2008 data primarily. Brant was included as without a conservation by-law since it was amended halfway through 2008 and it was thought that the uptake for the by-law was still not fully established and water demand was still fairly high in those summer months.

The success in reducing the water demand the summer months is evident, especially in the summer months. The month of July shows the average water demand for municipalities without established conservation by-laws is 7% higher than the average demand of all small municipalities (repeat of data in Figure 7), while those municipalities that have outdoor use conservation in place are 5% lower, for an overall difference of 12%. In all growing season months from May through September, the percentage increase for municipalities without by-laws is higher than for those that do.

4.0 Unserviced Domestic Water Use

Unserviced domestic water use is any residential use, including all indoor and outdoor water uses, which are not attached to a municipal distribution system. Generally this includes rural communities such as Burford, who are entirely on private wells. Unserviced domestic water use can represent a significant water use in some localized areas of the watershed.

Rural domestic per capita water use has traditionally been reported to be lower than urban domestic use. This may be attributed to rural residents being more aware of the demands placed on their wells and septic systems, the costs of running their system of pumps and also may be attributed to less outdoor 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). This water use is assumed to be relatively constant throughout the year. It should be noted that a large percentage of this water is likely returned to the shallow groundwater system via septic systems and taken from groundwater sources.

The rural populations of the Grand River watershed were estimated with the aide of the 2006 Census of Population estimates and Six Nations Reserve counts. The municipally serviced population, provided by the municipalities, was subtracted from the Census of Population numbers to determine an unserviced proportion. The estimated total rural unserviced population for the Grand River watershed is approximately 123,000 residents.

The unserviced per capita domestic water rate was then applied to this population sample to estimate water usage by this group across the watershed. Figure 9 shows the distribution and water demands of the rural unserviced population. The total water demand for all rural unserviced domestic use is **7.2 Mm^3/year**.

Figure 9 shows the rural population density across the watershed as a function of water use. The northern part of the watershed still has fairly low population density and low water demands by unserviced rural residents. The central portion of the watershed is primarily on municipal supply, and thus the unserviced population is also low.

The remainder of the watershed has a larger rural unserviced community. There is a high population density of unserviced residents in the areas surrounding of the urban centres of the Grand River watershed, as well as the City of Hamilton just outside the watershed. For example, northwest of Waterloo there is a thriving Mennonite community and the residents of the Six Nations reserve have a majority on private supply.

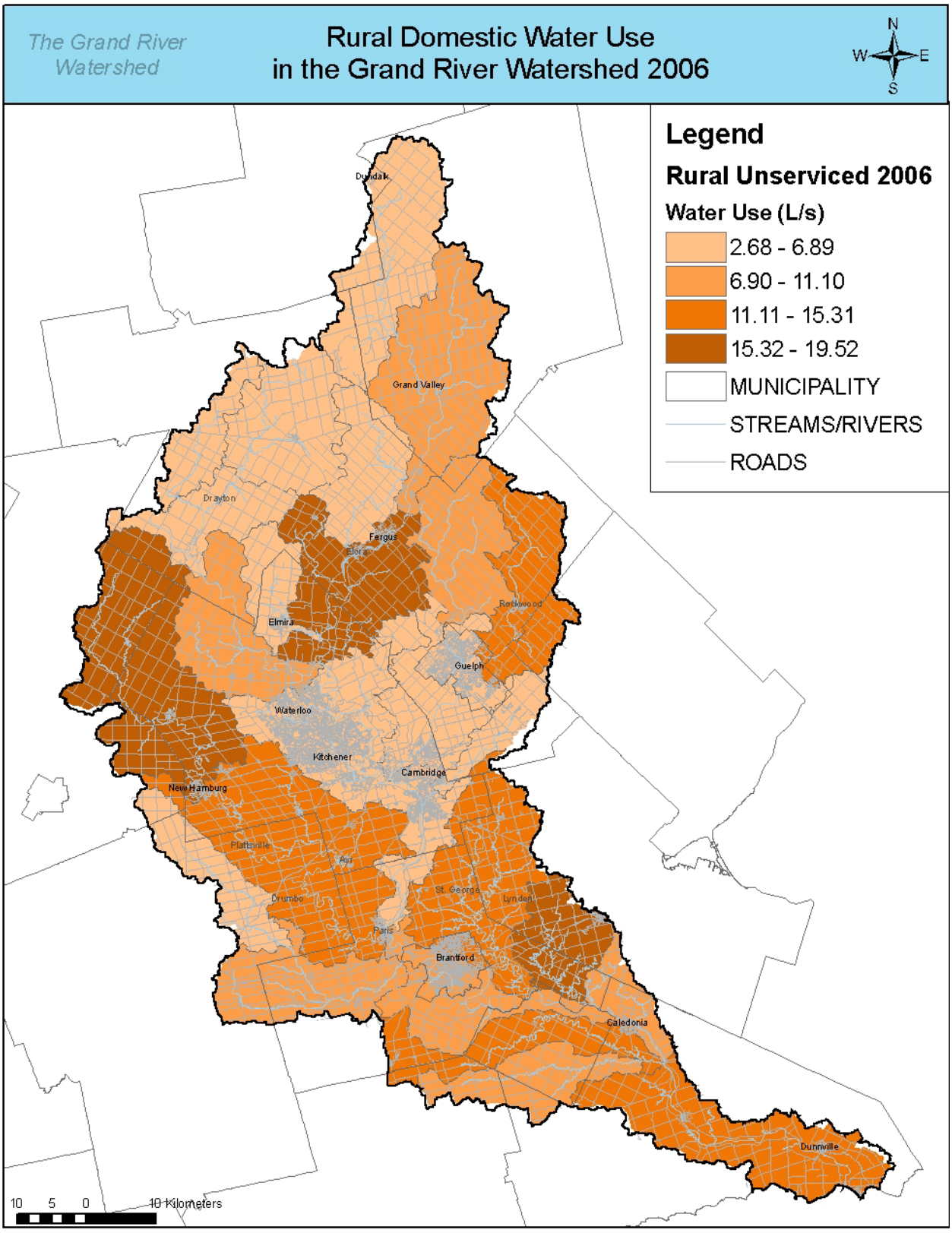

Figure 10. Rural domestic water demand

5.0 Permitted Water Takings

There are many other water uses which are regulated under the jurisdiction of the Ontario Ministry of the Environment (MOE) through the Permit to Take Water (PTTW) program. The MOE requires any person taking greater than 50,000 litres per day to apply for a PTTW, but domestic usage, firefighting and animal watering requirements are excluded from requiring a permit, as these are considered essential uses. The PTTW database is the only such water taking information portal available across Ontario for use in understanding water takings in the province.

Applicants must declare the maximum volume of water they may take in a day, as well as their purpose and the general timing of the takings. Many water takings are not continuous and year-round in nature, making yearly, seasonal and monthly water use estimates difficult to determine by extrapolating from a maximum daily rate. Simply using the maximum daily rate would make the estimate erroneously elevated as water takings for some purposes are infrequent, seasonal, dependent on climate, or are diversions of water from one location to another. The nature of the permit by category is helpful in determining the general water use pattern, however many factors such as management practices, climate, water efficiency and user knowledge and awareness of water conservation can make each permit very different from another.

The MOE has recently altered the program to require the permit holders to report their water usage to get a better estimate of actual water takings. The reporting structure had a three-phase approach, the first requiring municipalities and large industrial and commercial operations from Municipal/Industrial Strategy for Abatement (MISA[1]) sectors to begin submitting reports in 2006. Phase 2 included the remaining industrial and commercial sectors to submit in 2007, and finally Phase 3 included all other permit holders including agricultural permits to begin submitting reports in 2008. The availability of this data is limited, but was made available through a one-time data sharing contract for certain programs (such as Source Water Protection and Ontario Low Water Response) in 2008. It is hoped that it will be made more readily available in the future for water managers.

An additional factor has been introduced in the PTTW application system recently to classify the permits by their potential interference with other water users and risk to the environment. There are also 3 categories here for classification: Category 1 has the lowest risk of adverse environmental impacts such as permit renewals of the same or lesser amount from the same source and same purpose; and Categories 2 and 3 takings that have higher potential for 'causing adverse environmental impacts' or may interfere with other uses. An example Category 2 application includes permit renewals with an increased taking and requires a scoped assessment. Category 3 applications require a detailed ecological/hydrological/hydrogeological study including new permits from certain surfacewater sources such as headwater streams and permits that don't fall under the first two categories.

[1]MISA sectors include 9 industrial sectors covering the main toxic polluters: petroleum; pulp and paper; metal mining; industrial minerals; metal casting; organic chemical manufacturing; inorganic chemicals; iron and steel and electric power generation.

5.1 PTTW Database Information

5.1.1 Description of Permit to Take Water General Categories

Permits are categorized into broad and specific water use categories. Some of the PTTW water use categories are fairly self-explanatory, such as golf course irrigation, however there are a number of them that require a bit of explaining to fully understand their requirement for a permit. They are described here:

Agricultural: all agricultural water taking permits are primarily for irrigation, since livestock watering does not require a permit. These occur mostly during the growing season, however there are some specific uses, such as nursery, that may occur year-round.

Aquaculture: fish farming is done for a number of reasons including rearing fish for stocking other water bodies and for commercial sale for consumption. The rearing of fish generally occurs in ponds or holding tanks that require a constant flow of water to simulate natural conditions. While this constant supply is what requires aquaculture operations to apply for large volumes of water in their permit, the use is almost non-consumptive of the water and most of it returns to the environment. The water taking can, however, be considered a diversion or consumptive to a specific water body (such as an aquifer) if the water is not returned to its source but emptied into another water body (such as the nearby stream), which is common practice. Aquaculture is not very common in the Grand River watershed as there are only 6 active permits.

Aggregate Washing: The extraction and processing of sand, gravel and other aggregates requires the separation of the aggregate from the earth. The most common method of doing this is to wash or rinse the aggregate with water and empty the soiled water into a holding pond for settling out particulates. The initial removal of the water is the main water taking, however aggregate producers must report on their pumping rates from the washing and holding ponds to be granted a permit. Generally the water used occurs in a closed loop system, but there is a small percentage of water consumed in the process, through evaporative losses or cohesion to the aggregate. If a well or stream is used as the source of water, then the volumes of extracting this water are reported as completely consumptive. More information on aggregate washing can be seen in Section 5.3.2.

Dewatering: Dewatering is the process of removing water that has seeped into a pit or quarry that is dug below the water table. Aggregate pits, quarries and construction sites are common operations that require dewatering permits that pump water away from the activity, and either pump it to a holding pond for infiltration or into a surface water body. Often these permits are temporary (less than 1 year) and these are removed from consideration, however longer-term permits are included. This type of permit is a removal of water from the source (or diversion) instead of using it for a specific purpose.

Groundwater Remediation: When contaminant spills occur that leach into the ground, an aquifer may need to be pumped to remove the contaminant or prevent it from spreading. This process is called groundwater remediation. The water removed is often treated and returned back to the environment either through sanitary sewers or to a surface water body. This water taking is considered completely consumptive to the water source, or as a diversion to another water body.

Heat Pumps: Some buildings use heat pumps to heat and cool in the winter and summer months by extracting it out of water. There are only a handful of these in the Grand River watershed.

Miscellaneous/ Other: these categories are provided to the applicant if no other category can describe their water use. However, this category makes it extremely difficult to understand the true purpose or characteristics of the particular water taking.

5.1.1.1 Excluded Water Taking Categories

There are several water taking categories that, on a watershed basis, are considered non-consumptive, such that the water remains within the surface water body. While these takings are regulated by the PTTW program, they are not included as actual 'takings' since they are not removed, and considered 'run-of-the-river' uses. These include:

Dams and Reservoirs: The capture of water on the landscape due to a dam to create a reservoir requires a PTTW. The storage of water is done for a variety of reasons however, as the PTTW is solely for the capture of water behind a dam, it is considered a run-of-the-river use, non-consumptive and therefore is removed from consideration.

Power Production: Many large dams are able to generate some energy as water flows through turbines and this requires a PTTW. However, it is considered a run-of-the-river use and completely non-consumptive and therefore is removed from consideration.

Wetlands: Wetlands permits are generally only applied for by Ducks Unlimited Canada, for constructed wetlands. These wetlands are built to capture runoff during the spring period, and can therefore have very high water taking volumes associated with them. However, these structures will only utilize their full water taking during the initial filling and not as a sustained taking, and in fact return water to the environment instead of removing it. These permits were removed from consideration as it was felt they do not represent true water takings.

Wildlife Conservation: similar to wetland permits, wildlife conservation permits are used to keep a certain amount of water in the environment to sustain a community of wildlife in a pond or other water source. These permits are also excluded from consideration as they do not represent true water takings from the environment.

5.1.2 Cycle of Updates to PTTW Database

The PTTW database information was first obtained through a data request to the MOE in May 2005. However, permits are constantly being issued or renewed, so to keep up to date, the GRCA contracted AquaResource to create a database for maintenance purposes of the permits within the Grand River watershed jurisdiction. The GRCA then took this MS Access database and continues to input information when notifications are sent from the MOE regarding permits or through queries on the Environmental Registry. The information in this report strives to be the most current information available for permits in the GRCA jurisdiction. More changes to the database have been incorporated as MOE has sent updates in 2008 and 2010.

Water use categories that are not maintained as they are considered run-of-the-river uses and completely non-consumptive include: wildlife conservation, wetlands, dams and reservoirs and power production.

5.2 PTTW Statistics for the Grand River Watershed

The number of permits assessed for this report was 691, after subtracting all the excluded permits. The total number of permits in the Grand River watershed is between 700-750 with the excluded permits and fluctuates as permits are constantly being issued, renewed and expiring. The total number of sources associated with the 691 included permits is 1159, with a majority

(80%) coming from groundwater sources. The numbers of permits in the Grand River watershed are detailed in Table 5. Figure 10 is a map of the location of groundwater permits and Figure 11 for surface water permits.

Table 5. Permits to Take Water by category in the Grand River watershed

General Purpose	Specific Purpose	# of Permits	Ground	Surface	Grand Total
Agricultural	Field and Pasture Crops	106	99	69	168
	Fruit Orchards	4	4	1	5
	Market Gardens / Flowers	11	10	6	16
	Nursery	22	20	14	34
	Other - Agricultural	90	85	40	125
	Sod Farm	17	14	10	24
	Tender Fruit	4	6		6
	Tobacco	84	88	37	125
Agricultural Total		338	326	177	503
Commercial	Aquaculture	8	23	2	25
	Bottled Water	3	3		3
	Golf Course Irrigation	52	83	27	110
	Mall / Business	2	6		6
	Other - Commercial	10	25		25
	Snowmaking	1	3	1	4
Commercial Total		76	143	30	173
Construction	Dredging	1		2	2
Dewatering	Construction	4	3	1	4
	Other - Dewatering	6	12	4	16
	Pits and Quarries	6	9		9
Dewatering Total		16	24	5	29
Industrial	Aggregate Washing	30	46	7	53
	Brewing and Soft Drinks	1	1		1
	Cooling Water	5	9		9
	Food Processing	9	16		16
	Manufacturing	7	12	1	13
	Other – Industrial	17	24	1	25
Industrial Total		69	108	9	117
Institutional	Other - Institutional	3	5		5
	Schools	2	2		2
Institutional Total		5	7		7
Miscellaneous	Heat Pumps	4	6		6
Recreational	Aesthetics	1	1		1
	Other - Recreational	3	3	3	6
Recreational Total		4	4	3	7
Remediation	Groundwater	21	64		64
	Other - Remediation	1	7		7
Remediation Total		22	71		71
Water Supply	Campgrounds	14	23	1	24
	Communal	13	24		24
	Municipal	126	187	5	192
	Other - Water Supply	3	4		4
Water Supply Total		156	238	6	244
Grand Total		691	927	232	1159

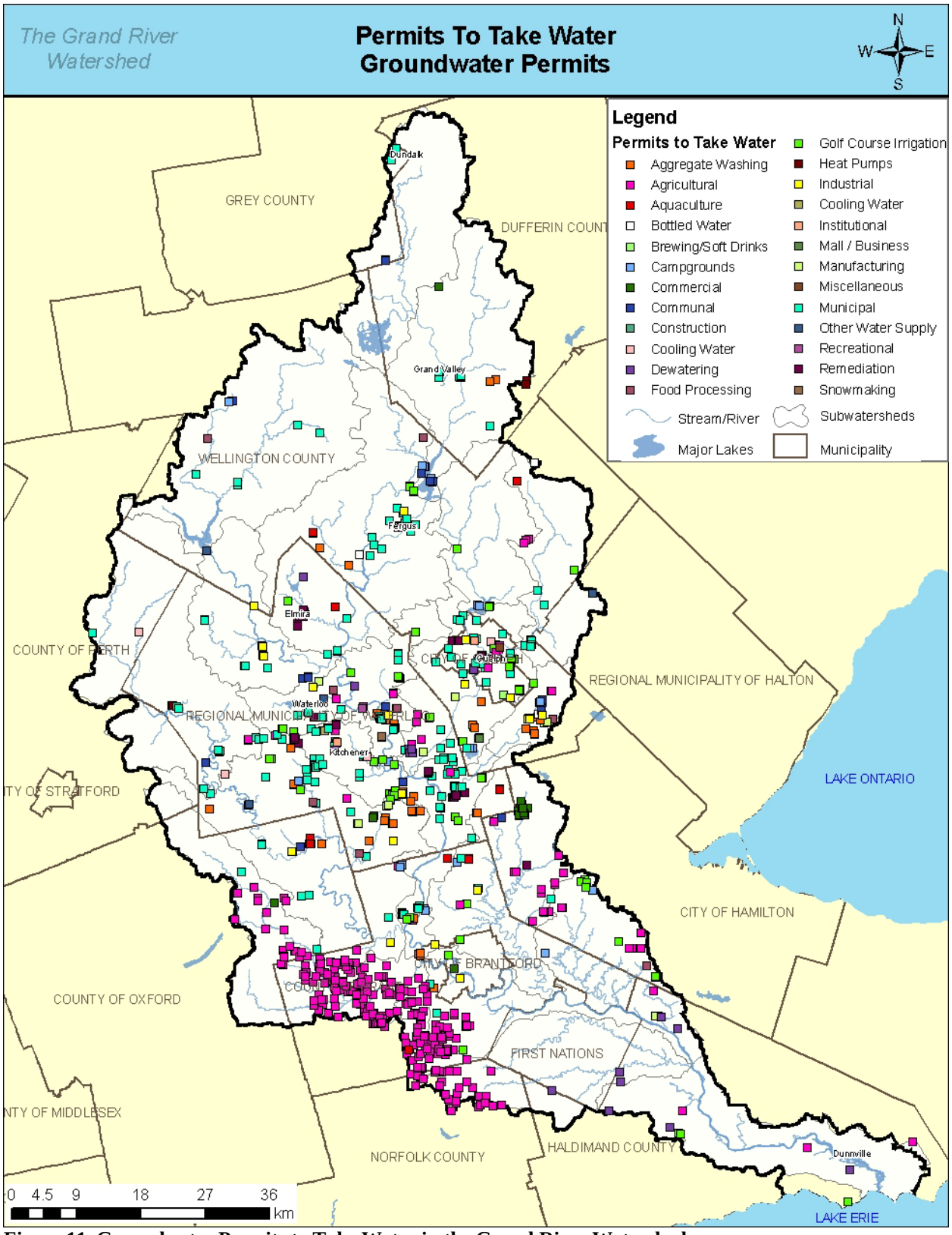

Figure 11. Groundwater Permits to Take Water in the Grand River Watershed

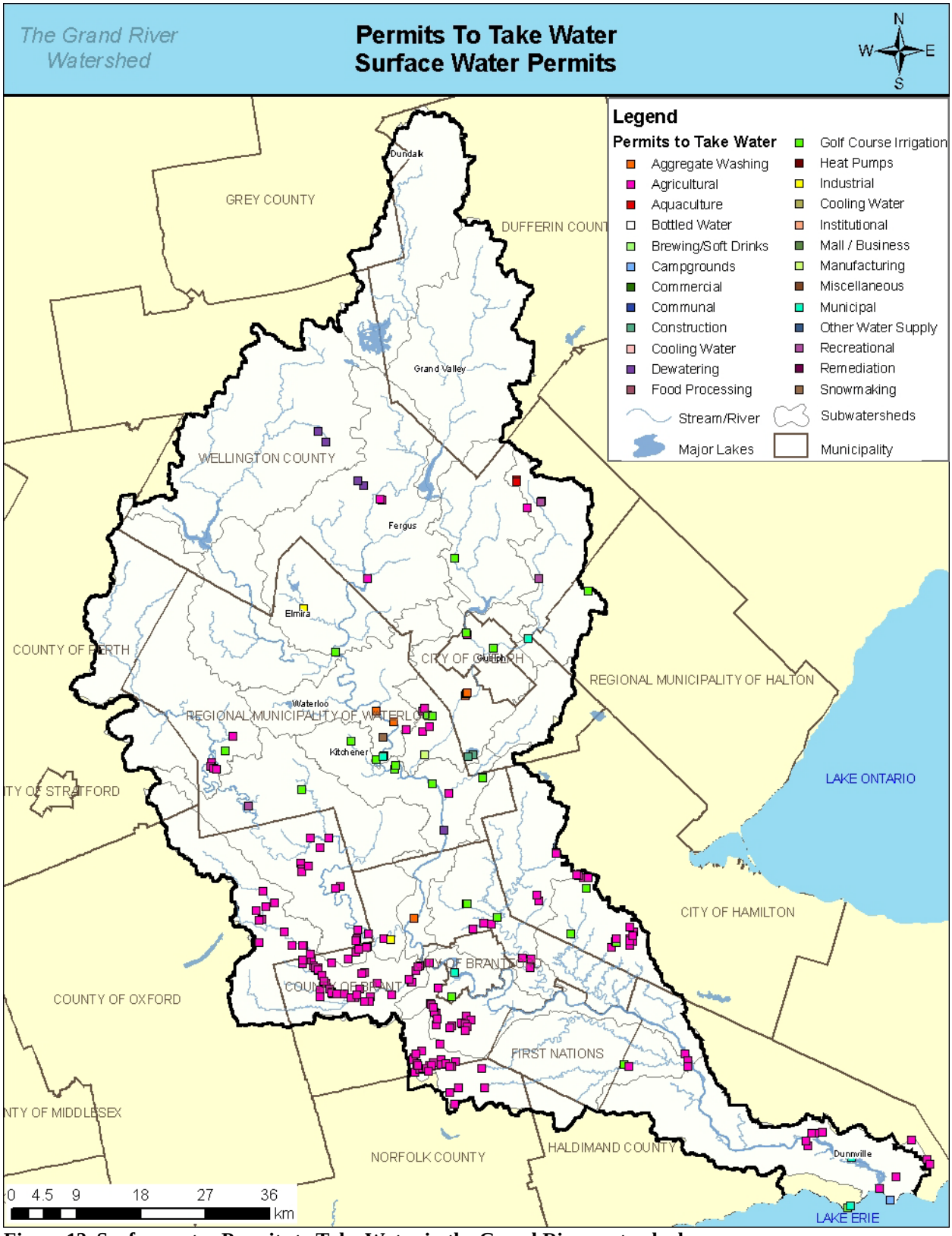

Figure 12. Surface water Permits to Take Water in the Grand River watershed

5.3 Actual Water Taking Records and Estimates

The availability of actual water taking information has vastly improved since the original WUI report was published. At that time, only some municipalities provided water taking information while all the non-municipal water takings were estimated based on their permitted maximum daily rate. The GRCA felt it was important to get a better understanding of actual water takings in the watershed from the records of the permit holders.

At first, a phone survey was conducted in the summer of 2005, focusing on the five highest water use sectors (excluding municipal, domestic and agricultural) of Dewatering, Aggregate Washing, Aquaculture, Remediation and Golf Course Irrigation. The permit holders in these five categories, as well as those in the Miscellaneous category were telephoned and asked a series of questions to get a better understanding of the amounts, timing and sources of their water takings. The survey refined the understanding for these categories but many were still gross estimates. Help was sought from the MOE, which lead to knowledge that the West Central Region office had been requesting pumping records from many of the permits they issued since 2000. An agreement was made to mine their paper files of any of the pumping records relevant to the Grand River watershed. This information was all organized into the GRCA-maintained PTTW database.

In the meantime, a province-wide program was initiated to require all permit holders to submit their pumping records. From 2005, the MOE began their requirements to report actual water takings for permit holders, in three phases. The three phases of reporting started with municipal and large industrial uses, then the remaining industrial and commercial users and finally agricultural permit holders in the last phase. A new Water Taking Reporting System (WTRS), houses the reports submitted by permit holders on their annual daily water use. The final of a 3-year phase-in was completed in 2008 and actual water takings were available via requests from the Water Taking Reporting System (WTRS) as of 2010.

For the reporting year of 2008, in the Grand River watershed, approximately 55.5% of all permits have actual water taking records available. The details of the reporting by specific use is seen in Table 6. Several water use categories had 100% of permits and sources submitting records, such as municipal, manufacturing, cooling water, bottled water, snowmaking and brewing and soft drinks.

Table 6. PTTW reporting by specific use

Category	Specific Purpose	% with Records	Specific Purpose	% with Records
Agricultural	All Agricultural	34%		
Commercial	Aquaculture	44%	Mall / Business	**100 %**
	Bottled Water	**100%**	Other - Commercial	44%
	Golf Course Irrigation	66%	Snowmaking	**100%**
Construction	Other - Construction	**0.00%**		
Dewatering	Construction	25%	Pits and Quarries	56%
	Other - Dewatering	44%		
Industrial	Aggregate Washing	79%	Food Processing	63%
	Brewing/Soft Drinks	**100%**	Manufacturing	**100.00%**
	Cooling Water	**100%**	Other - Industrial	44%
Institutional	Other - Institutional	60%	Schools	50%
Miscellaneous	Heat Pumps	**0.00%**		
Recreational	Aesthetics	**0.00%**	Other - Recreational	**0.00%**
Remediation	Groundwater	66%	Other - Remediation	**100%**
Water Supply	Campgrounds	36%	Municipal	**100%**
	Communal	38%	Other - Water Supply	50%
Grand Total				**55.48%**

The majority of the records that are missing are for agricultural takings. The lack in the agricultural sector may be due to several reasons: the database was released to Conservation Ontario in late 2008 which was the first year for agricultural reporting; many agricultural takers could have been late entering their information; it was their first reporting year (2008) and many glitches were experienced in entering the proper data into the online database; many lack the necessary internet connection required for data input; and 2008 was a wet year, which had little irrigation requirements so agricultural permit holders may not have thought it necessary to enter zero values.

Where available, the data in the WTRS is reported in the summaries in the most recent year (2008). However, when data was unavailable then estimates were used, based on continued research on typical water taking for each category or specific purpose, which is described in the next section.

Many of the agricultural water takings had to be estimated, as the requirements for submission were the latest for agricultural purposes for the PTTWs and many reports were unavailable for the 2007-2008 submission years. The 2007 year was targeted for agricultural water taking records, as this was a dry year and would give a representative year of higher water takings from agricultural irrigation. For other water takings, the most recent year of data (2008) was used.

5.3.1 Adjustments and other Estimates to the PTTW Database

In the absence of actual water taking information, estimates would have to be used to make adjustments to the permitted maximum daily rate for each permit. The estimates were based on the specific category of water taking, and the timing these uses were assumed to occur. Some permits give a range of dates when the permit can be active throughout the year, and many of the permits give the maximum number of days that the permit can be activated. This has helped with understanding the timing of water takings throughout the year. Monthly usage factors were suggested based on these dates, as a final adjustment to more accurately reflect the timing of

actual water usage. These have been incorporated into monthly adjustment factors based on the specific purpose of the permit.

For each water taking category, months when the permit was assumed to be active were given a value of 1, while inactive months with no takings were given a value of 0. For certain permits, fractions were included when the use was assumed to only occur for parts of the month. To illustrate, the assumption for campgrounds is that the season starts in May and water takings occur through until mid-October, since most shut down after Thanksgiving weekend. The half month in October has a monthly adjustment factor of 0.5. For irrigation permits, such as golf courses and agriculture, the fraction is obtained by dividing the number of estimated days of taking by the total number days in that month.

There are still known issues with the accuracy of the estimates when using the monthly adjustment factors. For instance, during the months that a permit is assumed to be active, the taking is assumed to be occurring at the maximum. While it is unlikely that most water takings will be continuously pumping at the maximum every day during the entire month, this is the assumption that has to be made in the absence of actual pumping data. The monthly adjustment factors can be seen in Table 7.

Table 7. Monthly Adjustment Factors for Permits without actual water taking data

Category	Specific Purpose	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Agriculture	All Agricultural	0	0	0	0	0	0.26	0.39	0.26	0.13	0	0	0
Commercial	Aquaculture	1	1	1	1	1	1	1	1	1	1	1	1
	Bottled Water	1	1	1	1	1	1	1	1	1	1	1	1
	Golf Course Irrigation	0	0	0	0	0.06	0.13	0.26	0.26	0.13	0.06	0	0
	Mall/Business	1	1	1	1	1	1	1	1	1	1	1	1
	Other - Commercial	1	1	1	1	1	1	1	1	1	1	1	1
	Snowmaking	1	1	0	0	0	0	0	0	0	0	0	1
Construction	Dredging	0	0	0	0	1	1	1	1	1	1	0	0
Dewatering	Other - Dewatering	1	1	1	1	1	1	1	1	1	1	1	1
	Other - Industrial	1	1	1	1	1	1	1	1	1	1	1	1
	Pits and Quarries	1	1	1	1	1	1	1	1	1	1	1	1
Industrial	Aggregate Washing	0	0	0	0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0
	Brewing/Soft Drinks	1	1	1	1	1	1	1	1	1	1	1	1
	Cooling Water	1	1	1	1	1	1	1	1	1	1	1	1
	Food Processing	1	1	1	1	1	1	1	1	1	1	1	1
	Manufacturing	1	1	1	1	1	1	1	1	1	1	1	1
	Other - Industrial	1	1	1	1	1	1	1	1	1	1	1	1
Institutional	Other - Institutional	1	1	1	1	1	1	1	1	1	1	1	1
	Schools	1	1	1	1	1	1	0	0	1	1	1	1
Miscellaneous	Heat Pumps	1	1	1	1	1	1	1	1	1	1	1	1
Recreational	All Recreational	0	0	0	0	0	1	1	1	1	0	0	0
Remediation	All 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	0.5	0	0
	Communal	1	1	1	1	1	1	1	1	1	1	1	1
	Other - Water Supply	1	1	1	1	1	1	1	1	1	1	1	1

In the assessment of water takings for this report, the data will also document when estimates or actual pumping data have been used.

5.3.2 Focus Study: Aggregate Washing Permits

Aggregate washing permits are a unique type of permit that required additional assessment for their water taking needs. It was thought that aggregate washing should be highlighted as these are unique water takings needing further explanation. These permits are for the extraction and processing of sand, gravel and other aggregates, as washing allows the separation of the aggregate from the earth. Many of these permits have very high permitted maximum rates, some sources in the tens of millions of litres per day. However, recirculation is common practice and many permits also stipulate that dewatering is not permitted. These maximum values could skew the water demand from the aggregate sector, but with recirculation, specific aggregate washing adjustments are needed to calculate the assessed water demand.

There are 30 aggregate washing permits in the watershed, with 53 sources total. The water is used to wash or rinse the aggregate to separate and remove all the fine sediments that may be stuck to the aggregate. This soiled water is emptied into a holding pond and once the water is clear of the settled particulates, it is moved back into the wash pond to be used again. Permits must list sources and pumping rates for both the initial water taking to fill the pond and also the water being transferred from one location to another, between washing and settling ponds.

The source of the wash pond water is from both within the pond itself, as groundwater will seep into the pond if below the water table, as well as outside sources such as wells and streams that pump water into the pond. The water demand thus primarily comes from the need to fill the washing ponds and also to top it up when the ponds get too low. Generally, water sources are groundwater based, either from the dugout ponds that have groundwater seeping in, or wells that supplement water to top up ponds. Surface water streams are also a source of water to fill the wash ponds. This initial filling and topping up are the more important water takings in aggregate washing to report for water management purposes.

The permits show very high permitted amounts on other sources, as they require enough permitted water capacity to run pumps for the wash water. Aggregate producers must report on all of their pumping rates, including the transfer of water from the washing and holding ponds, yet the water generally cycles in a closed loop system, and is recycled. Because the same water is used again and again, the reports of water pumped in this closed loop system artificially heightens the demand for water from this industry. If this volume was compared to other uses in the watershed, it would grossly over-estimate the total water for aggregate washing.

In attempts to estimate the amount of water removed from the shallow groundwater table – the water from within the pond area seeping into the ponds dug below the water table – a special aggregate pond ratio is proposed. The ratio would account for the water being extracted from the source, but not account for the pumping volume that just re-circulates water. This value would be used to adjust the water pumping amount to a volume that would be comparable to all the other water uses in the watershed, while not giving aggregate washing an artificially high prominence compared to other water takings. For new ponds (1 year or less) with pumping records available, the adjusted amount of the water taking was 30% of the pumped total. This value was chosen as the amount that is estimated to be seeping into the ponds from the groundwater shallow water table in the first year after the pond was constructed. After a year, the adjusted amount goes down to 15%, assuming that some siltation has occurred to create a lining along the bottom of the pond to prevent some flow of groundwater into the pond. This aggregate pond ratio was

applied to actual water taking records as well as the adjustment of the permitted maximum to estimate demand where data was not available.

For all sources filling the pond from outside sources of water, such as the wells and the streams, all actual water takings were reported at face value, not using the aggregate pond ratio. For the sources where data was not available, estimated amounts in the guidelines from Section 5.2.1 were used, based on the permitted maximum listed on that particular source. As listed in Table 7, aggregate washing occurs between May through November, the months when the ground is not frozen and construction is occurring.

5.3.2.1 Assessment of Water Taking by Aggregate Washing Permits

The total amount of water permitted from outside sources (15 wells or streams) amounts to only 10% of the total permitted maximum volume for the aggregate washing permits throughout the Grand River watershed. The rest of the sources are assumed to have recirculation occurring in wash or settling ponds and therefore have much higher permitted rates. A majority of both types of sources had actual pumping records available, only 7 needed to be estimated from the 53 total sources.

The actual pumping with the adjustments made with the aggregate pond ratio assesses the water taking for aggregate washing to 20.6 M m^3/year, or only 22.8% of the permitted maximum. Assessed water takings for the outside sources amounted to under 3% of their permitted maximum rates, while 24% of the permitted pumping rates for the ponds were assessed as being used. There were 19 sources that reported zero takings, meaning these permits were not actively pumping in the 2008 year, which reduced the total amount of water takings to these low values. The statistics on aggregate washing permits and their assessed water taking volumes for 2008 are seen in Table 8.

Table 8. Aggregate washing permit statistics 2008

Aggregate Washing	Water Source	Permitted Maximum (m^3/year)		Actual Water Taking (m^3/year)		Actual/Permitted (%)
Outside Sources	Wells or Streams	9,039,655	10.02%	597,499	2.90%	6.61%
Pond Sources	Wash or Settling Ponds	81,196,766	89.98%	19,981,954	97.10%	24.61%
TOTAL	**All Sources**	**90,236,421**	**100%**	**20,579,453**	**100%**	**22.81%**

6.0 Agricultural Water Use

Agricultural water use is an especially difficult use to estimate, as irrigation demands vary with climate, crop type, soil type and the level of drought tolerance the farmer is willing to risk. With the high percentage of permits being estimated (few actual water taking records) and little information regarding agricultural water use elsewhere in literature, another method was used to characterize water use for this sector. Water used in agriculture can be divided into 2 categories, based on timing of the water requirement and availability of information. Year-round water uses include livestock watering and farming operation water uses, and seasonal water uses comprises the second category, including crop irrigation.

6.1 Livestock and Farming Operations

Water use estimates in this category for livestock and farming operations are considered year-round water requirements. These water uses are exempt from requiring a PTTW, as they are considered essential uses. Livestock drinking water and sanitary requirements as well as washing of equipment do not require a PTTW unless the water is taken into storage prior to washing at a rate of more than 50,000 L/day. Thus, the estimates for this category 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 the gap in agricultural water use estimates and contracted out the research to updating and verifying agricultural water use data on a sector-by-sector basis. The study by Kreutzwiser and de Löe (1999, updated in 2004) at the University of Guelph, built upon previous work to refine existing water use coefficients for specific farming practices. A spreadsheet tool was created in the study to allow the user to import Census of Agriculture data and determine the total agricultural water use for a particular geographic unit.

Water use coefficients were determined for all of the livestock categories in the Census of Agriculture in the Kreutzwiser and de Loe (1999) study. By multiplying the water use coefficients (e.g. dairy cows consuming 90L/day) by the number of animals given in the Census of Agriculture, the total agricultural water use for a specific geographic region can be calculated. Data from the 2006 Census of Agriculture was used to generate water use estimates for this report. Figure 12 displays the results.

To better represent the livestock populations in the watershed, a request was made to Statistics Canada to translate the Census of Agriculture data into surfacewater catchment areas. The original sections, called census consolidated subdivisions (CCS), are small sections of municipalities but were translated to subwatersheds to provide consistency with other water uses in the watershed. The translation of data by Statistics Canada into these larger subwatershed areas allows for aggregated data, which lowers the amount of data that needs to be suppressed for lack of data and privacy reasons. One downfall is that weighted averaging was used to translate the data, which assumes that the data is evenly distributed through the CCS. This is a significant assumption which may not hold true when agricultural practices generally follow specific land-based properties (i.e. geology or soil type). However, it is the best available data for estimating livestock water demands for the Grand River watershed.

It is estimated that year-round agricultural water uses for livestock water needs accounts for **7.5Mm^3** per year (see Figure 12). Appendix C is a table of the water demand by subwatershed for livestock watering needs.

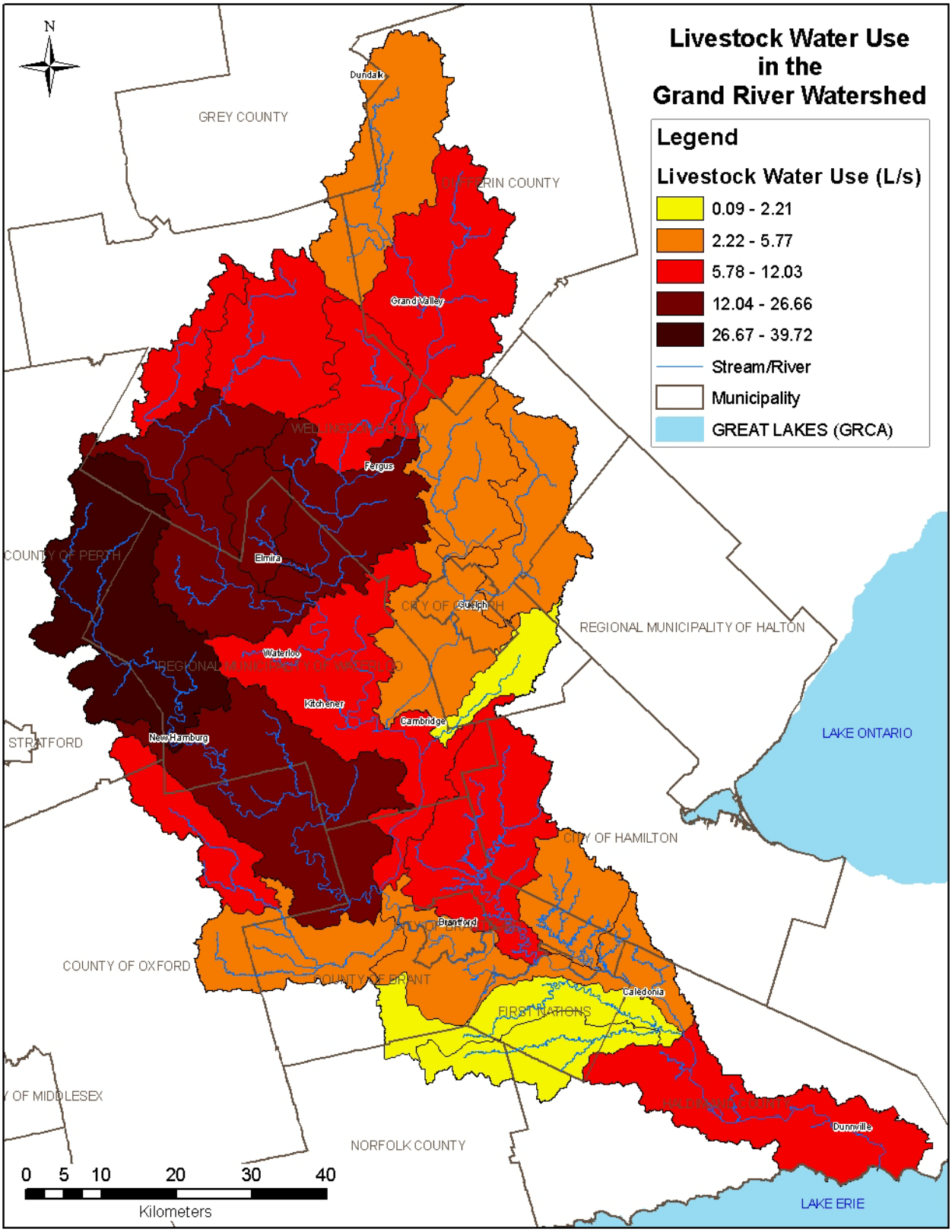

Figure 13. Livestock Water Use in the Grand River watershed

6.2 Crop Irrigation

Crop irrigation occurs only seasonally in Ontario, requiring a PTTW for any application of over 50,000 litres per day, which amounts to about half an inch of water (0.5") over an acre of land. Due to the variability of water demands for irrigation due to climatic variability year to year, it was not realistic to calculate water use for crop irrigation using the technique outlined for livestock/farming operations from the Section 6.1. The estimation would be done comparing assumptions made through an irrigation demand model and reports of actual water use by farmers in the watershed.

The previous Water Use Inventory report (GRCA, 2005) on crop irrigation had been based on irrigation demand models and the estimated amount of irrigated land, as reported by the Census of Agriculture data. However, as continued research and dedication to the need for better estimates of agricultural crop irrigation is made available, there are other methods to use and compare. Several methods are explained below.

6.2.1 Irrigation Trends from Reported Agricultural Water Takings

Water taking records from the farmers themselves are a valuable resource for understanding agricultural irrigation demands. Within the last couple years, this data gathering has become a requirement for all PTTW holders, however information on agricultural irrigation would be most beneficial over a series of differing climatic years. Fortunately, the PTTW program out of the West Central Region (WCR) had been progressive with trying to understand agricultural irrigation permits and their watering demands. The MOE WCR office started requesting additional information from irrigation applications around 2000, such as the irrigation equipment, pumping capacity and the duration of time they would irrigate per day. Based on this information, the permitted maximum issued on the permit would be a more realistic estimate of achievable taking by the farmer. On a water management perspective, these permitted maximums become a good basis for calculating estimates of watering needs.

Additionally, before the provincial reporting requirement, the WCR had been requesting many agricultural permit holders to submit actual water taking records. Many, but not all the permits in the watershed have had a requirement for annual reporting, some dating back to the 1980's, but more regularly since 2000. The provincial requirement for submitting records did not occur for agricultural irrigation permits until 2008.

The application and submission of reports in the WCR permit files made it much easier to understand agricultural irrigation water requirements and compare wet years to dry years. Once collected from their office, analysis of the data was done from as many records as possible, to find trends and get an average irrigation demand for most irrigators, relative to their permitted rate, across many years. The analysis found that irrigators are using approximately 60% of their permitted maximum daily volume, when they irrigate. Some factors attributing to the average use of 60% could be irrigating for less time at their permitted pumping rate, not having their pump at full capacity, or simply accounting for the highest demand possible in their permitted maximum but not requiring this regularly.

Anecdotal reports in the permit files and contact with local experts helped refine the irrigation season watering requirements. For instance, farmers will need more than one day to complete a full cycle of irrigation for all their fields, due to the range limit of the irrigation equipment. Farmers were consulted to ask how many irrigation cycles were needed in an average year. The

number of days needed for an irrigation cycle and the number of cycles in an average irrigation season gives an estimate of the total active days of a pumping on a permit.

6.2.1.1 Water Taking Regulation and Reporting

The requirement for all agricultural permits to submit reports on water takings occurred as the third of 3 phases in 2008, for water taken in 2007. The data is housed in the Water Taking Reporting System (WTRS) by MOE and data requests were made by Conservation Ontario (CO) to obtain this data for all conservation authorities in May 2009.

As this information was now made a requirement for all agricultural takers, it provided additional resources to determine water demand by the agricultural sector. The data is reported as a daily volume of water taking by each source on each permit.

While there were only 2 required years of reporting (2007 and 2008) for the agricultural permits, records had been submitted since the onset of the Water Taking Regulation since 2005 for some permits. For the agricultural takings, the year 2007 was chosen as the representative year to use, since 2007 was a drier year than 2008 with a higher percentage chance of needing irrigation and therefore more records. Also, if submissions for the 2008 year were late, then complete records may have been missing due to time of the request from CO.

Despite the greater number of records submitted for 2007, the daily reported rates of taking for agricultural takings amounted to only 35% of all sources in the Grand River watershed.

6.2.2 Irrigation Demand Model

The irrigation demand model was used in the previous GRCA Water Use Report (GRCA, 2005). This model was developed to estimate the number of irrigation occurrences in a season to predict when farmers would be required to irrigate their crops. The model used synthetic daily moisture data from the Guelph All-Weather Sequential Events Runoff (GAWSER) model, which was generated from the Water Availability component of the Water Budget Project (2009).

The GAWSER model, used for the Water Availability component uses a combination of quaternary geology, land cover, hummocky topography and precipitation to estimate the water cycle at all points in the watershed. The hydrologic model runs continuously from 1961 to 1999 to generate estimates of all aspects of the water cycle. By running in a continuous fashion, it is possible to generate a time series of soil moisture for well drained agricultural land. For further information on GAWSER and its application as a water management tool see GAWSER: A Versatile Tool For Water Management Planning, (Schroeter *et al*., 2000).

The number of irrigation events is calculated based on soil moisture content. It is generally accepted that vegetation becomes stressed when the soil moisture content drops below 55% of the soils water storage (Schwab *et al*., 1981) or halfway between field capacity and wilting point. It is assumed that crops would require irrigation at this point. The Irrigation Demand Model requires that the soil moisture remain under this point (55% soil moisture) for an extended period of time to trigger an event, in order to reduce the number of irrigation events that occur just before a large increase in soil moisture (such as 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 OMAFRA, 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). The irrigation season for this region used for the model is between June 20 and September 10, and irrigation events can only be triggered in between these dates. If the soil moisture falls below the critical 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 the irrigation demand model running continuously from 1961 to 1999, one can determine how irrigation demand changes from year to 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 model year (1961-1999) is included in Figure 13.

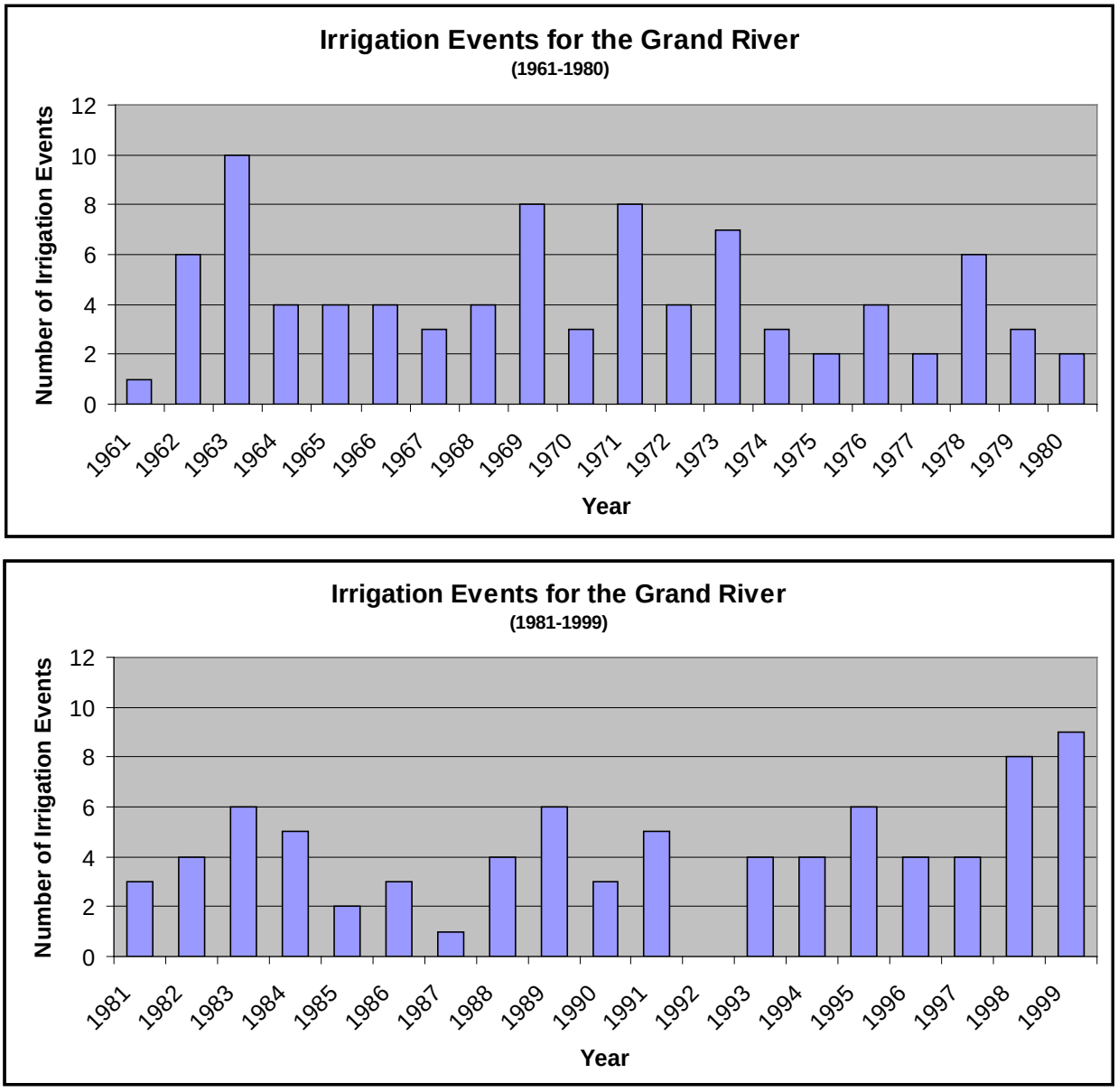

Figure 14. Irrigation events predicted 1961-1999

The volume of water that is required is calculated using the depth of water applied over the area of irrigated land in the entire watershed. The amount of irrigated area is reported in the Census of Agriculture, which details the year prior to the publication year of the Census data (i.e. Land in irrigation reported in the 2006 Census details what occurred in 2005). A comparison of the data from the last 4 Census years shows the fluctuation of irrigation demand, likely due to climatic trends (see Figure 14).

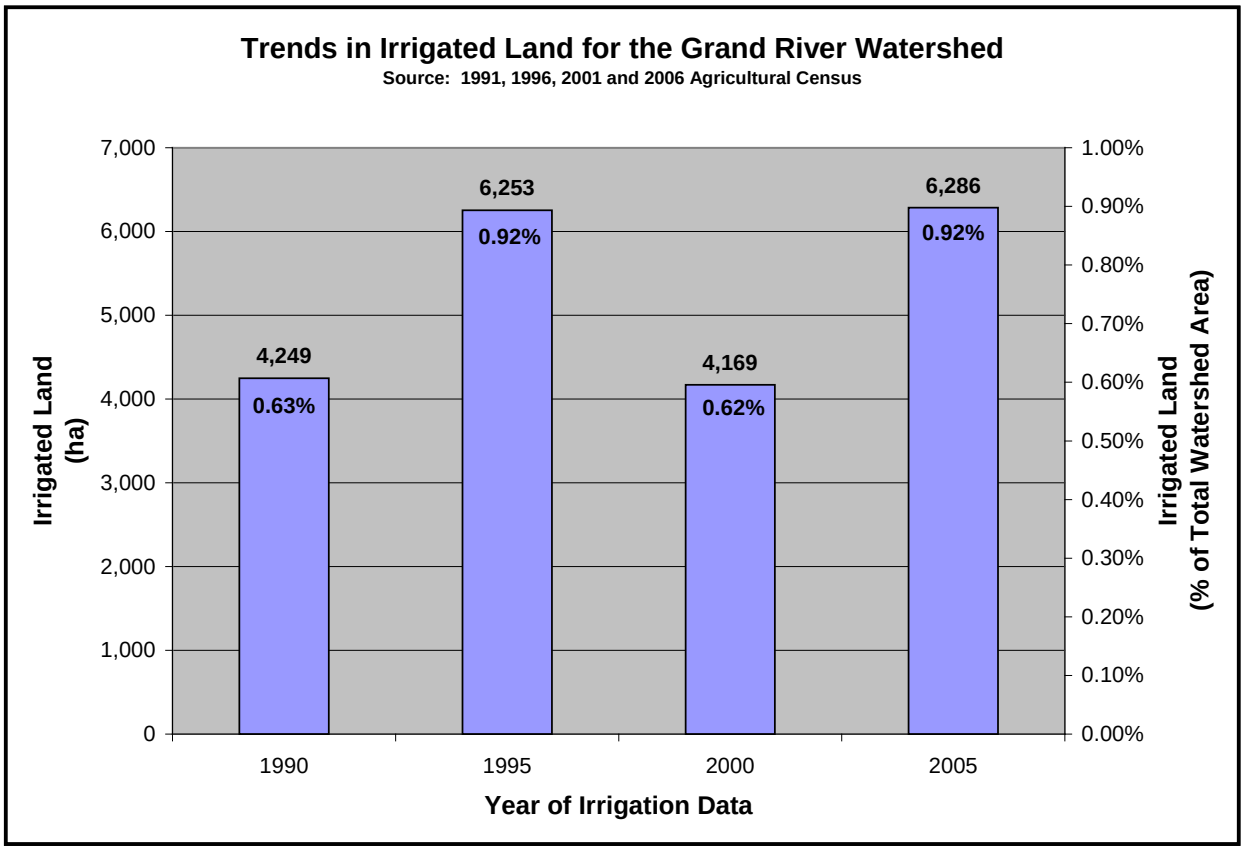

Figure 15. Trends in irrigated land area in the Grand River watershed for 4 Census years

To see whether precipitation trends match the irrigated land trends, analysis of data from the closest long term gauge to most agricultural permits was done. Delhi is just south-west of the Grand River watershed and has reliable information for the climatic and agricultural zone of many of the permits in the Grand River watershed. Data from this gauge shows that 1990 seemed to be a slightly above average year of precipitation (467 mm of precipitation from May-Sep). The year 1995 was a dry year (314 mm of precipitation from May-Sep) in the midst of a 7-year drought period that lasted until 1999 followed by a very wet 2000 year (725 mm of precipitation from May-Sep). The year 2005 had started out as a very dry year but did get more in July and August for an overall average precipitation season (433 mm of precipitation from May-Sep), as the 30-year normal for this station was 436mm (see Figure 15).

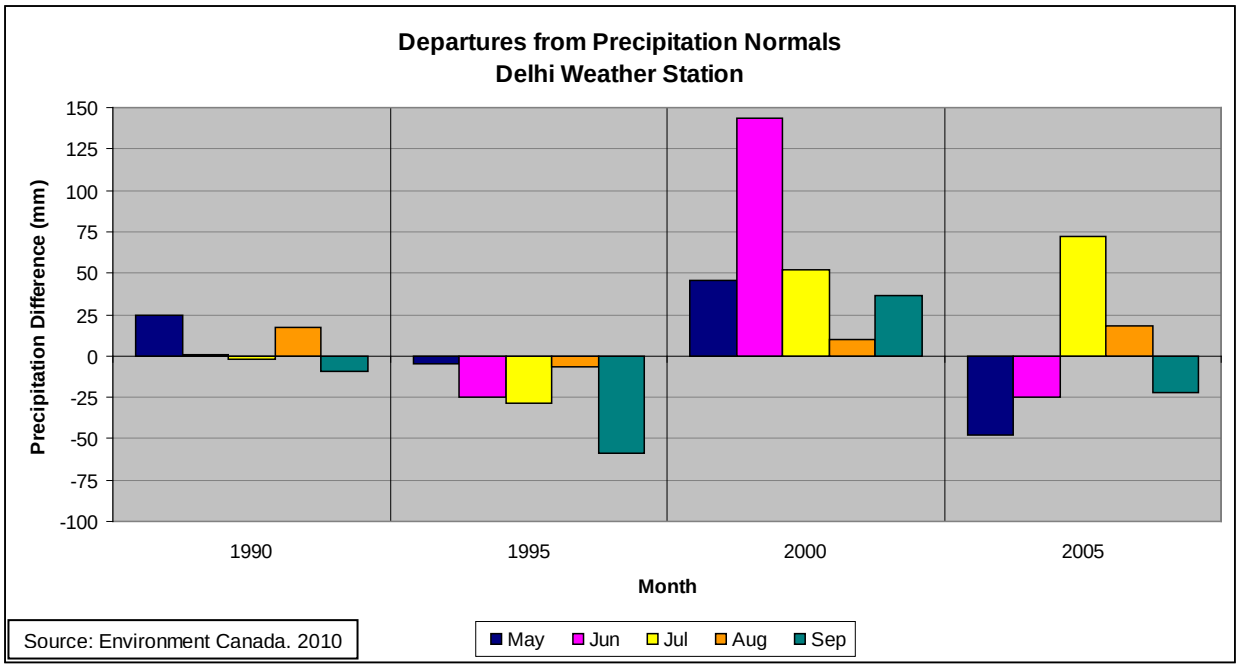

Figure 16. Departures from Normal Precipitation at Delhi for 4 Census years

A higher percentage of the cropped agricultural land required irrigation in 1995 and 2005 compared to 1990 and 2000 (Figure 14) would makes sense when comparing to the precipitation data in Figure 15.

The range of the number of irrigation events, as well as the associated water requirement for the watershed for two particular years showing a range of irrigated land area (low in 2000 and average in 2005) is seen in Table 9.

Table 9. Range of Irrigation Events and Irrigation Water Demand

Range	# of Irrigation Events	Water Demand 2000 (m^3)	Water Demand 2005 (m^3)
Minimum	0	0	0
1st Quartile	3	5,242,000	7,903,150
Median	**4**	**6,989,000**	**10,537,534**
3rd Quartile	6	10,483,000	15,806,300
Maximum	10	17,472,000	26,343,834

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 method.

6.2.3 Final Estimates Used for Crop Irrigation

With the information mined at the MOE WRC, the reporting through the WTRS, the irrigation demand model and local knowledge, a more reasonable estimate was obtained for overall agricultural water use in the Grand River watershed. All these avenues of information have combined to give a reasonable estimate of water demand from agriculture in wet, dry and

average precipitation years. Since the actual water takings were considered to be the only definitive source of water taking data, the final estimates of water demand were initially based on the permitted takings. The actual water takings data was used where available, but where these data were not available, the estimates were used based on the adjustments to the permitted maximum, as detailed in Section 6.2.1.

The final estimate for the irrigation season requires on average, 4 irrigation cycles, which matches with the median value for the irrigation demand model and was documented as the average number from local knowledge. Each irrigation cycle lasts 8 days, totaling 32 days of active irrigation per permit (SOURCE). The 32 day estimate reduces the estimated total volume of water needed if it was assumed to occur every day throughout the growing season. The 32-days are spaced throughout the peak demand for water from June through September, having 8 days in June, 12 days in July, 8 days in August and 4 days in September.

While growing season from June through September is a good approximation of the peak irrigation demand period, the actual water taking records show that water demands for crops actually occurs from as early as February and as late as November (see Table 10). The water takings in the off-peak irrigation months may be watering requirements for crops not related to irrigation, indoor watering requirements (nursery) before planting or errors in reporting or permit category (i.e. they may be for domestic water supply and not irrigation). They are included as to not alter the data given in the actual water taking records.

As these actual and estimated water takings are based on the permits, the permitted maximum water taking for the approximately 330 agricultural irrigation permits are used as a comparison (see Figure 16). Since the estimates had monthly variability and the reporting could be summarized by month, the results are shown in monthly increments to highlight the higher demand months. For an even more refined permitted maximum, the seasonality constraints set in some of the permits were applied to the adjustment. The seasonality constraints are which months (usually May through September) as well as the number of days that the taking is allowed to occur. The largest range of agricultural seasonality in the permits was March 1 through November 30 of each year and number of days ranged from 1 to 365, with a median of 35 days.

In years that require irrigation, there is more confidence of how much water is needed for agricultural purposes. With the actual and estimated values for agricultural irrigation, as detailed by subwatershed in Chapter 5.0, the amount of irrigation per year is approximately 10.2M m^3/year, or approximately 322 L/s.

Table 10. Average irrigation requirements in the Grand River Watershed

Irrigation Month	Mar-Apr	May	June	July	Aug	Sep	Oct	Nov	Total
Permitted Maximum (L/s)	155.5	906	3,652	6,131	5,763	4,403	872	107	1,836.6
Actual / Estimated Irrigation Amount (L/s)	5.83	23.09	949.87	1,382.5	963.7	487.7	16.13	3.50	321.53
Percent of Maximum	3.75%	2.55%	26.01%	22.55%	16.72%	11.08%	1.85%	3.26%	17.51%

In comparison with the irrigation demand model, the results very similar to the median value in an average year of irrigation demand. The irrigation demand model seems to be a good predictor of water takings for agriculture, and achieves almost identical results to the estimates based on

permits. In the absence of actual water taking records, both methods would yield adequate predictions of water demand for agricultural irrigation purposes.

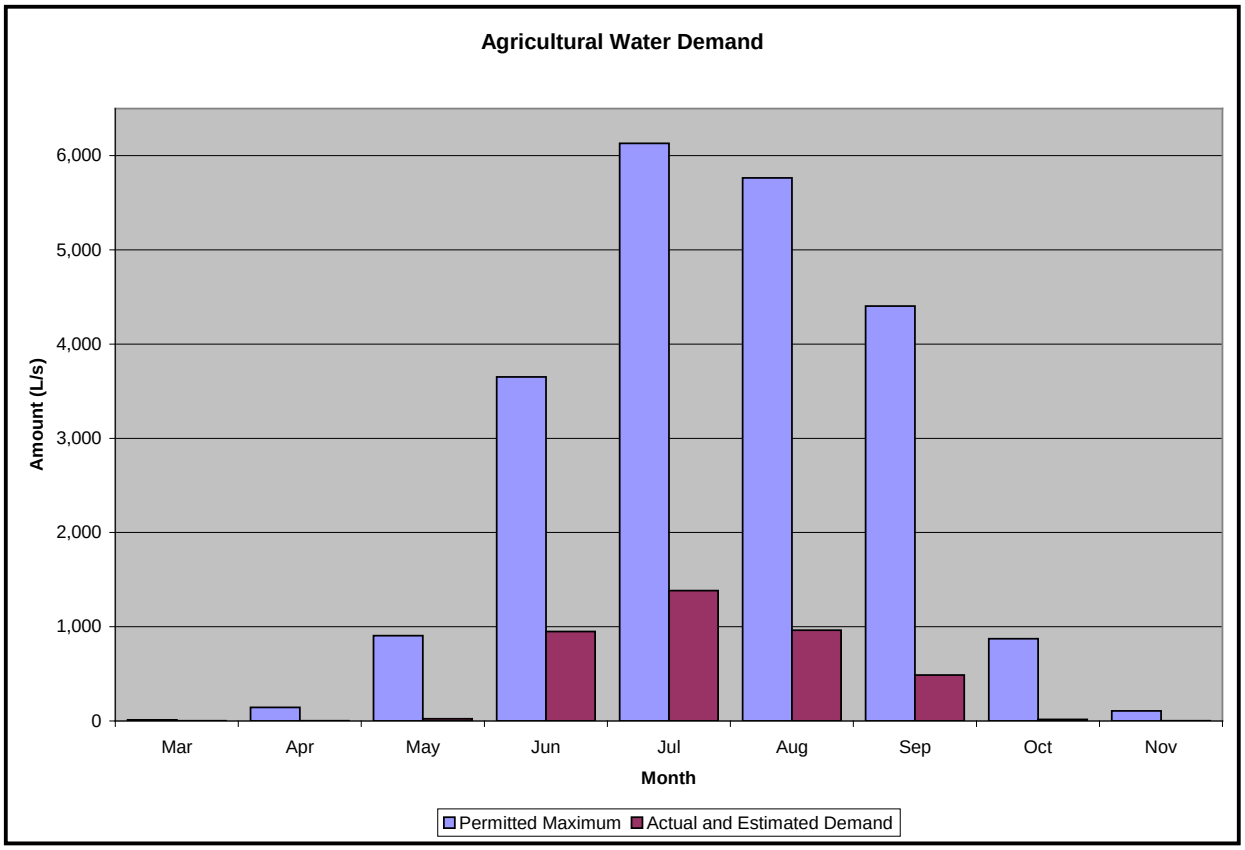

Figure 17. Comparison of permitted maximum agricultural water demand to estimates

7.0 Water Use by Subwatersheds

For reporting the PTTW data, the Grand River watershed was divided into subwatersheds, since there are so many permits to assess. Each section will detail the permitted maximum takings and the "assessed water takings" determined via actual and estimated water takings, which better represent the overall water takings for the subwatershed. A brief introduction to the water demands in the subwatershed will also be given to highlight the major water uses in that area.

The data will be calculated down to the units of litres per second (L/s), as the permitted maximum daily values were too big to visually quantify. A comparison was done of the permitted maximum rate to the assessed water takings (the combined actual and estimated values). It was thought smaller values and time period would be more accurate and easier to compare (such as to streamflows), as the variance over longer periods (monthly or annually) of the seasonal permits would be approximations with respect to the permitted maximum.

Appendix A gives a more detailed monthly breakdown of the adjusted water takings for each subwatershed, without the comparison to the permitted maximum. Appendix B shows maps of the location of the PTTWs in each subwatershed.

The Grand River watershed has 18 major subwatersheds that will be described here in 11 sections. Some of the subwatersheds were combined here if they were a subdivision of a river system, such as the upper and lower Nith Rivers. The Grand River subwatersheds are detailed in 4 separate sections from the headwaters to the outlet to Lake Erie.

7.1.1 Conestoga River

The Conestoga River is a major tributary located in the northwestern portion of the Grand River watershed. The headwaters start in Wellington County near Kenilworth, then flow through the Region of Waterloo and reach the Grand River in the community of Conestogo. The Conestogo Dam is a large reservoir just north of Glen Allan which subdivides the river into upper and lower portions. The subwatershed is primarily agricultural for livestock, and has the highest density of livestock in the watershed.

In terms of water takings, many of the large water takings are non-consumptive such as the dewatering and aggregate washing. There are no permitted takings for agriculture, as irrigation is not necessary for the crops grown in the area. However, livestock watering, which doesn't require a permit as an essential use is fairly substantial in this subwatershed. Livestock watering is detailed in Section 6.1. Municipal water takings are for 6 small communities in the watershed including Arthur, Drayton and Moorefield in Wellington County and Heidelberg, Linwood and St. Clements in the Region of Waterloo. Industrial takings are a good portion of the water takings after municipal takings, for a variety of uses. See Table 11 for the permitted and assessed water takings.

Table 11. Conestoga River Daily permitted and assessed water takings

Category	Specific Purpose	Permitted Max			Assessed Water Takings			
		Ground	Surface	Total	Actual/ Est.	Ground	Surface	Grand Total
Dewatering	Other - Dewatering		500.0	500.0	Actual		0.07	0.07
Industrial	Aggregate Washing	142.1		142.1	Actual	4.71		4.71
	Manufacturing	6.8		6.8	Actual	0.59		0.59
	Other - Industrial	8.2		8.2	Actual	2.03		2.03
					Est.	0.44		0.44
Industrial Total		157.1		157.1		7.77		7.77
Water Supply	Campgrounds	2.0		2.0	Actual	0.15		0.15
	Communal	7.3		7.3	Est.	88.40		88.40
	Municipal	173.2		173.2	Actual	24.07		24.07
	Other - Water Supply	0.9		0.9	Actual	0.06		0.06
Water Supply Total		312.0		312.0		112.68		112.68
Grand Total (in L/s)		340.5	500.0	**840.5**		120.45	0.07	**120.52**

The total permitted maximum daily rate for both subwatersheds together annually is 840.5 L/s, for 32 sources on 19 permits. The actual pumping records and estimates reduce that amount to a yearly average of 121 L/s or less than 15% of the annual permitted maximum. One quarter (25%) of the sources had estimated water use, the rest had actual water taking records.

7.1.2 Eramosa and Speed Rivers

The Eramosa River is on the east central side of the Grand River watershed. It flows through Guelph-Eramosa Township into the City of Guelph where it meets up with the Speed River. The Eramosa drains a significant portion of two major moraines: the Paris-Galt and Orangeville moraines. Rain falls onto these moraines and eventually reaches the Eramosa River, producing high quality water even during the summer months. The City of Guelph surface water taking is from the Eramosa River between April and November. Maintaining water table levels is critical for maintaining flows in the Eramosa River, so both groundwater and surface water takings must be managed carefully. A variety of other uses in the subwatershed are also listed as the daily permitted maximum in Table 12.

Table 12. Eramosa River Daily permitted and assessed water takings

Category	Specific Purpose	Permitted Maximum			Assessed Water Takings			
		Ground	Surface	Total	Actual/ Est.	Ground	Surface	Grand Total
Agricultural	Field and Pasture Crops		7.58	7.58	Est.		0.40	0.40
	Other - Agricultural	7.58		7.58	Actual	3.05		3.05
Agricultural Total		7.58	7.58	15.16		3.05	0.40	3.45
Commercial	Aquaculture	7.57	45.49	53.06	Actual	26.57	48.93	75.50
	Bottled Water	12.88		12.88	Actual	4.60		4.60
	Golf Course Irrigation	43.87	44.47	88.34	Actual	3.84	3.60	7.45
Commercial Total		64.32	89.95	154.27		35.01	52.54	87.55
Recreational	Other - Miscellaneous		218.00	218.00	Est.		0.00	0.00
	Other - Recreational		4.55	4.55	Est.		1.14	1.14
Recreational Total			222.55	222.55			1.14	1.14
Water Supply	Municipal	593.15	368.31	961.46	Actual	248.59	39.09	287.67
Grand Total (in L/s)		665.05	688.39	**1,353.44**		286.65	93.16	**379.81**

The water takings in the Eramosa River subwatershed are fairly evenly distributed between surface and groundwater takings, however many of the surface water takings will only occur during the summer months while groundwater takings are year-round. There are 15 permits in the Eramosa River subwatershed.

The actual and estimated water takings are seen in Table 12, which shows that annually the average water taking is 380 L/s, or approximately 28% of the permitted maximum. There were actual records of water takings for 84% of all 25 sources in the Eramosa River subwatershed, which is the highest percentage of actual records across all the subwatersheds.

The Speed River is a major tributary of the Grand River on the east central portion of the watershed. The Guelph Lake dam and reservoir divides the Speed into 2 subwatersheds above and below the dam. The upper Speed River above the Guelph Dam drains an area of the Orangeville Moraine, which is an area of high runoff and low summer flows. Very few permits exist in the upper Speed subwatershed. Below the Guelph Dam, the flow of the Speed River is dependent on discharges from the Guelph Lake dam and the contributions from the Eramosa River below Guelph. Water use in this subwatershed is substantial, particularly from groundwater, for 68 permits and 119 sources (see Table 13).

The Eramosa River joins with the Speed River in the City of Guelph and continues to the Grand River in Cambridge. The Speed River also assimilates waste from the City of Guelph water treatment plant so minimum flow targets need to be met in the river for this purpose.

Table 13. Speed River Daily permitted and assessed water takings

General Purpose	Specific Purpose	Permitted Maximum			Assessed Water Takings			
		Ground	Surface	Total	Actual /Est.	Ground	Surface	Grand Total
Agricultural	Field and Pasture Crops	6.22		6.22	Est.	1.37		1.37
	Market Gardens / Flowers	63.06		63.06	Actual	1.38		1.38
	Other - Agricultural		7.19	7.19	Actual		0.09	0.09
					Est.		0.22	0.22
	Sod Farm	65.40	44.89	110.29	Actual	0.10	0.85	0.95
					Est.	0.50	0.50	1.00
Agricultural Total		164.42	52.08	216.50		5.42	1.66	7.08
Commercial	Golf Course Irrigation	182.73	45.46	228.19	Actual	5.73	1.37	7.10
					Est.	1.48	0.45	1.92
	Mall / Business	15.23	0.00	15.23	Actual	1.38		1.38
Commercial Total		197.96		243.42		8.59	1.82	10.40
Construction	Dredging		131.48	131.48	Est.		21.61	21.61
Dewatering	Other - Dewatering	6.70		6.70	Est.	6.70		6.70
	Pits and Quarries	159.14		159.14	Actual	129.36		129.36
Dewatering Total		165.84		165.84		136.06		136.06
Industrial	Aggregate Washing	139.00	70.08	209.09	Actual	3.26	0.00	3.26
	Brewing and Soft Drinks	6.40		6.40	Actual	0.00		0.00
	Cooling Water	1.27		1.27	Actual	0.62		0.62
	Manufacturing	11.75	5.83	17.58	Actual	2.11	0.00	2.11
	Other - Industrial	38.50		38.50	Actual	1.22		1.22
Industrial Total		196.93	75.91	272.84		26.78	0.00	26.78
Institutional	Other - Institutional	31.34		31.34	Actual	2.07		2.07
					Est.	1.58		1.58
Miscellaneous	Heat Pumps	15.75		15.75	Est.	11.07		11.07
Remediation	Groundwater	5.10		5.10	Actual	2.13		2.13
					Est.	0.78		0.78
	Other-Remediation	3.81		3.81	Actual	1.02		1.02
Remediation Total		8.91		8.91		3.93		3.93
Water Supply	Campgrounds	2.95		2.95	Est.	1.49		1.49
	Municipal	1117.78		1117.78	Actual	391.58		391.58
	Other - Water Supply	20.46		20.46	Est.	11.23		11.23
Water Supply Total		1141.19		1141.19		404.30		404.30
Grand Total	(in Litres/second)	1,892.60	304.93	**2,197.5**		597.73	25.09	**622.82**

The total permitted water takings for the Speed River subwatershed are quite varied as much of the takings are near the City of Guelph but not close enough for municipal connections. Many of the industries in the Guelph area have PTTW for private well sources. There are no agricultural water takings in this subwatershed.

The actual water taking reports account for approximately 69% of the sources and with the remaining 30% estimated, the total water taking amounts to 623 L/s or about 28% of the permitted maximum (see Table 13).

7.1.3 Mill Creek

Mill Creek is a small tributary of the Grand River, on the central eastern portion of the Grand River watershed. It begins in Puslinch Township near the Village of Aberfoyle and flows in a southwest direction towards Cambridge. Mill Creek drains large portions of two moraines, the Paris and Galt moraines, which are closely connected to the creek and discharge significant amounts of groundwater into Mill Creek. These baseflows keep Mill Creek cold even during the summer months and the Creek is known for high quality water suitable for brook trout spawning. The Creek is highly dependent on the water table for summer flows and is extremely vulnerable to prolonged droughts and water takings.

The permitted water takings (see Table 14) are quite high for the small subwatershed area. The subwatershed has valuable deposits of gravel and aggregate material and thus much of the water takings are for aggregate washing. The high quality water also is extracted for water bottling purposes. All the takings in the Mill Creek subwatershed are groundwater takings, for 16 permits with 29 sources.

Table 14. Mill Creek: Daily permitted and assessed water takings

Category	Specific Purpose	Permitted Maximum		Assessed Water Takings		
		Ground	Total	Actual/ Est.	Ground	Grand Total
Agricultural	Other - Agriculture	0.80	0.80	Est.	0.08	0.08
Commercial	Bottled Water	41.67	41.67	Actual	27.75	27.75
	Golf Course Irrigation	7.60	7.60	Est.	0.53	0.53
Commercial Total		49.27	49.27		28.27	28.27
Industrial	Aggregate Washing	735.68	735.68	Actual	102.41	102.41
				Est.	30.79	30.79
	Food Processing	1.27	1.27	Actual	0.19	0.19
	Manufacturing	5.21	5.21	Actual	1.46	1.46
	Other - Industrial	17.42	17.42	Actual	0.40	0.40
Industrial Total		759.58	759.58		135.26	135.26
Miscellaneous	Heat Pumps	0.69	0.69	Est.	0.69	0.69
Water Supply	Campgrounds	4.55	4.55	Est.	2.09	2.09
	Communal	21.93	21.93	Actual	1.70	1.70
	Municipal	50.00	50.00	Actual	26.77	26.77
Water Supply Total		76.48	76.48		30.56	30.56
Grand Total	(in L/s)	886.82	**886.82**		194.86	**194.86**

The aggregate takings in Mill Creek are the highest demand on this small subwatershed. As seen in Table 14, the actual and estimated water takings are much less, about 22% less than the total permitted maximum. The number estimated values was a bit higher than other subwatersheds and the overall watershed average, as 54% of the sources were estimated.

7.1.4 Fairchild Creek

Fairchild Creek is located on the eastern side of the Grand River watershed, south of Mill Creek and in the County of Brant and City of Hamilton. It is a large area geographically at approximately 695 km^2, but is fairly rural in nature with small communities spread out amongst the subwatershed. There are only two municipal water supplies, the small community of St.

George in the County of Brant and Lynden in the City of Hamilton right on the edge of the watershed boundary. The surficial geology is mostly clay, and therefore the creek is very sinuous and driven primarily by runoff processes. This also means that few of the water takings are from surfacewater, as flows are unreliable in the summer months. The majority are from groundwater sources. Agriculture is a dominant water use, as well as irrigation for several golf courses. Aggregate washing is also using some water in this subwatershed. The total permitted maximum water demand is 520 L/s, as seen in Table 15, for 37 permits and 68 sources.

Table 15. Fairchild Creek: Daily permitted and assessed water takings

General Purpose	Specific Purpose	Permitted Maximum			Assessed Water Takings			
		Ground	Surface	Total	Actual/ Est.	Ground	Surface	Grand Total
Agricultural	Field and Pasture Crops		104.93	104.93	Actual		0.00	0.00
					Est.		0.57	0.57
	Fruit Orchards	7.36		7.36	Est.	0.39		0.39
	Market Gardens / Flowers	1.16		1.16	Est.	0.06		0.06
	Nursery	33.62	20.23	53.85	Actual	0.55	2.01	2.56
					Est.	0.55	0.34	0.88
	Other - Agricultural	65.66		65.66	Actual	0.01		0.01
					Est.	2.66		2.66
	Sod Farm		6.03	6.03	Est.		0.32	0.32
	Tender Fruit	22.08		22.08	Est.	1.16		1.16
Agricultural Total		129.88	131.19	261.07		5.38	3.23	8.61
Commercial	Aquaculture	4.55		4.55	Actual	0.00		0.00
	Golf Course Irrigation	19.33	23.61	42.94	Actual	0.65	0.66	1.31
					Est.	0.88		0.88
	Other - Commercial	16.99		16.99	Actual	0.11		0.11
					Est.	1.84		1.84
Commercial Total		40.86	23.61	64.47		3.48	0.66	4.14
Industrial	Aggregate Washing	36.37		36.37	Actual	0.00		0.00
	Other - Industrial	27.29		27.29	Actual	0.00		0.00
					Est.	15.92		15.92
Industrial Total		63.65		63.65		15.92		15.92
Recreational	Fish Ponds	7.56		7.56	Est.	4.43		4.43
Remediation	Groundwater	2.34		2.34	Est.	2.34		2.34
Water Supply	Campgrounds	1.18		1.18	Est.	0.54		0.54
	Communal	18.85		18.85	Actual	0.97		0.97
					Est.	0.91		0.91
	Municipal	94.70		94.70	Actual	12.42		12.42
	Other - Water Supply	6.31		6.31	Actual	0.00		0.00
Water Supply Total		121.05		121.05		14.83		14.83
Grand Total	(in L/s)	365.34	154.80	**520.15**		46.39	3.89	**50.28**

Many of the permits in the Fairchild Creek were estimated for the adjusted water use values (see Table 15). There were quite a few agricultural permits, which across the watershed were limited in actual water taking records, however there were also estimates needed in other categories. The number of estimated sources (36) was more than the number of actual records (31), at 53.7%.

7.1.5 Grand River Headwaters Subwatersheds

The headwaters area of the Grand River watershed includes the subwatersheds north of the Shand Dam and Belwood Lake. These subwatersheds are mostly contained in the County of Dufferin, but are also touching Grey and Wellington Counties. Luther Marsh and Luther Dam are located in this area. There are very few water takings here, only 12 permits, but includes municipal water takings for 4 small communities including Dundalk, Grand Valley, Waldemar and Marsville. The Grand River is a small river in the headwaters, and thus all the water takings for these subwatersheds are from groundwater sources. The majority is municipal, but aggregate washing is also contributing to the permitted maximum water demands, totaling 296 L/s (see Table 16).

Table 16.Grand Headwaters: Daily permitted and assessed water takings

Category	Specific Purpose	Permitted Maximum		Assessed Water Takings		
		Ground	Total	Actual/ Est.	Ground	Grand Total
Commercial	Other - Commercial	13.33	13.33	Actual	1.31	1.31
Industrial	Aggregate Washing	143.97	143.97	Actual	0.00	0.00
Miscellaneous	Heat Pumps	3.56	3.56	Est.	3.56	3.56
Water Supply	Campgrounds	4.25	4.25	Est.	5.96	5.96
	Communal	45.05	45.05	Est.	37.48	37.48
	Municipal	85.84	85.84	Actual	14.50	14.50
Water Supply Total		135.14	135.14		57.94	57.94
Grand Total	(in L/s)	296.01	**296.01**		62.80	**62.80**

After adjustments for the actual and estimated water takings, Table 16 shows that the annual amount is approximately 63 L/s, with 59% of the 22 sources having actual water taking records.

7.1.6 Grand River from Conestogo to Shand

The Grand River below the Shand Dam and downstream to the confluence of the Conestogo River makes up a subwatershed of high and varied water takings. Municipalities with water takings in this area include Fergus and Elora in Centre Wellington; Conestogo Plains, West Montrose, Elmira and several wells in the Integrated Urban System (IUS) of the Region of Waterloo. The area is fairly rural but most of the water takings occur in close proximity to the urban centres, being just outside the municipally serviced area. A long-term consumptive water taking in this area to note are the groundwater extractions for remediation efforts.

The permitted maximum shows the split between groundwater and surface water is fairly even, but more leaning towards the surface water side due to a large dewatering operation (see Table 17). However, the dewatering is negligible in actual water takings. Overall, the adjusted water takings account for only 12% of the permitted maximums. Many of the sources had actual water taking records, at 81.6%, one of the highest percentages for any subwatershed. There are a total of 39 permits with 75 sources in the Grand Above Conestogo to Shand subwatershed.

Table 17. Grand Conestogo to Shand: Daily permitted and assessed water takings

Category	Specific Purpose	Permitted Maximum			Assessed Water Takings			
		Ground	Surface	Total	Actual / Est.	Ground	Surface	Grand Total
Agricultural	Other - Agricultural		0.74	0.74	Actual		0.00	0.00
Commercial	Aquaculture	143.95		143.95	Actual	52.33		52.33
					Est.	26.53		26.53
	Bottled Water	18.95		18.95	Actual	0.08		0.08
	Golf Course Irrigation	36.37	13.15	49.51	Actual	0.60	0.71	1.31
					Est.	0.04		0.04
Commercial Total		199.26	13.15	212.41		79.58	0.71	80.29
Dewatering	Construction	7.58		7.58	Est.	4.13		4.13
	Other - Dewatering		900.00	900.00	Actual		0.09	0.09
	Pits and Quarries	17.83		17.83	Est.	0.86		0.86
Dewatering Total		25.41	900.00	925.41		5.00	0.09	5.08
Industrial	Aggregate Washing	69.44		69.44	Actual	11.00		11.00
	Food Processing	16.15		16.15	Est.	16.15		16.15
	Other - Industrial	1.07	3.78	4.85	Actual		0.13	0.13
					Est.	1.07		1.07
Industrial Total		86.66	3.78	90.44		28.21	0.13	28.34
Remediation	Groundwater	115.85		115.85	Actual	24.55		24.55
	Other - Remediation	57.66		57.66	Actual	10.20		10.20
Remediation Total		173.51		173.51		34.75		34.75
Water Supply	Campgrounds	4.80		4.80	Est.	2.42		2.42
	Municipal	330.53		330.53	Actual	60.41		60.41
	Other - Water Supply	52.62		52.62	Actual	2.01		2.01
Water Supply Total		387.95		387.95		64.84		64.84
Grand Total (in L/s)		872.78	917.67	**1,790.46**		212.38	0.92	**213.30**

7.1.7 Central Grand Subwatersheds

The central Grand subwatersheds include the 2 subwatersheds from the Conestogo River down to Doon and Doon through to Brantford. Much of this area is urbanized, in the Region of Waterloo (RMOW) and portions of the City of Brantford. Many of the water takings, like other Grand subwatersheds, are in close proximity but outside municipally serviced areas. This subwatershed has the most diverse collection of water taking categories, but since it is the central part of the watershed with three large urban centres, municipal water use has the largest volume (see Table 18). There are 101 permits in these subwatersheds.

Water use in the central portion of the Grand River watershed is high from both groundwater and surface water sources. At peak demand during dry spells, there could be as much as 20 percent of the water removed from the Grand River for a variety of uses. Municipal water takings include many of the wells and the surface water intake for the IUS of the RMOW.

Table 18. Central Grand: Daily permitted and assessed water takings

Category	Specific Purpose	Permitted Maximum			Assessed Water Takings			
		Ground	Surface	Grand Total	Actual/ Est.	Ground	Surface	Grand Total
Agricultural	Field and Pasture Crops	6.32		6.32	Actual	0.31		0.31
	Nursery	3.80		3.80	Est.	0.20		0.20
	Other - Agricultural	9.70	2.52	12.22	Actual	0.16		0.16
					Est.	0.42	0.00	0.42
Agricultural Total		19.82	2.52	22.34		1.09	0.00	1.09
Commercial	Aquaculture	5.45		5.45	Est.	3.41		3.41
	Golf Course Irrigation	278.98	97.87	376.85	Actual	29.79	2.84	32.64
					Est.	3.30	2.30	5.59
	Snowmaking	32.62	0.01	32.63	Actual	1.84	0.00	1.84
Commercial Total		317.04	97.88	414.93		38.34	5.14	43.48
Dewatering	Construction	12.64	28.39	41.03	Actual	0.00		0.00
					Est.	7.80	16.65	24.45
	Other - Dewatering	63.14		63.14	Est.	0.00		0.00
Dewatering Total		75.78	28.39	104.17		7.80	16.65	24.45
Industrial	Aggregate Washing	410.09	182.30	592.39	Actual	86.34	2.54	88.88
					Est.	19.19		19.19
	Cooling Water	79.52		79.52	Actual	42.95		42.95
	Food Processing	14.90		14.90	Actual	3.42		3.42
					Est.	8.53		8.53
	Other - Industrial	25.40		25.40	Actual	0.21		0.21
					Est.	24.07		24.07
Industrial Total		529.91	182.30	712.21		184.70	2.54	187.24
Institutional	Other - Institutional	1.90		1.90	Est.	1.74		1.74
Recreational	Other - Recreational	37.15		37.15	Est.	37.15		37.15
Remediation	Groundwater	6.48		6.48	Actual	2.25		2.25
					Est.	2.93		2.93
	Other - Remediation	16.97		16.97	Actual	35.16		35.16
					Est.	4.46		4.46
Remediation Total		23.45		23.45	44.80		44.80	44.80
Water Supply	Campgrounds	5.64		5.64	Actual	0.51		0.51
					Est.	0.44		0.44
	Communal	31.65		31.65	Actual	0.11		0.11
					Est.	29.50		29.50
	Municipal	2,537.6	2,839.81	5,377.41	Actual	822.76	513.01	1,335.77
	Other - Water Supply	2.58		2.58	Actual	0.34		0.34
Water Supply Total		2,577.5	2,839.81	5,417.28		853.66	513.01	1,366.68
Grand Total (in L/s)		3,582.5	3,150.92	**6,733.43**		1,169.27	537.34	**1,706.61**

The adjusted water takings show that 25% of the permitted maximum is used, with 67% of the 191 sources having actual water taking records.

7.1.8 Southern Grand Subwatersheds

The most southerly portion of the Grand includes 2 subwatersheds from below Brantford down to York and York through to Dunnville and Port Maitland. These subwatersheds cover the County of Brant, the City of Hamilton, Six Nations lands and Haldimand County.

Agricultural water takings are substantial here, similar to other subwatersheds in the lower half of the watershed. Municipal takings include the lake intake for the Haldimand County community of Dunnville and Mount Pleasant in Brant County. Unlike most subwatersheds, however, the majority of water takings in the Southern Grand are from surface water sources. The Brantford municipal water taking is directly from the Grand River for their drinking water supplies. These subwatersheds have 100 permits with 137 sources, as detailed in Table 19.

Other water takings are likely occurring in the Six Nations Reserve for a variety of uses, however they do not require PTTWs so they will not be quantified here. The Ohsweken water taking is detailed in the Section 3.0 of this report.

Table 19. Southern Grand: Daily permitted and assessed water takings

Category	Specific Purpose	Permitted Maximum			Assessed Water Takings			
		Ground	Surface	Grand Total	Actual/ Est.	Ground	Surface	Grand Total
Agricultural	Field and Pasture Crops	372	200	572	Actual	0.18	1.41	1.59
					Est.	7.50	6.62	14.11
	Market Gardens / Flowers	12		12	Est.	0.50		0.50
	Nursery	55	51	106	Actual	0.97	0.26	1.22
	Other - Agricultural	233	130	363	Actual	0.22	1.47	1.69
					Est.	7.46	4.82	12.28
	Sod Farm		152	152	Est.		7.97	7.97
	Tobacco	273	171	444	Actual	2.29	0.00	2.29
					Est.	7.31	1.94	9.24
Agricultural Total		945	703	1648		26.42	24.49	50.91
Commercial	Golf Course Irrigation	125	50	175	Actual	2.54	2.92	5.47
					Est.	2.90	0.60	3.50
	Other - Commercial	2		2	Actual	0.02		0.02
Commercial Total		127	50	177		5.47	3.52	8.99
Dewatering	Other - Dewatering	124		124	Actual	0.00		0.00
	Pits and Quarries	364		364	Actual	49.12		49.12
Dewatering Total		487		487		49.12		49.12
Industrial	Aggregate Washing	68		68	Est.	5.98		5.98
	Food Processing	3		3	Actual	0.00		0.00
	Manufacturing	95		95	Actual	2.91		2.91
	Other - Industrial	5		5	Est.	4.55		4.55
Industrial Total		171		171		13.44		13.44
Water Supply	Campgrounds	5	2	7	Est.	2.27	0.08	2.35
	Municipal	57	3,362	3,419	Actual	10.63	548.96	559.59
Water Supply Total		62	3,364	3,426		12.90	549.04	561.94
Grand Total	(in L/s)	1,713	4,117	**5,909**		107.27	577.05	**684.40**

The adjusted water takings for actual and estimated values show that less than 12% of the permitted maximum is being used. Actual records were available for only 48% of the sources.

7.1.9 McKenzie Creek

McKenzie Creek flows west to east through Brant and Norfolk Counties and through the Six Nations reserve in the southern portion of the Grand River watershed. McKenzie Creek is an intermediate-sized tributary with two distinct flow regimes based on its surficial geology. The headwaters are located in the Norfolk Sand plain, dominated by good baseflows but also high water use. The lower half flows through the Haldimand clay plain which is primarily runoff-driven. Boston Creek tributary joins up with McKenzie Creek just south of Caledonia and the combined flows enter the Grand River at York. There is a small dam called Victoria Mills Dam on McKenzie Creek just at the border with the Six Nations Reserve and Norfolk County.

Agricultural irrigation is a major water use in the summer months, putting stress on the Creek. There are no municipal water takings in this subwatershed, all residents are on private systems, generally on wells. Most of the 114 sources of water takings are from groundwater sources, although about 25% are from surface water (see Table 20). Overall there are 84 permits in this subwatershed. Other water takings are likely occurring in the Six Nations Reserve for a variety of uses, however they do not require PTTWs so they will not be quantified here.

Table 20. McKenzie Creek: Daily permitted and assessed water takings

Category	Specific Purpose	Permitted Maximum			Assessed Water Takings			
		Ground	Surface	Grand Total	Actual/ Est.	Ground	Surface	Grand Total
Agricultural	Field and Pasture Crops	562.99	323.55	886.54	Actual	0.79	0.91	1.70
					Est.	19.16	7.11	26.27
	Fruit Orchards	15.15		15.15	Actual	0.00		0.00
	Market Gardens / Flowers	71.65	61.45	133.10	Actual	0.29	0.18	0.47
					Est.	2.72	3.19	5.91
	Other - Agricultural	578.48	83.45	661.93	Actual	0.57	1.08	1.65
					Est.	14.56	2.51	17.08
	Sod Farm	6.00	6.00	11.99	Actual	0.36	0.05	0.42
	Tobacco	201.68		201.68	Actual	1.54		1.54
					Est.	4.34		4.34
Agricultural Total		1,435.95	474.44	1,910.39		44.33	15.04	59.37
Commercial	Aquaculture	8.33		8.33	Est.	8.33		8.33
	Golf Course Irrigation		13.45	13.45	Est.		0.71	0.71
Commercial Total		8.33	13.45	21.78		8.33	0.71	9.04
Dewatering	Other - Dewatering	11.37		11.37	Est.	11.37		11.37
	Pits and Quarries	106.13		106.13	Est.	106.13		106.13
Dewatering Total		117.50		117.50		117.50		117.50
Grand Total (in L/s)		1,561.78	487.89	**2,049.67**		170.17	15.74	**185.91**

Since so many of the water takings in McKenzie Creek were agricultural, there were few actual water taking records, only 42.7% of the sources had them available. However, with the estimates as well, the annual water taking adjusted to be less than 10% of the permitted maximum. The adjustments also account for the seasonality of the water takings in this area, many months are assumed to be idle with respect to the water takings, especially the winter months.

7.1.10 Nith River

The Nith River is a major tributary of the Grand River, on the western side of the watershed. The headwaters begin in Perth County and travels south through Waterloo and Oxford Counties before joining up with the Grand in the Town of Paris, Brant County.

The upper subwatershed – Nith Above New Hamburg – drains an area of till pains where runoff is high and the response to rainfall in the River is flashy. Natural streamflow in the upper portions of the Nith River is minimal during dry periods. There are few permitted water takings in the upper Nith, only 13 permits with 22 sources. However, the highest agricultural water use for livestock for the entire Grand River watershed is in this subwatershed.

The lower subwatershed – Nith River below New Hamburg to the Grand confluence – flows through the Waterloo Moraine and picking up substantial groundwater discharge, which maintains baseflows during the dry season. There are substantial water takings in the lower Nith River subwatershed, dominated by municipal takings for the Region of Waterloo, which are all from groundwater sources. About 11% of the water takings are from surface water in the two subwatersheds (see Table 21). There are 58 permits with 116 sources in this subwatershed.

Table 21. Lower Nith River Daily permitted and assessed water takings

General Purpose	Specific Purpose	Permitted Maximum			Assessed Water Takings			
		Ground	Surface	Total	Actual/ Est.	Ground	Surface	Grand Total
Agricultural	Field and Pasture Crops	97.70	97.72	195.41	Actual	0.58	0.14	0.72
					Est.	2.35	4.31	6.66
	Fruit Orchards		3.17	3.17	Est.		0.17	0.17
	Other - Agricultural		66.90	66.90	Est.		3.52	3.52
	Tobacco	85.71	37.70	123.41	Est.	4.51	1.98	6.49
Agricultural Total		183.41	205.50	388.90				
Commercial	Aquaculture	18.50		18.50	Est.	18.50		18.50
	Golf Course Irrigation	104.37	8.53	112.91	Actual	0.13	0.06	0.19
					Est.	0.56		0.56
	Other - Commercial	14.11		14.11	Actual	0.92		0.92
Commercial Total		136.98	8.53	145.51				
Industrial	Aggregate Washing	434.94		434.94	Actual	94.47		94.47
					Est.	68.58	14.87	83.45
	Cooling Water	4.86		4.86	Actual	1.56		1.56
	Food Processing	16.95		16.95	Actual	2.25		2.25
					Est.	4.86		4.86
	Manufacturing	4.25		4.25	Actual	0.35		0.35
	Other - Industrial	311.58	90.91	402.50	Actual	0.01		0.01
					Est.	22.07	0.00	22.07
Industrial Total		772.58	90.91	863.49		194.14	14.87	209.01
Remediation	Other - Remediation	55.83		55.83	Actual	21.31		21.31
Water Supply	Campgrounds	1.25		1.25	Est.	0.62		0.62
	Municipal	1,336.28		1,336.28	Actual	403.58		403.58
	Other - Water Supply	3.03		3.03	Est.	3.03		3.03
Water Supply Total		1,340.56		1,340.56		407.23		407.23
Grand Total	(in L/s)	2,489.36	304.94	**2,794.3**		650.22	25.05	**675.27**

Agricultural irrigation is prominent in the lower Nith, mostly from surface water sources. However, the remainder of the water takings for a variety of uses is mostly from groundwater resources. Approximately 63% of the sources had actual water use records, and the rest were estimated, many from the agricultural irrigation permits.

The actual and estimated values reduce the taking to about 35% of the maximum for the lower Nith, and 29% for the upper Nith subwatershed (Table 22).

Table 22. Upper Nith Daily permitted and assessed water takings

Category	Specific Purpose	Permitted Maximum			Assessed Water Takings			
		Ground	Surface	Total	Actual/ Est.	Ground	Surface	Grand Total
Agricultural	Market Gardens / Flowers		8.33	8.33	Est.		0.38	0.38
	Nursery	32.16		32.16	Actual	1.10		1.10
Agricultural Total		32.16	8.33	40.50		1.10	0.38	1.49
Commercial	Golf Course Irrigation		15.16	15.16	Actual		0.29	0.29
Industrial	Cooling Water	1.79		1.79	Actual	0.42		0.42
	Heat Pumps	1.22		1.22	Est.	1.22		1.22
Industrial Total		3.00		3.00		1.64		1.64
Recreational	Other - Recreational		3.97	3.97	Est.		3.99	3.99
Water Supply	Communal	2.27		2.27	Actual	0.12		0.12
					Est.	0.76		0.76
	Municipal	97.89		97.89	Actual	39.22		39.22
Water Supply Total		100.16		100.16		40.10		40.10
Grand Total (in L/s)		135.33	27.47	**162.79**		42.84	4.66	**47.50**

7.1.11 Whitemans Creek

The Whitemans Creek subwatershed is located in the southern portion of the Grand River watershed on the western side, draining through Brant and Oxford Counties. The flows in Whitemans Creek are largely dependent on groundwater from the high water table on the Norfolk Sand plain. The Creek supports a good cold-water fishery due to the sustained coldwater baseflows, but is also subject to many water takings for agricultural irrigation. The Whitemans Creek subwatershed is dominated by agricultural land uses; it has the most concentrated demand for agricultural irrigation in the Grand River watershed.

Aside from agriculture, there are very few other water takings in the Whitemans Creek subwatershed, despite there being 130 permits in the watershed. There is one municipal water taking for the community of Bright in Oxford County and two commercial operations.

The majority of water takings are from groundwater, however there is a substantial demand for water for irrigation from the Creek during the summer months, when flows would be the lowest. It would be possible for the maximum taking in the creeks to significantly affect the flow in Whitemans Creek if they occurred simultaneously. Average summer low flows in the creek are 1600 L/s, while the maximum permitted water taking is 57% of that flow (915.5L/s), as seen in Table 23. Also, there is a strong connection between the shallow groundwater and surfacewater, due to the surficial geology of the region. Groundwater takings from dugout ponds, which make

up a good portion of the ground sources, could affect streamflows depending on their proximity to the creeks.

Table 23. Whitemans Creek: Daily Permitted Water Taking (Litres/second)

Category	Specific Purpose	Permitted Maximum			Assessed Water Takings			
		Ground	Surface	Grand Total	Actual/ Est.	Ground	Surface	Grand Total
Agricultural	Field and Pasture Crops	839.19	186.97	1,026.16	Actual	7.21	0.00	7.21
					Est.	26.14	8.72	34.86
	Fruit Orchards	7.57		7.57	Est.	0.40		0.40
	Nursery	10.46		10.46	Actual	0.39		0.39
	Other - Agricultural	394.73	238.54	633.27	Actual	3.43	0.00	3.43
					Est.	18.01	6.77	24.77
	Sod Farm	191.05	33.28	224.33	Actual	8.64		8.64
					Est.	5.73	1.75	7.48
	Tender Fruit	29.90		29.90	Actual	0.96		0.96
					Est.	0.08		0.08
	Tobacco	1,130.96	456.73	1,587.69	Actual	15.87	1.39	17.26
					Est.	35.35	21.02	56.37
Agricultural Total		2,603.85	915.52	3,519.37		122.28	39.65	161.93
Commercial	Golf Course Irrigation	21.07		21.07	Actual	0.49		0.49
	Other - Commercial	1.52		1.52	Est.	1.52		1.52
Commercial Total		22.59		22.59		2.00		2.00
Water Supply	Municipal	3.79		3.79		1.07		1.07
Grand Total (in L/s)		2,664.32	915.52	**3,545.75**		125.36	39.65	**164.93**

Much work has been done in collaboration with the agricultural irrigators in Whitemans Creek subwatershed to deal with seasonal drought issues and creek flows in the summer months. Water takings for agricultural irrigation have also been in fluctuating over the past 5 years with the collapse of the tobacco quota system and a shift towards other crops such as ginseng and vegetables. However, the area has seen a return of more tobacco in the past year due to contracts directly with cigarette manufacturers to grow tobacco. It is very uncertain which permits are in use year to year, as irrigation is also highly dependent on climate and precipitation patterns as well as the crops grown. Some of the replacement crops may not need irrigation and while ginseng and vegetables do, it is uncertain whether the water demand is higher for these crops or for tobacco.

The estimates of water taking assume all permits are in use; about 73% of the sources were estimated meaning only 26% having actual records available to refine the usage. The percentage of actual records for permits is the lowest in the Whitemans Creek subwatershed relative to all other Grand River subwatersheds. As mentioned previously, agricultural permits had a fairly low return rate of actual records for their permits and since the Whitemans Creek subwatershed is primarily agricultural, the estimation of water takings was necessary for a majority of the sources.

8.0 Analysis/ Summary of Water Use

This section will summarize all the water use data that has been described in previous sections and compare them all on an annual basis. On an annual basis, Figure 17 shows all the water uses in the Grand River watershed and how they compare percentage-wise to each other. On a monthly basis, Table 24 lists all water uses described in the report and compares them against one another, as well as illustrates the monthly variation of water use.

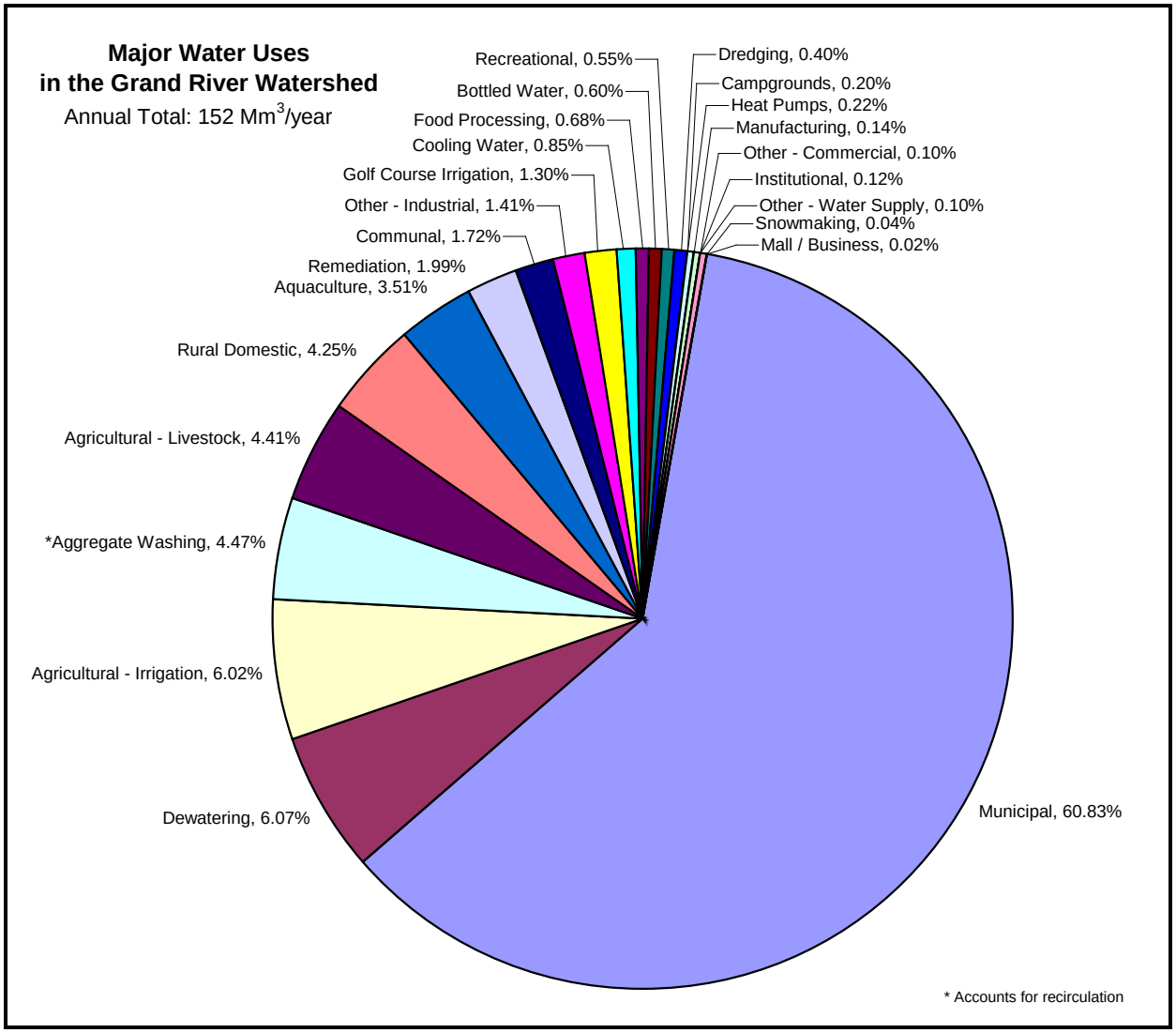

Figure 18. Major water uses on an annual basis pie chart

The pie chart in Figure 17 shows that municipal water use is the most significant water use in the Grand River watershed, by a huge margin. Municipal water use is 10 times more than the next major water use, which is dewatering (6%). Municipal water use may seem elevated at 60.8% of total water use, but it is the most accurate category as it is the only one based entirely on actual water takings. The percentage is higher than the previous report (37%), but accuracies of all categories have improved and most water takings have been refined. Other water takings also have a good percentage of actual water taking records instead of estimating use with the permitted maximum.

Table 24. Total water use comparison

	Water Taking Category	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
		1000's of cubic metres												
1	Municipal	8,320	7,760	8,580	8,410	8,900	9,230	9,580	9,100	8,590	8,700	8,150	7,830	▼ **103,340**
2	Dewatering	730	800	780	890	930	900	930	920	930	950	790	770	▼ **10,320**
3	Agricultural - Irrigation	0.70	0.6	6.9	8.5	63.3	2,484	3,734	2,599	1,273	43.4	9.3	0.4	▲ **10,220**
4	Aggregate Washing	20	10	10	200	1130	1130	1180	1090	1070	1180	560	20	▼ **7,600**
5	Agricultural - Livestock	637	575	637	616	637	616	637	637	616	637	616	637	▼ **7,496**
6	Rural Domestic	613	554	613	594	613	594	613	613	594	613	594	613	▲ **7,223**
7	Aquaculture	470	450	510	520	540	470	480	440	480	530	490	560	▼ **5,960**
8	Remediation	213	204	207	239	230	188	1,002	189	222	245	258	210	▼ **3,380**
9	Communal	240	220	240	230	260	250	260	260	250	260	230	236	▲ **2,930**
10	Other - Industrial	191	175	192	185	192	215	241	230	215	193	185	190	▼ **2,400**
11	Golf Course Irrigation	3.3	2.5	2.8	22	262	451	607	488	313	42	3.2	3.1	▼ **2,210**
12	Cooling Water	120	122	127	114	110	110	107	131	142	139	137	78	▼ **1,440**
13	Food Processing	93	85	92	90	92	99	103	102	102	102	96	99	▼ **1,150**
14	Bottled Water	80	80	80	90	100	100	100	90	70	70	90	80	▼ **1,020**
15	Recreational	66	60	66	64	66	99	103	103	99	81	64	66	▼ **940**
16	Dredging	0	0	0	0	114	114	114	114	114	114	0	0	▼ **680**
17	Heat Pumps	32	29	32	31	32	31	32	32	31	32	31	32	▲ **370**
18	Campgrounds	0.4	0.4	0.5	0.8	59	59	64	59	57	41	0.7	0.4	▼ **340**
19	Manufacturing	14.8	17.4	17.4	19.8	19.9	18.4	19.2	19.9	23.7	27.5	20.9	15.2	▼ **230**
20	Institutional	12.5	16.9	17.6	19.0	17.5	16.0	16.6	17.4	17.6	18.7	17.0	10.5	▲ **200**
21	Other - Commercial	9.8	8.8	9.7	9.5	10.6	12.0	20.3	17.5	30.8	17.0	9.7	9.6	▼ **170**
22	Other - Water Supply	15	14	15	14	14	13	14	14	13	14	13	13	▼ **166**
23	Snowmaking	12.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.2	34.2	▼ **60**
24	Mall / Business	3.9	4.0	3.7	2.6	2.9	3.5	3.9	5.1	3.7	3.7	3.2	3.2	▼ **40**
	TOTAL (1000's of m^3)	**10,392**	**9,824**	**10,749**	**10,907**	**12,800**	**15,661**	**18,379**	**15,697**	**13,726**	**12,492**	**10,927**	**10,012**	▼ **151,730**

In Table 24, the upwards and downwards facing arrows show the change from the previous report. An increase in the value is a red upwards arrow while a smaller value compared to the previous report is symbolized by a black downwards arrow.

Overall, the estimate of total water use has decreased by half (50%) from the previous report, due to the availability of actual records and better estimates for water takings since that publication. While the permits are still a necessary accounting tool for water use, because the reporting system is in place, reliance on the permitted maximum taking for estimates of water use has been diminished. The total water demand estimate in the Grand River watershed is 152Mm^3 each year.

Current municipal water use is slightly below the estimated value from the 2005 report, by about 6%. As population growth has been seen in the watershed, several other factors may be contributing to this unusual result, such as the elimination of estimated municipal water takings, a reduction in industrial/commercial water takings, water conservation or lower seasonal water demands due to climatic patterns.

One of the best improvements in the estimates from the previous report was seen for the Dewatering category. In the 2005 report, Dewatering was the second highest use, at 47.5 Mm^3/year, primarily on estimates based on the permitted maximum. However, currently almost half of the permits have reported takings, thus dewatering has dropped to a quarter of that previous estimated value, to 10.3 Mm^3/year. The dewatering category is still second overall for 2008, but with greatly reduced reliance on estimation techniques. Almost all the categories have seen an improvement of the assessed water takings through a reduction in the number of estimated sources.

Only four categories had increased water demand, including rural domestic, agricultural irrigation, other institutional and industrial heat pumps. However, the latter two had more permits or had no permits in the watershed previously. For the only estimate that wasn't based on permits but instead on population, namely rural domestic use, their water demand increased. The rural domestic water use increased by 8%, based on the population growth that occurred over the 5 years between the Census years.

To illustrate the difference in seasonal water takings, Figure 18 shows the monthly distribution of water takings. While agricultural irrigation on an annual basis is fourth overall, it becomes the second highest water use in the months of June through August when irrigation is occurring at its peak. Aggregate washing is also a very high water use, second overall, but similar to irrigation, it only occurs in the warmer months of the year. The remaining non-municipal water takings are fairly evenly spread throughout the year.

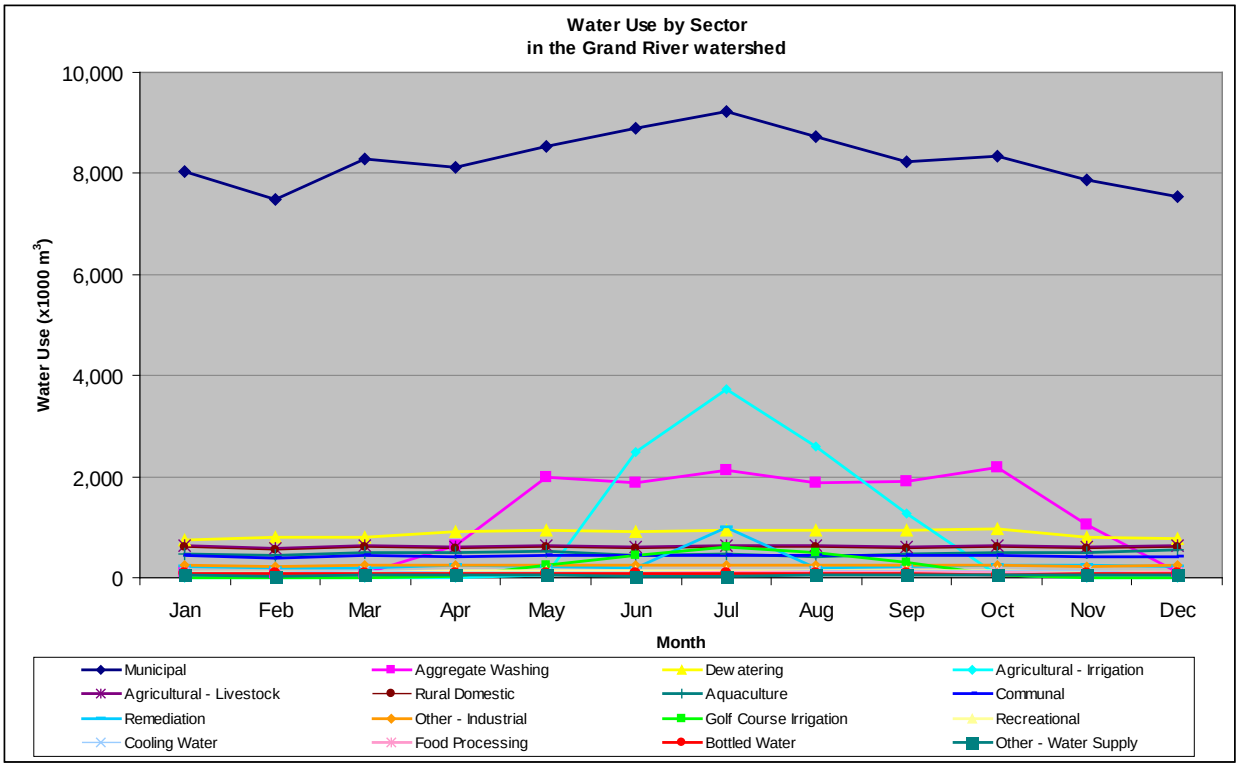

Figure 19. Monthly variation of water use for selected water uses

9.0 Consumptive Use

While pumping data on water takings is the main focus of this report, the impact these water takings have on the hydrologic system of the Grand River watershed is also important to consider. Any water that is taken from a source is considered a consumptive use if it is not returned to that source. If only a fraction of that water taken is consumed, then a 'consumptive use factor' can be applied to the taking. While this is a water use inventory report, the consumptive use factor was not included in the Summary of Water Use (Section 8.0), but is included here as an additional consideration for water budget purposes.

Water takings are often temporary removals of water from a source, since a portion of the water is returned to that system at a later time. The amount of water that is NOT returned is considered 'consumed' by the taking, and is relevant to water budgeting purposes. For example, golf courses that take water from their ponds to irrigate will see some of this water returned to the pond through runoff or via infiltration through the soil. Since the water has returned to its source, it is not lost from this system and less of an impact than if it was none of the water was returned. The fraction of the amount of water consumed relative to the amount pumped and reported in the water takings is called the 'Consumptive Use Factor'. A list of these consumptive use factors is seen in Table 25, based on the type of taking (PTTW specific uses) and the source of the water. The sources of water are divided into 3 groups: deep groundwater, which includes drilled wells into the confined aquifer; shallow groundwater, which includes sandpoints and other shallow wells, dugout ponds and other sources that remove water from the water table; and surface water, such as streams, online ponds and rivers.

Table 25 shows that for golf course irrigation, 70% of the water that is pumped from surface or shallow ground water is consumed, and only 30% returns to that source. This factor incorporates the processes of infiltration and recharge that returns some of the pumped water back to the surface source or the water table. However, for deep well takings, a small proportion of the water that is used for irrigation returns to the deep aquifer so the consumptive use factor of 0.95 shows most of the water being consumed by the taking. So this ratio is based on the source of supply (groundwater and surface water), and the nature of the return path to that source.

Water taking categories that are entirely consumptive, include water bottling, food processing, and brewing and soft drinks, because the water needed is entirely incorporated into the product, hence none returns to the source. On the other end of the spectrum, some uses are almost completely non-consumptive, such as processes that retain water on the landscape at the source including dams and reservoirs and water flowing through a aquaculture operation for fish. Other 'non-consumptive' uses as previously mentioned in Section 5.1.1.1, are excluded as a water taking since their consumption is only evaporative losses.

Table 25. Consumptive use factors for specific water takings

Category	Specific Purpose	Consumptive Factor		
		Surface Source	Ground Confined	Ground Shallow
Agricultural	Field and Pasture Crops	0.8	0.95	0.8
	Fruit Orchards	0.8	0.95	0.8
	Market Gardens / Flowers	0.9	0.95	0.9
	Nursery	0.9	0.95	0.9
	Other - Agricultural	0.8	0.95	0.8
	Sod Farm	0.9	0.95	0.9
	Tender Fruit	0.8	0.95	0.8
	Tobacco	0.9	0.95	0.9
Commercial	Aquaculture	0.005	1	---
	Bottled Water	1	1	1
	Golf Course Irrigation	0.7	0.95	0.7
	Mall / Business	0.25	1	---
	Other - Commercial	1	1	---
	Snowmaking	0.5	0.8	0.5
Construction	Other - Construction	0.75	1	1
	Road Building	0.75	1	1
Dewatering	Construction	0.005	1	1
	Other - Dewatering	0.005	1	1
	Pits and Quarries	0.005	1	1
Industrial	Aggregate Washing	1	1	0.07
	Brewing and Soft Drinks	1	1	1
	Cooling Water	0.25	1	1
	Food Processing	1	1	1
	Manufacturing	0.1	1	1
	Other - Industrial	0.1	1	1
Institutional	Hospitals	0.25	1	1
	Other - Institutional	0.25	1	1
	Schools	0.25	1	1
Miscellaneous	Dams and Reservoirs	0.005	---	---
	Heat Pumps	0.5	0.5	0.5
	Other - Miscellaneous	1	1	1
	Pumping Test	---	1	1
Remediation	Groundwater	---	1	---
	Other - Remediation	---	1	---
Water Supply	Campgrounds	0.2	1	---
	Communal	0.2	1	---
	Municipal	0.2	1	---
	Other - Water Supply	0.2	1	---

(Adapted from ARI for GRCA, 2009)

Other uses identified in the Grand River watershed have varying degrees of consumption based on the source of water. By default, most of the deep groundwater takings are assumed to be completely consumptive as any return of water to these aquifers is assumed to occur on such a long time frame, if at all, that any lower consumptive use factor seemed unrealistic. Surface

water and some shallow groundwater takings have some return, to factor in runoff, infiltration and recharge processes, as well as pumping back to the source by the taker, such as wastewater treatment plant discharges and recycling of water. For example, agricultural takings are given an 80-90% consumptive use factor, due to runoff, infiltration and irrigation inefficiencies; while municipal or other water supply water takings are only 20% consumptive since wastewater treatment flows return much of the water back to the system. Aggregate washing, through the cycling of water between wash and settling ponds, also has a very low consumptive use factor but sources of this wash water (wells and rivers) are consumed completely. The comparison of water takings in the Grand River watershed based on the consumptive use factor are shown in Figure 19. A shift in the ranking of some water uses is seen, the most significant is aggregate washing from third highest in water takings, down to tenth when considering consumptive use. The total amount of water consumed on an annual basis decreases from the total pumped volume of 152 Mm^3/year to approximately 85% of that or 128 Mm^3/year.

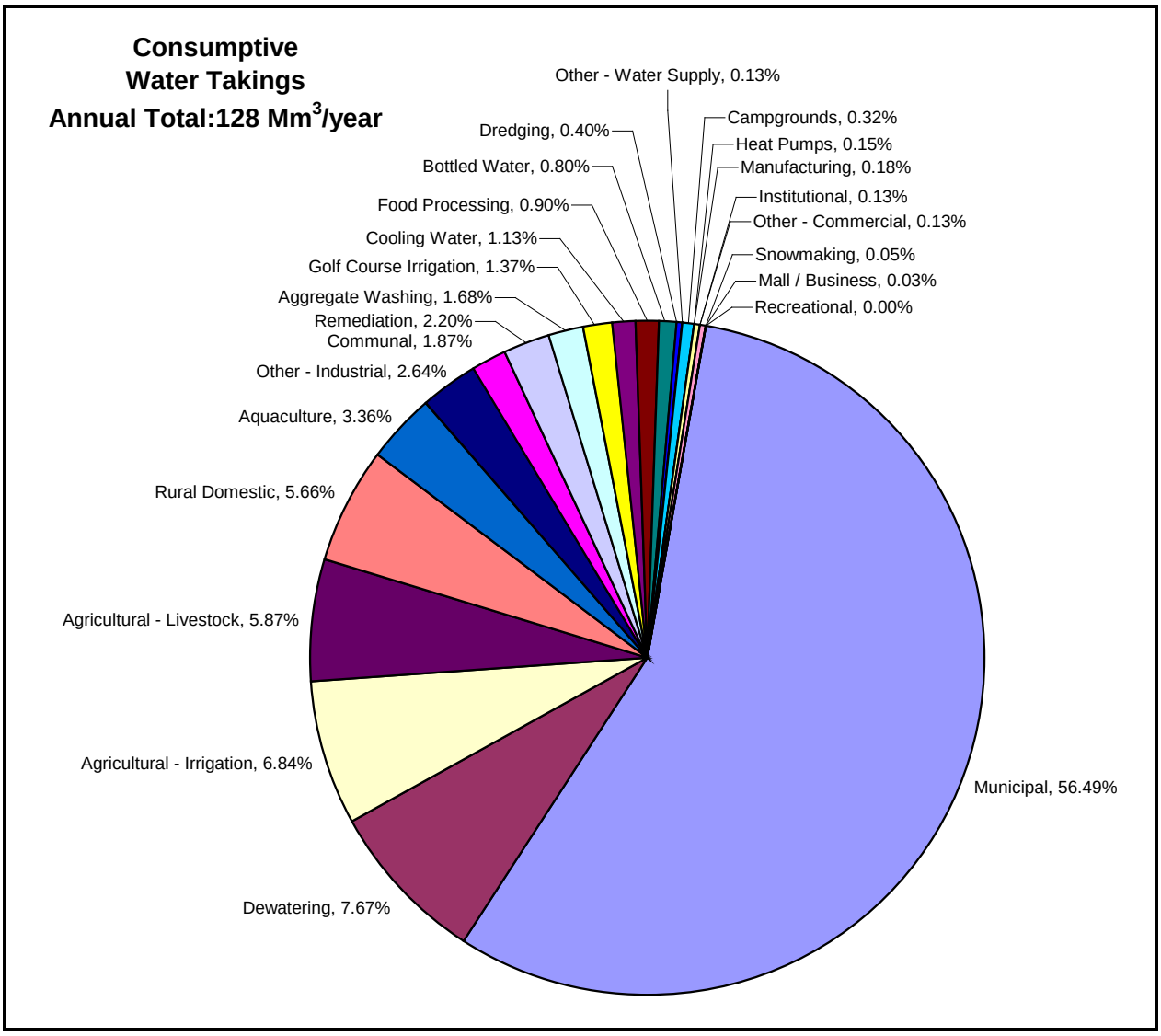

Figure 20. Consumptive water taking comparison of all water uses pie chart

To illustrate the difference in the amount of water permitted, taken and consumed by the PTTW in the watershed, Figure 20 shows the difference in each volume of water. The permitted maximum is quite high, representing all the water takings that could occur, but the reported and estimated volume pumped is the approximation of the actual water that is taken from the system. Finally, the consumed volume is what is not returned to the watershed hydrological system as it is removed from the watershed or consumed in the processes.

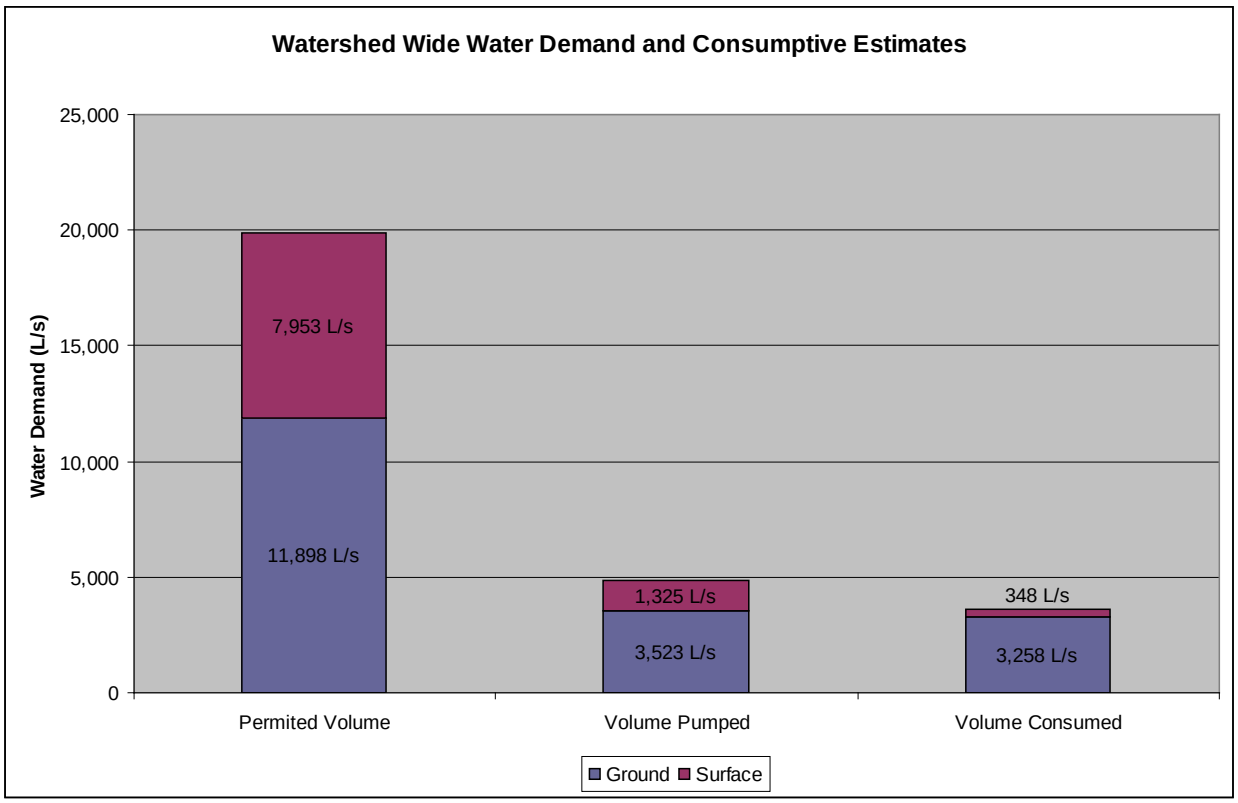

Figure 21. Comparison of water demand estimates with consumptive factors

Consumptive Use Factor for Aggregate Washing

A small percentage of water throughout the washing cycle is consumed in the process, through evaporative losses or cohesion to the aggregate. The consumptive use ratio for the pumping of the water from source to holding ponds is 7%. For the initial takings from other sources however, such as from a well or stream, the volumes of extracting this water are considered as completely consumptive (ratio =1).

10.0 Conclusions

The availability of water use data in the past five years has grown extensively and has allowed for better estimates of overall water use in the Grand River. The data set is not entirely complete, as only 55% of water sources had actual water taking records, but this is much improved since prior to the Water Taking Reporting System. The improvement in actual records allowed for an improvement in estimates where records were unavailable. Trends could be taken from the records and incorporated with additional local expert knowledge to better understand the categories of use and its typical demands. This report has strived to give the best estimate possible of water taking in the Grand River watershed in each category of water use.

This report has identified the following water uses as the 15 most important takings (pumped) across the watershed:

1. Municipal Water Supply
2. Dewatering
3. Agricultural – Irrigation
4. Aggregate washing
5. Agricultural – Livestock watering
6. Rural Domestic Water Supply
7. Aquaculture
8. Remediation
9. Communal Water Supply
10. Unspecified Industrial Uses
11. Golf Course Irrigation
12. Industrial Cooling Water
13. Food Processing
14. Bottled Water
15. Recreational Uses

The annual totals of these categories are useful for comparison, but it must be noted that many of these water takings occur on a seasonal basis and the intensity of water demands at certain times of the year shift for different uses. Most importantly, agricultural irrigation rises dramatically in the summer months and becomes the second most intense use the watershed.

The previous Water Use Inventory Report (GRCA, 2005) identified several shortcomings of water taking data that has been much improved since then. One of these issues was the reliance on and use of the permitted maximum takings of the PTTW for estimates of water demand. However, the adjustments made from trends seen in the actual reported water takings, especially in the agricultural irrigation category greatly reduced the uncertainty and accuracy in the estimates.

While the population has grown about 14% in the watershed since the previous report, the demand approximations have vastly reduced the total volume of water used on an annual basis. In the Grand River watershed, this inventory has found that 152 Mm^3/year is taken from surface and groundwater sources, a reduction of almost 50% from the 298 Mm^3/year as estimated 5 years ago. If the percentage of actual reporting of water takings improve, the approximation could be further refined and better reflect actual water demand in the watershed. As the WRTS continues to collect information, the hope is that all sources of water takings will have reports on the water that is taken from that location.

11.0 References

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12.0 Appendices

Appendix A: Monthly Assessment of Pumped Water Takings by Subwatershed

Appendix B: Maps of Permits to Take Water by Subwatershed

Appendix A: Monthly Assessed Water Takings

These tables show the monthly assessed water takings (actual and/or estimated) for all the permits in each subwatershed.

Conestoga River

Category	Specific Purpose	Actual/ Est.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Dewatering	Other - Dewatering	Actual						0.00	0.36	0.30	1.59				2.25
Industrial	Aggregate Washing	Actual					22.88	28.85	30.91	23.15	23.90	18.82			148.52
	Manufacturing	Actual	0.00	0.00	0.75	0.96	1.56	2.31	2.61	2.34	2.25	2.27	1.88	1.77	18.70
	Other - Industrial	Actual	5.76	5.77	5.69	5.34	5.88	5.24	5.06	4.90	4.91	5.41	5.24	4.89	64.09
		Est.	1.12	1.12	1.12	1.12	1.12	1.18	1.26	1.18	1.18	1.12	1.12	1.12	13.76
Industrial Total			6.88	6.90	7.55	7.42	31.44	37.58	39.84	31.56	32.24	27.62	8.25	7.78	245.07
Water Supply	Campgrounds	Actual	0.00	0.00	0.00	0.00	0.73	0.81	1.22	1.31	0.49	0.28	0.00	0.00	4.86
	Communal	Est.	236.76	213.85	236.76	229.12	236.76	229.12	236.76	236.76	229.12	236.76	229.12	236.76	2,787.63
	Municipal	Actual	61.52	60.92	59.82	61.72	66.56	67.91	67.48	63.92	62.47	63.87	61.53	61.25	758.98
	Other - Water Supply	Actual				0.00	0.24	0.37	0.60	0.49	0.23	0.08			2.01
Water Supply Total			298.28	274.77	296.57	290.85	304.28	298.22	306.06	302.48	292.32	301.00	290.65	298.00	3,553.48
Grand Total in 1000xm^3			305.16	281.67	304.13	298.27	335.73	335.80	346.26	334.33	326.15	328.62	298.89	305.79	**3,800.80**

Eramosa River

Category	Specific Purpose	Actual/ Est.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Agricultural	Field and Pasture Crops	Est.						3.14	4.72	3.14	1.57				12.58
	Other - Agricultural	Actual	0.00	0.00	0.00	0.00	0.00	0.00	14.02	38.74	37.47	17.07	0.00	0.00	107.31
Agricultural Total			0.00	0.00	0.00	0.00	0.00	3.14	18.74	41.88	39.05	17.07	0.00	0.00	119.88
Commercial	Aquaculture	Actual	208.15	201.92	240.88	223.26	216.52	153.96	159.84	122.68	167.27	222.27	212.72	251.60	2,381.06
	Bottled Water	Actual	6.27	13.99	15.28	20.51	19.02	13.12	8.50	12.29	4.96	4.34	13.76	13.00	145.03
	Golf Course Irrigation	Actual				4.29	24.10	33.51	82.08	44.06	43.07	3.35	0.30	0.05	234.81
Commercial Total			214.41	215.91	256.16	248.06	259.64	200.59	250.42	179.02	215.30	229.96	226.78	264.65	2,760.90
Recreational	Other - Miscellaneous	Est.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Other - Recreational	Est.	3.05	2.75	3.05	2.95	3.05	2.95	3.05	3.05	2.95	3.05	2.95	3.05	35.86
Recreational Total			3.05	2.75	3.05	2.95	3.05	2.95	3.05	3.05	2.95	3.05	2.95	3.05	35.86
Water Supply	Municipal	Actual	749.0	628.3	714.2	696.3	1,006.2	696.8	835.0	748.8	658.8	800.1	870.1	668.6	9,072.1
Grand Total in 1000xm^3			966.4	847.0	973.4	947.3	1,268.9	903.4	1,107.2	972.7	916.1	1,050.2	1,099.8	936.3	**11,988.7**

Speed River

Category	Specific Purpose	Actual/ Est.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Agricultural	Field & Pasture Crops	Est.				5.41	5.41	5.41	5.41	5.41	5.41	5.41	5.41		43.27
	Market Gardens / Flowers	Actual					0.00	21.24	33.98	36.70	31.96				123.87
	Other - Agricultural	Actual								2.76					2.76
		Est.				0.45	0.90	5.42	7.23	5.27	2.86	0.45			22.57
	Sod Farm	Actual					22.02	65.81	79.86	70.10	18.26	1.10			257.14
		Est.						7.86	11.78	7.86	3.93				31.43
Agricultural Total						5.86	28.33	105.73	138.25	128.08	62.41	13.95	5.41		488.01
Commercial	Golf Course Irrigation	Actual	0.20	0.14	0.14	9.14	24.47	24.85	67.93	65.34	29.34	1.93	0.23	0.26	223.98
		Est.					4.11	9.79	18.01	16.44	8.22	4.11			60.69
	Mall / Business	Actual	3.93	4.03	3.69	2.58	2.88	3.53	3.91	5.14	3.72	3.68	3.18	3.17	43.45
Commercial Total			4.13	4.17	3.83	11.72	31.47	38.18	89.86	86.92	41.28	9.73	3.41	3.43	328.12
Construction	Other - Construction	Est.					113.60	113.60	113.60	113.60	113.60	113.60	0.00	0.00	681.60
Dewatering	Other - Dewatering	Est.	17.95	16.21	17.95	17.37	17.95	17.37	17.95	17.95	17.37	17.95	17.37	17.95	211.34
	Pits and Quarries	Actual	304.49	308.48	339.28	364.85	374.06	358.53	370.90	313.98	339.55	342.44	345.88	317.14	4,079.57
Dewatering Total			322.44	324.69	357.22	382.22	392.01	375.90	388.85	331.93	356.92	360.39	363.25	335.09	4,290.90
Industrial	Aggregate Washing	Actual					15.22	14.01	16.32	15.02	15.79	17.36	8.97	0.00	102.68
	Brewing & Soft Drinks	Est.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Cooling Water	Actual	1.36	1.40	1.55	1.47	1.81	1.77	1.45	1.20	2.11	2.02	2.06	1.21	19.43
	Manufacturing	Actual	4.75	7.63	4.84	6.32	5.22	3.85	5.89	4.03	6.67	9.38	6.24	1.83	66.65
	Other - Industrial	Actual	4.04	3.86	4.30	4.27	4.47	4.38	4.47	4.34	4.36				38.48
		Est.	52.43	47.36	52.43	50.74	52.43	50.74	52.43	52.43	50.74	52.43	50.74	52.43	617.37
Industrial Total			62.58	60.25	63.13	62.81	79.16	74.77	80.56	77.02	79.68	81.19	68.01	55.48	844.62
Institutional	Other - Institutional	Actual	0.76	6.23	6.08	7.63	5.66	4.71	5.20	5.90	6.26	7.06	5.74	3.93	65.16
		Est.	4.24	3.83	4.24	4.10	4.24	4.10	4.24	4.24	4.10	4.24	4.10	4.24	49.93
Institutional Total			5.00	10.06	10.32	11.73	9.90	8.81	9.44	10.14	10.37	11.30	9.85	8.17	115.09
Miscellaneous	Heat Pumps	Est.	16.90	15.26	16.90	16.35	16.90	16.35	16.90	16.90	16.35	16.90	16.35	16.90	198.93
Remediation	Groundwater	Actual	7.21	8.01	9.80	8.98	8.67	9.00	9.65	9.25	7.56	6.30	7.44	7.56	99.45
		Est.	2.08	1.87	2.08	2.01	2.08	2.01	2.08	2.08	2.01	2.08	2.01	2.08	24.44
Remediation Total			9.29	9.89	11.88	10.99	10.75	11.01	11.73	11.32	9.57	8.38	9.45	9.64	123.89
Water Supply	Campgrounds	Actual				0.04	0.07	0.18	0.65	0.74	0.27	0.12	0.00	0.00	2.06
		Est.					7.91	7.65	7.91	7.91	7.65	7.91			46.92
	Municipal	Actual	1,030.7	971.6	1,023.7	1,025.8	932.9	1,137.8	1,118.2	1,150.3	1,197.1	1,119.4	962.4	1,031.0	12,700.9
Water Supply Total			1,030.7	971.6	1,023.7	1,025.8	940.9	1,145.6	1,126.7	1,158.9	1,205.0	1,127.4	962.4	1,031.0	12,749.8
Grand Total	in 1000xm^3		1,451.0	1,395.9	1,487.0	1,527.5	1,623.0	1,889.9	1,975.9	1,934.8	1,895.2	1,742.8	1,438.2	1,459.7	**19,821.0**

Mill Creek

Category	Specific Purpose	Actual/ Est.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Agricultural	Market Gardens / Flowers	Actual	0.67	0.51	0.04	0.12	0.09	0.19	0.39	0.10	0.08	0.20	0.32	0.33	3.04
	Other - Agricultural	Est.					0.33	0.41	0.50	0.50	0.41	0.33			2.48
Agricultural Total			0.67	0.51	0.04	0.12	0.42	0.60	0.89	0.59	0.50	0.53	0.32	0.33	5.53
Commercial	Bottled Water	Actual	78.62	61.26	63.89	66.52	77.07	81.83	86.45	80.25	65.06	64.00	79.97	70.08	875.01
	Golf Course Irrigation	Est.					1.58	3.15	4.73	4.73	1.58	0.79			16.56
Commercial Total			78.62	61.26	63.89	66.52	78.65	84.99	91.18	84.98	66.63	64.79	79.97	70.08	891.57
Industrial	Aggregate Washing	Actual					221.38	211.42	226.64	209.97	201.30	258.88	130.79		1,530.76
		Est.					165.50	166.26	173.94	149.93	143.32	163.49	8.56		971.00
	Food Processing	Actual								0.90	1.24	1.44	1.27	1.09	5.94
	Manufacturing	Actual	1.56	2.77	3.52	3.91	4.32	4.25	4.26	4.46	4.65	4.64	4.13	3.62	46.09
	Other - Industrial	Actual	0.02	0.05	0.03	0.18	1.06	1.90	2.48	1.79	1.98	2.12	0.90	0.17	12.67
Industrial Total			1.59	2.82	3.55	74.46	392.25	383.83	407.32	367.04	352.50	430.57	145.65	4.88	2,566.46
Miscellaneous	Heat Pumps	Est.	1.86	1.68	1.86	1.80	1.86	1.80	1.86	1.86	1.80	1.86	1.80	1.86	21.90
Water Supply	Campgrounds	Est.					12.18	11.78	12.18	12.18	11.78	5.89			65.99
	Communal	Actual	3.68	5.60	4.07	3.69	4.57	5.48	4.83	4.90	3.86	3.54	3.00	3.28	50.51
	Municipal	Actual	68.40	66.84	65.59	68.60	72.98	69.06	73.06	72.00	68.61	73.71	71.15	74.07	844.07
Water Supply Total			72.09	72.44	69.65	72.29	89.73	86.32	90.07	89.07	84.25	83.15	74.16	77.35	960.57
Grand Total	in 1000xm^3		154.82	138.70	138.99	215.20	562.91	557.54	591.31	543.55	505.68	580.90	301.90	154.51	**4,446.02**

Fairchild Creek

Category	Specific Purpose	Actual/ Est.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Agricultural	Field and Pasture Crops	Actual	0	0	0	0	0	0	0	0	0	0	0	0	0
		Est.						4.49	6.74	4.49	2.25				17.97
	Fruit Orchards	Est.						3.05	4.58	3.05	1.53				12.21
	Market Gardens / Flowers	Est.						0.48	0.72	0.48	0.24				1.92
	Nursery	Actual				0.0	1.47	24.20	26.36	24.24	10.69	4.73	1.82	0.00	93.52
		Est.				0.59	1.18	6.68	10.02	6.68	2.75				27.89
	Other - Agricultural	Actual				0.13	1.21	5.33	3.57	1.40	4.12	0.65			16.41
		Est.						20.95	31.42	20.95	10.47				83.78
	Sod Farm	Est.						2.50	3.75	2.50	1.25				10.00
	Tender Fruit	Est.						9.16	13.74	9.16	4.58				36.63
Agricultural Total						0.72	3.86	76.83	100.89	72.95	37.87	5.39	1.82	0.00	300.34
Commercial	Aquaculture	Actual	0	0	0	0	0	0	0	0	0	0	0	0	0.0
		Est.				19.60	20.25	19.60	20.25	20.25	19.60	20.25			139.82
	Golf Course Irrigation	Actual				1.56	6.97	7.76	13.71	5.08	6.13	0.16			41.38
		Est.					1.53	4.64	8.49	7.70	3.85	1.53			27.75
	Other - Commercial	Actual	0.31	0.19	0.23	0.25	0.32	0.28	0.49	0.48	0.36	0.18	0.18	0.15	3.42
		Est.	4.93	4.45	4.93	4.77	4.93	4.77	4.93	4.93	4.77	4.93	4.77	4.93	58.04
Commercial Total			5.24	4.64	5.16	26.18	34.01	37.04	47.88	38.44	34.72	27.06	4.95	5.08	270.39
Industrial	Aggregate Washing	Actual	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Other - Industrial	Actual	0	0	0	0	0	0	0	0	0	0	0	0	0.0
		Est.	42.65	38.52	42.65	41.27	42.65	41.27	42.65	42.65	41.27	42.65	41.27	42.65	502.17
Industrial Total			42.65	38.52	42.65	41.27	42.65	41.27	42.65	42.65	41.27	42.65	41.27	42.65	502.17
Remediation	Groundwater	Est.	6.26	5.66	6.26	6.06	6.26	6.06	6.26	6.26	6.06	6.26	6.06	6.26	73.73
Water Supply	Campgrounds	Est.					3.16	3.06	3.16	3.16	3.06	1.53			17.14
	Communal	Actual	2.25	2.21	2.37	2.01	2.51	3.31	3.95	3.80	2.17	1.87	1.96	2.09	30.48
		Est.	2.43	2.20	2.43	2.36	2.43	2.36	2.43	2.43	2.36	2.43	2.36	2.43	28.65
	Municipal	Actual	30.58	30.44	30.28	31.93	37.58	36.49	38.14	32.02	34.06	31.03	29.63	29.34	391.52
	Other - Water Supply	Actual	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water Supply Total			35.27	34.85	35.09	36.29	45.69	45.21	47.68	41.42	41.64	36.86	33.95	33.86	467.79
Grand Total	in 1000xm^3		89.42	83.67	89.16	110.53	132.47	206.42	245.36	201.72	161.56	118.22	88.05	87.85	**1614.42**

Grand River Headwaters

Category	Specific Purpose	Actual/ Est.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Commercial	Other - Commercial	Actual	0	0	0	0	0	0.6	8.0	5.2	20.5	7.1	0	0	41.2
Industrial	Aggregate Washing	Est.	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Miscellaneous	Heat Pumps	Est.	9.54	8.62	9.54	9.23	9.54	9.23	9.54	9.54	9.23	9.54	9.23	9.54	112.32
Water Supply	Campgrounds	Est.	0	0	0	0	11.38	11.02	11.38	11.38	11.02	11.38	0	0	67.66
	Communal	Est.	100.39	90.67	100.39	97.15	120.66	116.77	120.66	120.66	116.77	120.66	97.15	100.39	1,302.3
	Municipal	Actual	36.68	33.19	35.69	33.71	37.34	43.94	43.15	40.58	39.16	36.78	42.32	34.62	457.2
Water Supply Total			137.07	123.86	136.07	130.86	169.39	171.72	175.19	172.63	166.95	168.82	139.47	135.01	1,827.1
Grand Total	in 1000xm^3		146.61	132.48	145.61	140.09	178.93	181.5	192.7	187.3	196.7	185.4	148.70	144.55	**1,980.6**

Grand Conestogo to Shand

Category	Specific Purpose	Actual/ Est	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Agricultural	Other - Agricultural	Actual	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Commercial	Aquaculture	Actual	118.09	117.65	124.73	137.70	144.55	140.87	144.45	144.27	139.02	143.31	138.72	156.93	1,650.29
		Est.	71.04	64.17	71.04	68.75	71.04	68.75	71.04	71.04	68.75	71.04	68.75	71.04	836.49
	Bottled Water	Actual	0	0	0	0.03	0.54	0.88	0.86	0.20	0.03	0.06	0.01	0	2.61
	Golf Course Irrigation	Actual	0	0	0	1.10	5.65	8.24	13.73	8.08	4.55	0.00	0	0	41.36
		Est.					0.10	0.20	0.39	0.39	0.20	0.10			1.38
Commercial Total			189.14	181.82	195.78	207.58	221.89	218.94	230.48	223.99	212.56	214.51	207.48	227.97	2,532.13
Dewatering	Construction	Est.					20.29	19.64	20.29	20.29	19.64	20.29	9.82		130.27
	Other - Dewatering	Actual						0	0	2.70	0	0	0	0	2.70
	Pits and Quarries	Est.					3.12	3.02	10.32	3.12	3.02	3.12	1.51		27.26
Dewatering Total							23.42	22.66	30.62	26.12	22.66	23.42	11.33	0	160.23
Industrial	Aggregate Washing	Actual	0	0	0	13.53	56.15	51.87	59.97	26.40	57.17	55.12	26.72	0	346.92
	Food Processing	Est.	43.25	39.06	43.25	41.85	43.25	41.85	43.25	43.25	41.85	43.25	41.85	43.25	509.18
	Other - Industrial	Actual	0.33	0.32	0.33	0.32	0.34	0.32	0.33	0.34	0.32	0.34	0.32	0.33	3.96
		Est.	2.86	2.58	2.86	2.76	2.86	2.76	2.86	2.86	2.76	2.86	2.76	2.86	33.64
Industrial Total			46.44	41.96	46.44	58.46	102.59	96.81	106.41	72.84	102.11	101.56	71.66	46.44	893.69
Remediation	Groundwater	Actual	63.08	62.59	59.59	82.53	71.30	45.97	68.26	62.40	82.78	76.61	79.50	49.32	803.94
	Other - Remediation	Actual	29.13	23.16	29.66	25.85	18.08	13.03	5.29	7.42	21.38	47.03	61.35	40.44	321.81
Remediation Total			92.21	85.74	89.25	108.38	89.39	59.00	73.55	69.83	104.16	123.64	140.84	89.75	1,125.75
Water Supply	Campgrounds	Est.	0.00	0.00	0.00	0.00	12.85	12.44	12.85	12.85	12.44	12.85	0.00	0.00	76.28
	Municipal	Actual	157.87	151.63	152.94	152.86	162.09	159.57	165.47	160.54	160.98	163.95	153.25	163.94	1,905.10
	Other - Water Supply	Actual	7.21	6.42	6.37	5.72	5.15	4.65	4.81	4.65	4.50	4.65	4.50	4.65	63.28
Water Supply Total			165.08	158.05	159.32	158.58	180.09	176.66	183.13	178.04	177.92	181.45	157.75	168.59	2,044.66
Grand Total	in 1000xm^3		492.86	467.57	490.78	533.00	617.37	574.07	624.19	570.81	619.40	644.59	589.06	532.75	**6,756.46**

Central Grand Subwatersheds

Category	Specific Purpose	Actual/Est.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Agricultural	Field and Pasture Crops	Actual					1.37	3.40	3.60	0.92	0.50				9.78
	Nursery	Est.						1.57	2.36	1.57	0.79				6.30
	Other - Agricultural	Actual						2.01	2.23	0.73	0.00				4.98
		Est.						3.30	4.96	3.30	1.65	0.00			13.21
Agricultural Total							1.37	10.29	13.15	6.52	2.94	0.00			34.27
Commercial	Aquaculture	Est.	5.23	5.23	5.23	5.23	14.60	14.13	14.60	14.60	13.09	5.23	5.23	5.23	107.59
	Golf Course Irrigation	Actual	0.0	0.0	0.0	2.56	156.22	238.67	240.13	219.39	153.16	19.04	0.04	0.0	1,029.21
		Est.	2.60	2.35	2.60	2.52	2.60	38.95	57.25	39.04	20.74	2.60	2.52	2.60	176.39
	Snowmaking	Actual	12.71	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.19	34.24	58.14
Commercial Total			20.54	7.58	7.83	10.31	173.43	291.8	312.0	273.0	186.98	26.86	18.97	42.07	1,371.3
Dewatering	Construction	Actual	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Est.	20.89	18.87	20.89	93.81	96.94	93.81	96.94	96.94	93.81	96.94	20.22	20.89	770.95
	Other - Dewatering	Est.	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Dewatering Total			20.89	18.87	20.89	93.81	96.94	93.81	96.94	96.94	93.81	96.94	20.22	20.89	770.95
Industrial	Aggregate Washing	Actual	14.89	14.03	12.63	55.09	81.46	87.76	94.57	72.54	67.39	70.96	44.54	15.00	630.86
		Est.					91.48	88.53	91.48	91.48	88.53	91.48	62.02		605.02
	Cooling Water	Actual	116.72	117.73	121.44	105.36	101.93	100.66	97.60	123.87	132.79	131.60	130.78	73.95	1,354.43
	Food Processing	Actual	9.62	9.24	8.94	9.09	8.01	7.82	9.10	8.66	8.72	9.78	9.66	9.08	107.71
		Est.	22.85	20.64	22.85	22.11	22.85	22.11	22.85	22.85	22.11	22.85	22.11	22.85	269.01
	Other - Industrial	Actual	0.80	0.85	1.07	0.75	0.52	0.54	0.48	0.40	0.43	0.38	0.22	0.09	6.54
		Est.	64.47	58.23	64.47	62.39	64.47	62.39	64.47	64.47	62.39	64.47	62.39	64.47	759.04
Industrial Total			229.35	220.72	231.39	254.78	370.72	369.81	380.56	384.25	382.37	391.52	331.72	185.43	3,732.61
Institutional	Other - Institutional	Est.	5.08	4.59	5.08	4.92	5.08	4.92	5.08	5.08	4.92	5.08	4.92	0.00	54.78
	Schools	Actual	0.34	0.29	0.21	0.40	0.45	0.29	0.06	0.13	0.33	0.32	0.27	0.26	3.35
Recreational	Other - Recreational	Est.	62.94	56.85	62.94	60.91	62.94	91.37	94.41	94.41	91.37	78.17	60.91	62.94	880.18
	Aesthetics	Est.	0.00	0.00	0.00	0.00	0.00	4.92	5.08	5.08	4.92	0.00	0.00	0.00	20.01
Recreational Total			62.94	56.85	62.94	60.91	62.94	96.29	99.50	99.50	96.29	78.17	60.91	62.94	900.19
Remediation	Groundwater	Actual	7.71	7.85	8.59	8.14	8.37	7.53	7.89	6.45	7.33	6.68	7.42	7.11	91.06
		Est.	19.80	17.88	19.80	19.16	19.80	19.16	19.80	19.80	19.16	19.80	19.16	19.80	233.09
	Other - Remediation	Actual	23.57	22.78	24.11	23.60	25.17	24.11	825.98	23.85	23.82	24.66	22.48	24.45	1,088.59
Remediation Total			51.08	48.51	52.50	50.89	53.33	50.79	853.67	50.10	50.30	51.14	49.06	51.36	1,412.74
Water Supply	Campgrounds	Actual	0.45	0.44	0.49	0.75	2.26	3.19	4.57	3.30	1.86	1.39	0.67	0.44	19.80
		Est.					2.55	2.46	2.55	2.55	2.46	1.23			13.79
	Communal	Est.	81.17	73.31	81.17	78.55	81.17	78.55	81.17	81.17	78.55	81.17	78.55	81.17	955.67
	Municipal	Actual	3,470.7	3,305.5	3,723.9	3,615.7	3,678.7	3,644.6	3,941.6	3,829.4	3,426.4	3,308.0	3,122.5	3,132.6	42,199.7
	Other - Water Supply	Actual	0.02	0.17	0.13	0.58	1.05	0.73	0.88	1.09	0.85	0.83	0.49	0.46	7.28
Water Supply Total			3,552.4	3,379.4	3,805.7	3,695.6	3,765.7	3,729.5	4,030.7	3,917.6	3,510.2	3,392.6	3,202.2	3,214.7	43,196.2
Grand Total	in 1000xm^3		3,942.6	3,736.8	4,186.6	4,171.7	4,530.0	4,647.5	5,791.7	4,833.1	4,328.1	4,042.6	3,688.3	3,577.7	**51,476.4**

Southern Grand Subwatersheds

Category	Specific Purpose	Actual/ Est.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Agricultural	Field and Pasture Crops	Actual					5.07	20.30	14.89	9.69	0.27				50.22
		Est.						114.29	171.43	102.23	57.14				445.10
	Market Gardens/Flowers	Est.						4.92	7.38	1.05	2.46				15.82
	Nursery	Actual		0.07	0.19	1.09	10.41	8.56	6.40	4.42	3.88	2.06	1.49	0.02	38.58
	Other - Agricultural	Actual						6.54	10.98	20.58	15.32				53.41
		Est.						102.30	153.46	102.30	51.15				409.21
	Sod Farm	Est.						62.85	94.27	62.85	31.42				251.40
	Tobacco	Actual						21.73	33.03	17.49	0.00				72.25
		Est.						72.88	109.32	72.88	36.44				291.53
Agricultural Total			0.00	0.07	0.19	1.09	15.48	414.38	601.16	393.49	198.09	2.06	1.49	0.02	1,627.51
Commercial	Golf Course Irrigation	Actual	0.36			0.36	22.69	47.00	43.01	29.11	21.13	1.80	0.00	0.00	165.47
		Est.					5.91	18.73	34.00	30.55	15.27	5.91			110.37
	Other - Commercial	Actual						0.15	0.20	0.09	0.16	0.05			0.64
Commercial Total			0.36			0.36	28.60	65.88	77.21	59.74	36.56	7.76			276.48
Dewatering	Other - Dewatering	Actual													0.00
	Pits and Quarries	Actual	85.45	179.67	106.55	122.17	111.84	117.89	116.17	163.81	166.27	166.77	100.27	112.21	1,549.07
Dewatering Total			85.45	179.67	106.55	122.17	111.84	117.89	116.17	163.81	166.27	166.77	100.27	112.21	1,549.07
Industrial	Aggregate Washing	Est.					27.32	26.44	27.32	27.32	26.44				134.85
	Food Processing	Actual													0.00
	Manufacturing	Actual	8.21	6.81	7.85	7.90	7.97	7.12	5.54	8.19	9.26	9.42	7.30	6.19	91.76
	Other - Industrial	Est.	12.18	11.00	12.18	11.78	12.18	11.78	12.18	12.18	11.78	12.18	11.78	12.18	143.36
Industrial Total			20.39	17.81	20.02	19.69	47.47	45.34	45.04	47.69	47.48	48.92	45.53	18.37	423.74
Water Supply	Campgrounds	Est.					13.82	14.04	14.82	11.13	13.70	6.69			74.19
	Municipal	Actual	1,351.0	1,237.1	1,325.8	1,318.6	1,446.4	1,940.4	1,712.0	1,532.1	1,463.1	1,703.9	1,412.5	1,204.5	17,647.3
Water Supply Total			1,351.0	1,351.0	1,237.1	1,325.8	1,318.6	1,460.2	1,954.4	1,726.8	1,543.3	1,476.8	1,710.6	1,412.5	1,204.5
Grand Total in 1000xm^3			1,457.2	1,434.6	1,452.6	1,461.9	1,663.6	2,597.9	2,566.4	2,208.0	1,925.2	1,936.1	1,559.7	1,335.1	**21,605.2**

McKenzie Creek

Category	Specific Purpose	Actual/ Est.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Agricultural	Field and Pasture Crops	Actual	0.00	0.01	6.58	0.30	1.33	6.71	9.57	16.09	18.48	0.87	0.28	0.05	60.28
		Est.						207.10	310.65	207.10	103.55				828.41
	Fruit Orchards	Actual	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Market Gardens / Flowers	Actual			0.12	0.38	0.78	0.76	0.86	4.42	7.15	0.37			14.85
		Est.						46.61	69.91	46.61	23.30				186.42
	Other - Agricultural	Actual	0.00	0.00	0.00	0.00	0.00	6.56	10.25	18.27	16.84	0.00	0.00	0.00	51.92
		Est.						134.63	201.95	134.63	67.32				538.54
	Sod Farm	Actual						0.26	5.96	1.96	5.01				13.19
	Tobacco	Actual	0.00	0.00	0.00	0.00	0.00	7.16	12.66	23.90	4.77	0.00	0.00	0.00	48.49
		Est.						34.25	51.38	34.25	17.13				137.00
Agricultural Total								444.04	673.19	487.23	263.56	1.25	0.28	0.05	1,879.09
Commercial	Aquaculture	Est.	22.32	20.16	22.32	21.60	22.32	21.60	22.32	22.32	21.60	22.32	21.60	22.32	262.80
	Golf Course Irrigation	Est.	0.00	0.00	0.00	0.00	0.00	5.58	8.37	5.58	2.79	0.00	0.00	0.00	22.31
Commercial Total			22.32	20.16	22.32	21.60	22.32	27.18	30.69	27.90	24.39	22.32	21.60	22.32	285.11
Dewatering	Other - Dewatering	Est.	15.71	15.71	15.71	16.69	16.69	16.69	16.69	16.69	16.69	16.69	16.69	15.71	196.39
	Pits and Quarries	Est.	284.3	256.8	284.3	275.1	284.3	275.1	284.3	284.3	275.1	284.3	275.1	284.3	3,347.05
Dewatering Total			300.0	272.5	300.0	291.8	301.0	291.8	301.0	301.0	291.8	301.0	291.8	300.0	3,543.44
Grand Total in 1000xm^3			322.3	292.6	329.0	314.1	325.4	763.0	1,004.8	816.1	579.7	324.5	313.7	322.4	**5,707.64**

Lower Nith River

Category	Specific Purpose	Actual/ Est.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Agricultural	Field and Pasture Crops	Actual						6.83	13.02	2.75					22.60
		Est.						52.50	78.75	52.50	26.25				210.00
	Fruit Orchards	Est.						1.32	1.97	1.32	0.66				5.26
	Other - Agricultural	Actual						27.75	41.62	27.75	13.87				110.98
	Tobacco	Est.						51.18	76.77	51.18	25.59				204.73
Agricultural Total								139.57	212.13	135.49	66.37				553.57
Commercial	Aquaculture	Actual	49.55	44.76	49.55	47.95	49.55	47.95	49.55	49.55	47.95	49.55	47.95	49.55	583.42
	Golf Course Irrigation	Actual	0.08	0.04	0.10	0.22	0.38	0.93	1.45	1.30	0.67	0.39	0.16	0.15	5.86
		Est.					1.96	3.92	5.88	3.92	1.96				17.63
	Other - Commercial	Actual	0.41	0.43	0.32	0.40	0.47	0.60	0.38	0.69	0.52	0.57	0.74	0.42	5.94
Commercial Total			50.04	45.22	49.97	48.57	52.36	53.40	57.26	55.46	51.10	50.50	48.85	50.12	612.84
Industrial	Aggregate Washing	Actual	0.36	0.01	0.11	69.18	95.23	106.42	109.70	95.83	100.65	125.99	28.93	5.80	738.21
		Est.					402.36	389.39	402.36	402.36	389.39	402.36	243.34		2,631.6
	Cooling Water	Actual	2.14	2.86	3.33	6.16	5.61	5.04	6.25	3.92	6.05	3.47	2.66	1.83	49.31
	Food Processing	Actual	0.00	0.00	0.00	0.00	0.00	9.96	10.19	9.26	11.41	11.71	8.34	10.15	71.02
		Est.	13.01	11.75	13.01	12.59	13.01	12.59	13.01	13.01	12.59	13.01	12.59	13.01	153.15
	Manufacturing	Actual	0.25	0.23	0.47	0.73	0.87	0.86	0.91	0.85	0.87	1.76	1.30	1.81	10.89
	Other - Industrial	Actual	0.01	0.01	0.01	0.01	0.04	0.03	0.08	0.06	0.04	0.01	0.00	0.02	0.31
		Est.						28.60	47.67	38.14	28.60				143.01
Industrial Total			15.77	14.85	16.92	88.67	517.11	552.88	590.16	563.44	549.59	558.31	297.15	32.61	3,797.5
Remediation	Other - Remediation	Est.	53.91	54.73	47.11	62.43	70.52	61.62	56.44	51.89	51.79	56.08	52.59	52.78	671.89
Water Supply	Campgrounds	Est.					3.24	3.24	3.24	3.24	3.24	3.24			19.44
	Communal	Actual	0.88	0.79	0.49	1.24	3.15	3.67	2.65	2.24	2.63	2.84	1.84	0.59	23.00
	Municipal	Actual	1,004.6	947.2	1,100.1	1,043.9	1,026.7	998.5	1,143.0	1,031.1	1,053.2	975.0	1,071.2	1,075.2	12,727.4
	Other - Water Supply	Est.	8.12	7.34	8.12	7.86	8.12	7.86	8.12	8.12	7.86	8.12	7.86	8.12	95.66
Water Supply Total			1,013.7	955.3	1,108.7	1,053.0	1,041.2	1,013.3	1,157.0	1,044.7	1,066.9	989.2	1,080.9	1,083.9	12,865.5
Grand Total	in 1000xm^3		1,133.4	1,070.1	1,222.7	1,252.7	1,681.2	1,820.8	2,073.0	1,851.0	1,785.8	1,654.1	1,479.5	1,219.4	**18,501.3**

Appendix A: Monthly Assessment of Pumped Water Takings by Subwatershed

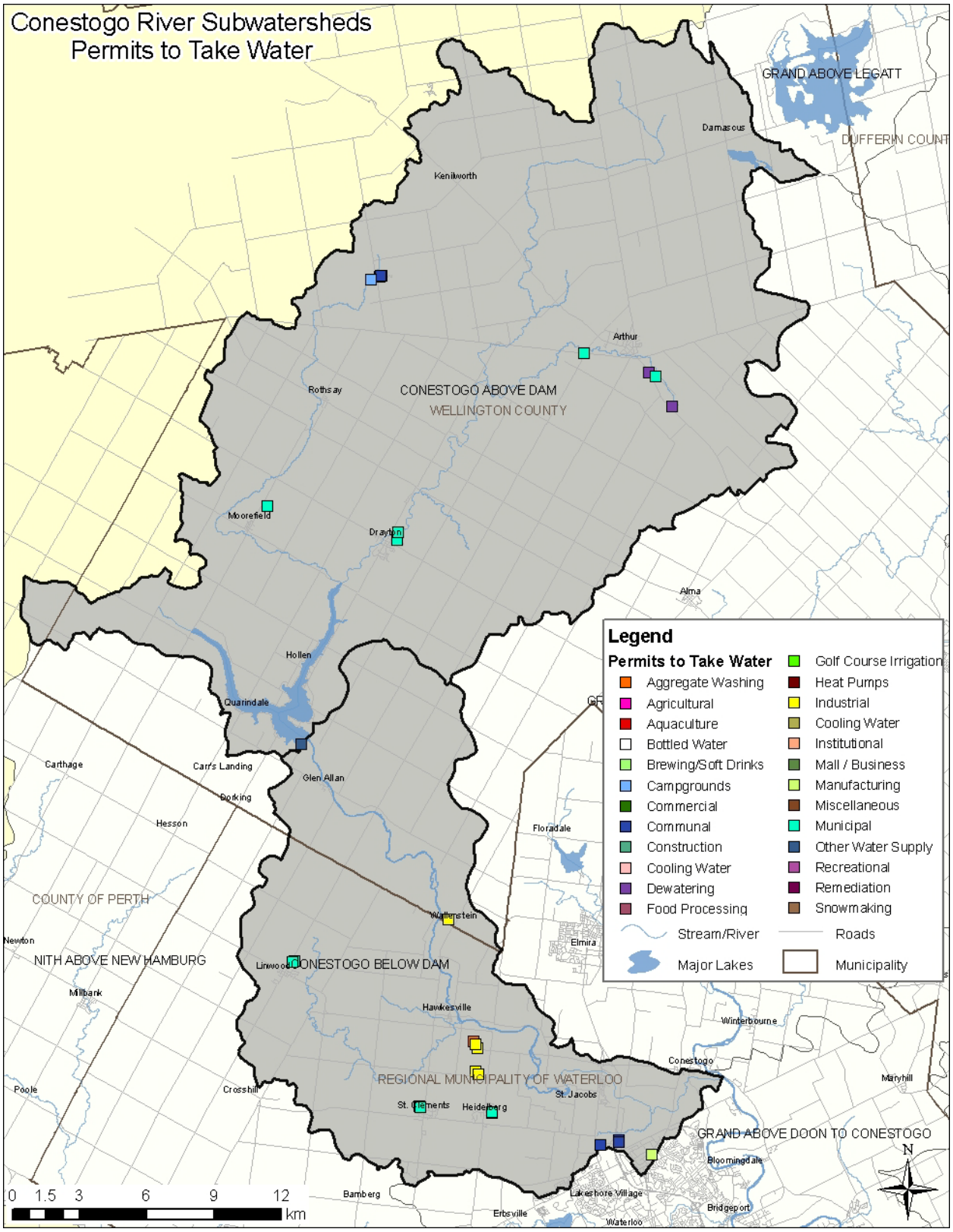
Upper Nith River

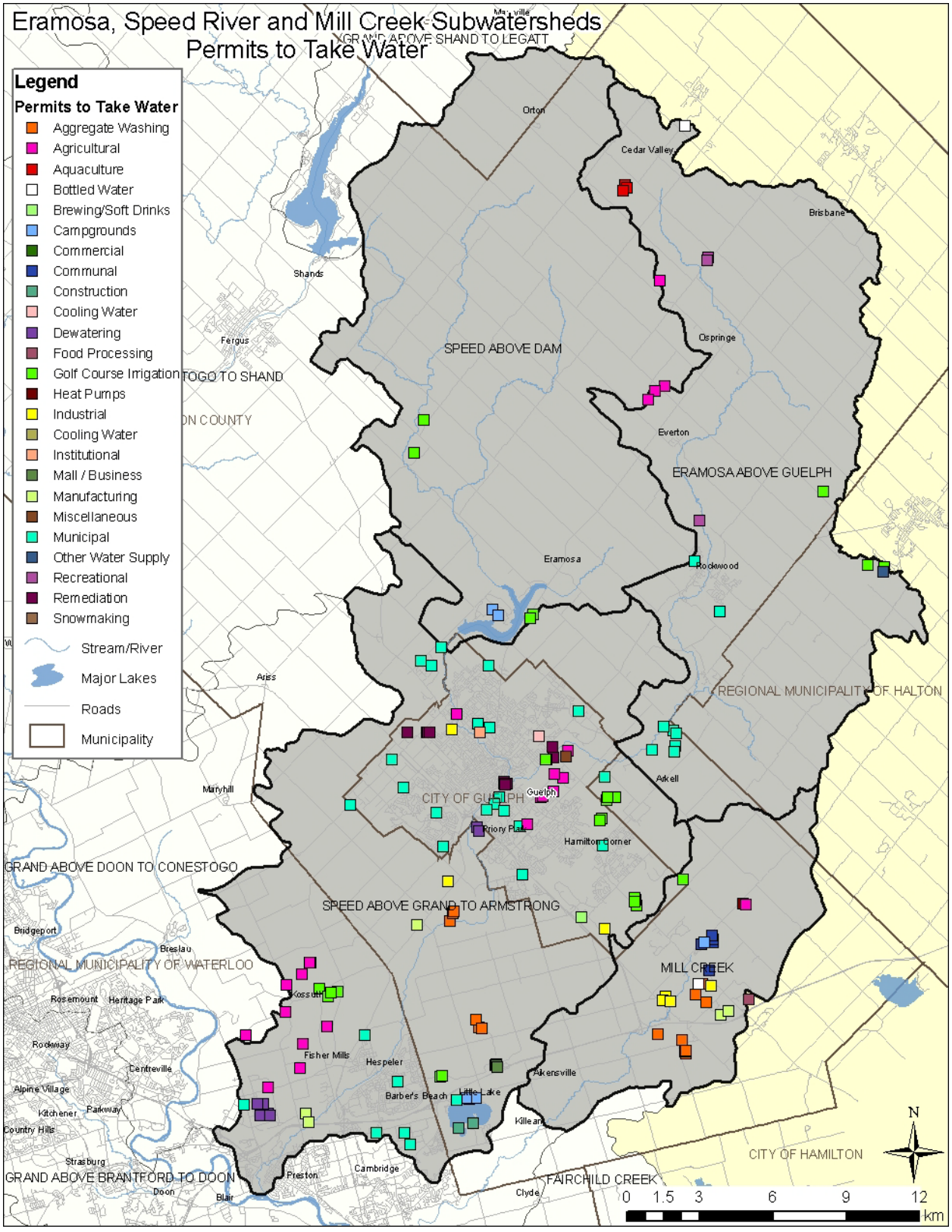
Category	Specific Purpose	Actual/ Est.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Agricultural	Market Gardens/ Flowers	Est.						3.46	5.18	3.46					12.10
	Nursery	Actual					0.82	21.22	12.15	0.61					34.80
	Other - Agricultural	Est.						1.65	2.47	1.65					5.76
Agricultural Total							0.82	26.33	19.80	5.71	0.82				53.48
Commercial	Golf Course Irrigation	Actual					1.17	2.39	2.71	2.58	0.24				9.08
Industrial	Cooling Water	Actual	0.09	0.31	0.45	0.52	0.58	2.92	1.57	1.71	1.36	1.37	1.31	0.99	13.18
	Heat Pumps	Est.	3.26	3.15	3.26	3.15	3.26	3.15	3.26	3.26	3.15	3.26	3.15	3.26	38.54
Industrial Total			3.35	3.46	3.71	3.67	3.84	6.07	4.83	4.96	4.51	4.62	4.46	4.25	51.71
Institutional	Schools	Est.	2.03	1.97	2.03	1.97	2.03	1.97	2.03	2.03	1.97	2.03	1.97	2.03	24.04
Miscellaneous	Heat Pumps	Est.	3.26	3.15	3.26	3.15	3.26	3.15	3.26	3.26	3.15	3.26			38.54
Water Supply	Communal	Actual				0.19	0.47	0.55	0.24	0.63	0.75	0.84			3.66
	Municipal	Actual	100.51	94.58	98.15	110.00	92.96	104.47	106.80	104.72	105.70	106.43	106.80	105.73	1,236.84
Water Supply Total			100.51	94.58	98.15	110.19	93.43	105.02	107.04	105.35	106.44	107.27	106.80	105.73	1,240.50
Grand Total in 1000xm^3			105.88	100.00	103.89	115.82	101.29	141.77	136.41	120.63	113.97	113.92	113.23	112.01	**1,378.82**

Whitemans Creek

Category	Specific Purpose	Actual/ Est.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Agricultural	Field and Pasture Crops	Actual						43.34	60.90	62.57	60.52				227.32
		Est.						274.84	412.26	274.84	137.42				1,099.36
	Fruit Orchards	Est.						3.14	4.71	3.14	1.57				12.55
	Nursery	Actual					1.27	4.64	2.95	3.04	0.33				12.22
	Other - Agricultural	Actual				0.02	0.17	33.05	44.02	27.86	0.03	3.16			108.31
		Est.						195.32	292.98	195.32	97.66				781.29
	Sod Farm	Actual					9.46	109.66	100.89	47.73	4.60				272.33
		Est.						59.01	88.52	59.01	29.51				236.04
	Tender Fruit	Actual						0.00	24.59	5.67	0.00				30.26
		Est.						0.61	0.92	0.61	0.31				2.45
	Tobacco	Actual						95.12	256.20	203.04	47.12				601.47
		Est.						444.41	666.62	444.41	222.21				1,777.66
Agricultural Total						0.02	10.91	1,263.14	1,955.54	1,327.24	601.27	3.16			5,161.28
Commercial	Golf Course Irrigation	Actual				0.21	2.12	2.54	5.21	4.60	0.42	0.21			15.31
	Other - Commercial	Est.	4.06	3.67	4.06	3.93	4.06	3.93	4.06	4.06	3.93	4.06	3.93	4.06	47.79
Commercial Total			4.06	3.67	4.06	4.14	6.18	6.46	9.27	8.66	4.35	4.27	3.93	4.06	63.09
Water Supply	Municipal	Actual	2.96	2.69	2.94	2.79	2.96	2.90	3.20	2.96	2.79	2.58	2.46	2.67	33.89
Grand Total in 1000xm^3			7.01	6.35	7.00	6.95	20.04	1,272.51	1,968.01	1,338.86	608.40	10.00	6.39	6.73	**5,258.26**

Appendix B: Maps by Subwatershed




Eramosa, Speed River and Mill Creek Subwatersheds
Permits to Take Water
Legend
Permits to Take Water
Aggregate Washing
Agricultural
Aquaculture
Bottled Water
Brewing/Soft Drinks
Campgrounds
Commercial
Communal
Construction
Cooling Water
Dewatering
Food Processing
Golf Course Irrigation
Heat Pumps
Industrial
Cooling Water
Institutional
Mall / Business
Manufacturing
Miscellaneous
Municipal
Other Water Supply
Recreational
Remediation
Snowmaking
Stream/River
Major Lakes
Roads
Municipality
GRAND ABOVE SHAND TO LEGATT
SPEED ABOVE DAM
TOGO TO SHAND
ERAMOSA ABOVE GUELPH
REGIONAL MUNICIPALITY OF HALTON
CITY OF GUELPH
SPEED ABOVE GRAND TO ARMSTRONG
GRAND ABOVE DOON TO CONESTOGO
REGIONAL MUNICIPALITY OF WATERLOO
MILL CREEK
GRAND ABOVE BRANTFORD TO DOON
FAIRCHILD CREEK
CITY OF HAMILTON
Orton
Cedar Valley
Brisbane
Shands
Fergus
Ospringe
Everton
Eramosa
Rockwood
Ariss
Maryhill
Guelph
Arkell
Priory Park
Hamilton Corner
Bridgeport
Breslau
Rosemount
Heritage Park
Rockway
Centreville
Alpine Village
Kitchener
Parkway
Country Hills
Strasburg
Doon
Blair
Fisher Mills
Hespeler
Barber's Beach
Little Lake
Akensville
Killean
Preston
Cambridge
Clyde
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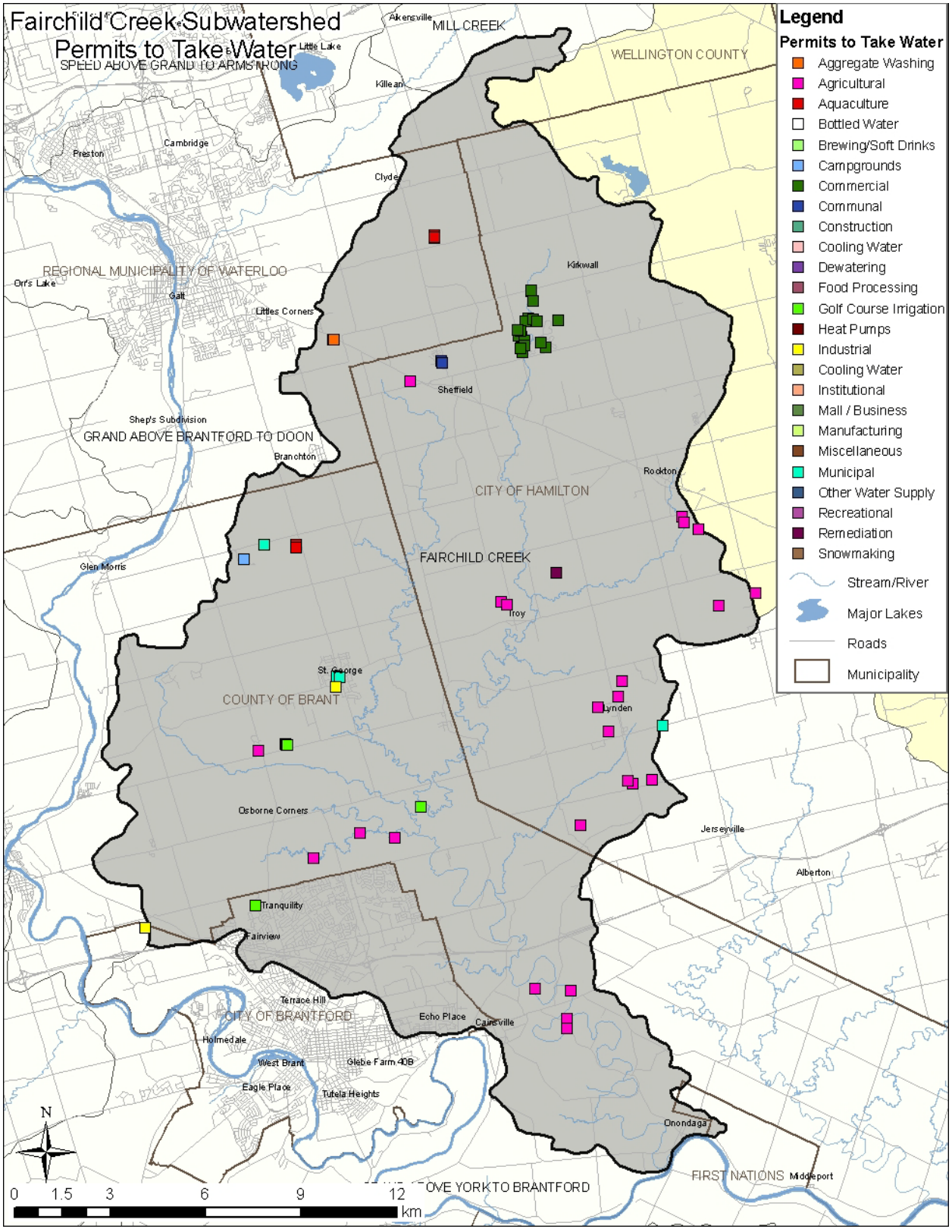
km


Fairchild Creek Subwatershed
Permits to Take Water
SPEED ABOVE GRAND TO ARMSTRONG
Akensville
MILL CREEK
Little Lake
WELLINGTON COUNTY
Killean
Cambridge
Preston
Clyde
Kirkwall
REGIONAL MUNICIPALITY OF WATERLOO
Orr's Lake
Galt
Littles Corners
Sheffield
Shep's Subdivision
GRAND ABOVE BRANTFORD TO DOON
Branchton
Rockton
CITY OF HAMILTON
FAIRCHILD CREEK
Glen Morris
Troy
St. George
COUNTY OF BRANT
Lynden
Osborne Corners
Jerseyville
Alberton
Tranquility
Fairview
Terrace Hill
CITY OF BRANTFORD
Echo Place
Cainsville
Holmedale
West Brant
Glebe Farm 40B
Eagle Place
Tutela Heights
Onondaga
FIRST NATIONS
Middleport
OVE YORK TO BRANTFORD
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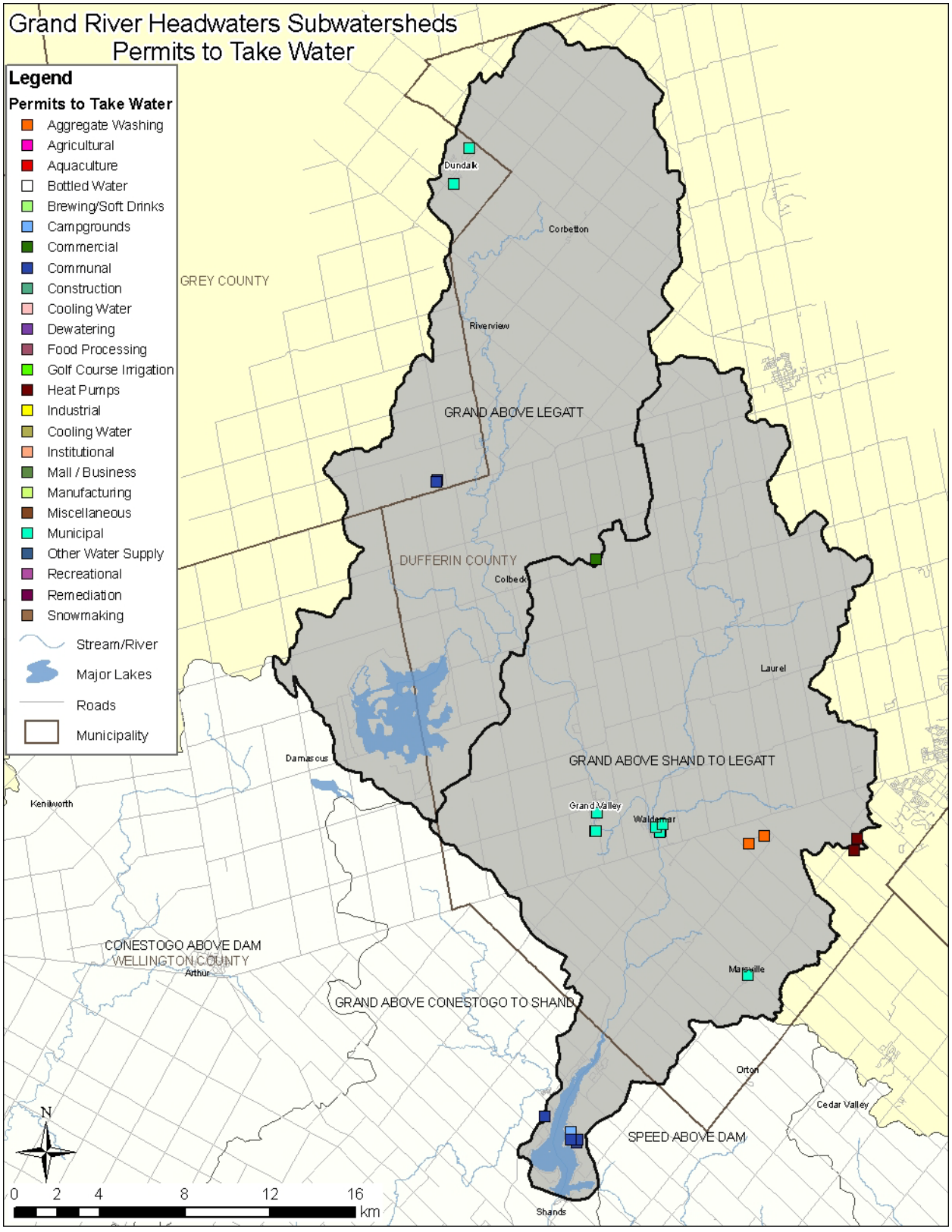
km
Legend
Permits to Take Water
Aggregate Washing
Agricultural
Aquaculture
Bottled Water
Brewing/Soft Drinks
Campgrounds
Commercial
Communal
Construction
Cooling Water
Dewatering
Food Processing
Golf Course Irrigation
Heat Pumps
Industrial
Cooling Water
Institutional
Mall / Business
Manufacturing
Miscellaneous
Municipal
Other Water Supply
Recreational
Remediation
Snowmaking
Stream/River
Major Lakes
Roads
Municipality


Grand River Headwaters Subwatersheds
Permits to Take Water
Legend
Permits to Take Water
Aggregate Washing
Agricultural
Aquaculture
Bottled Water
Brewing/Soft Drinks
Campgrounds
Commercial
Communal
Construction
Cooling Water
Dewatering
Food Processing
Golf Course Irrigation
Heat Pumps
Industrial
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Manufacturing
Miscellaneous
Municipal
Other Water Supply
Recreational
Remediation
Snowmaking
Stream/River
Major Lakes
Roads
Municipality
GREY COUNTY
DUFFERIN COUNTY
WELLINGTON COUNTY
Dundalk
Corbetton
Riverview
Colbeck
Laurel
Damascus
Kenilworth
Grand Valley
Waldemar
Arthur
Marsville
Orton
Cedar Valley
Shands
GRAND ABOVE LEGATT
GRAND ABOVE SHAND TO LEGATT
CONESTOGO ABOVE DAM
GRAND ABOVE CONESTOGO TO SHAND
SPEED ABOVE DAM
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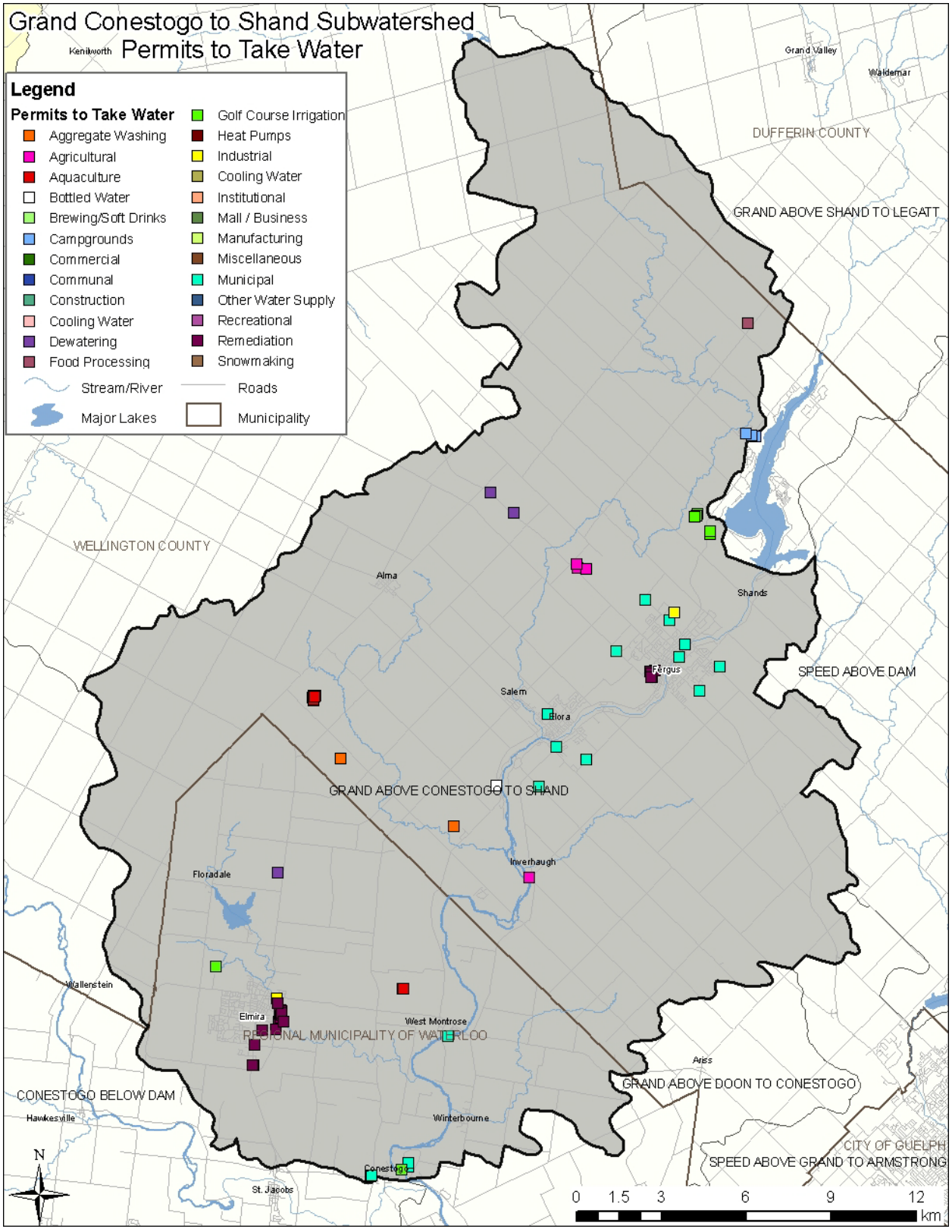
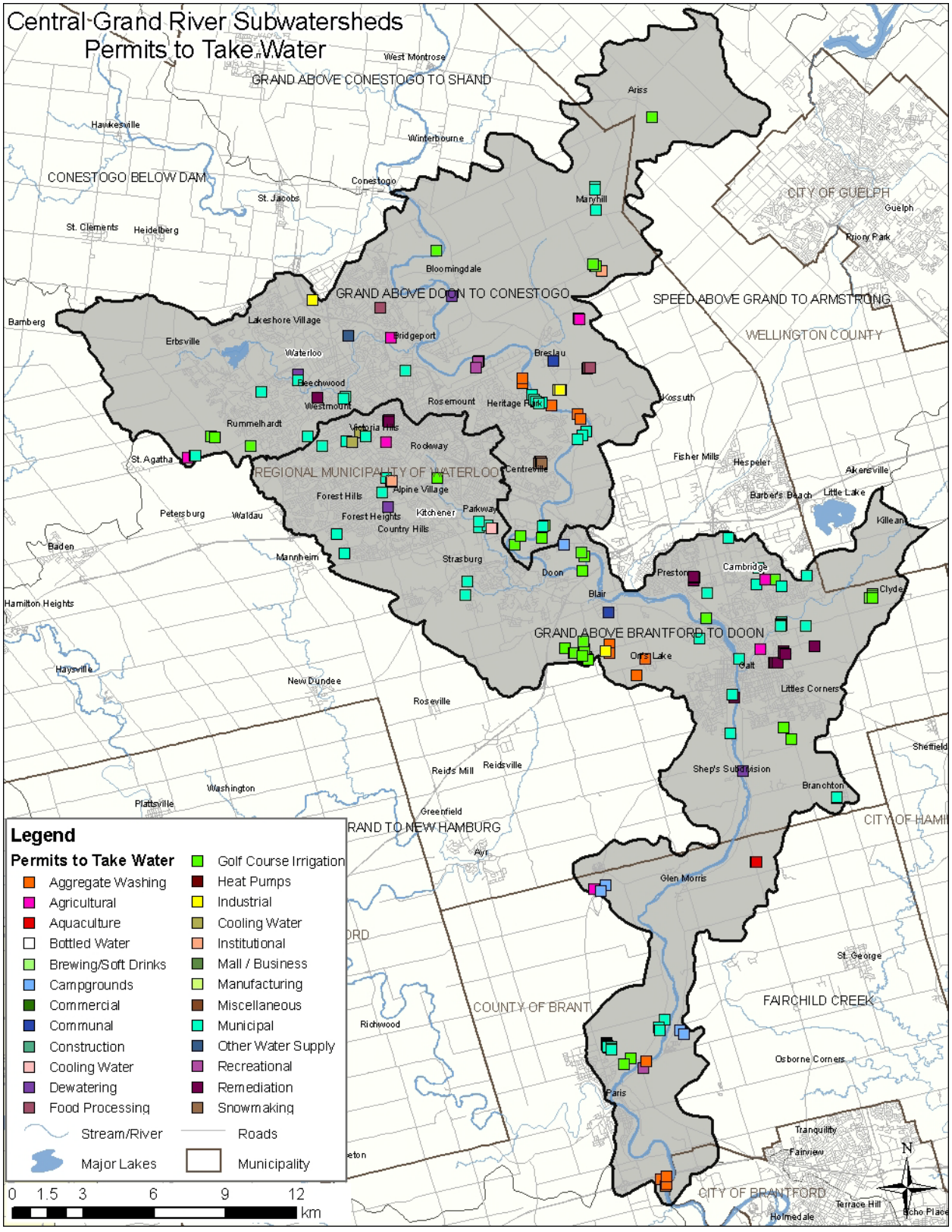
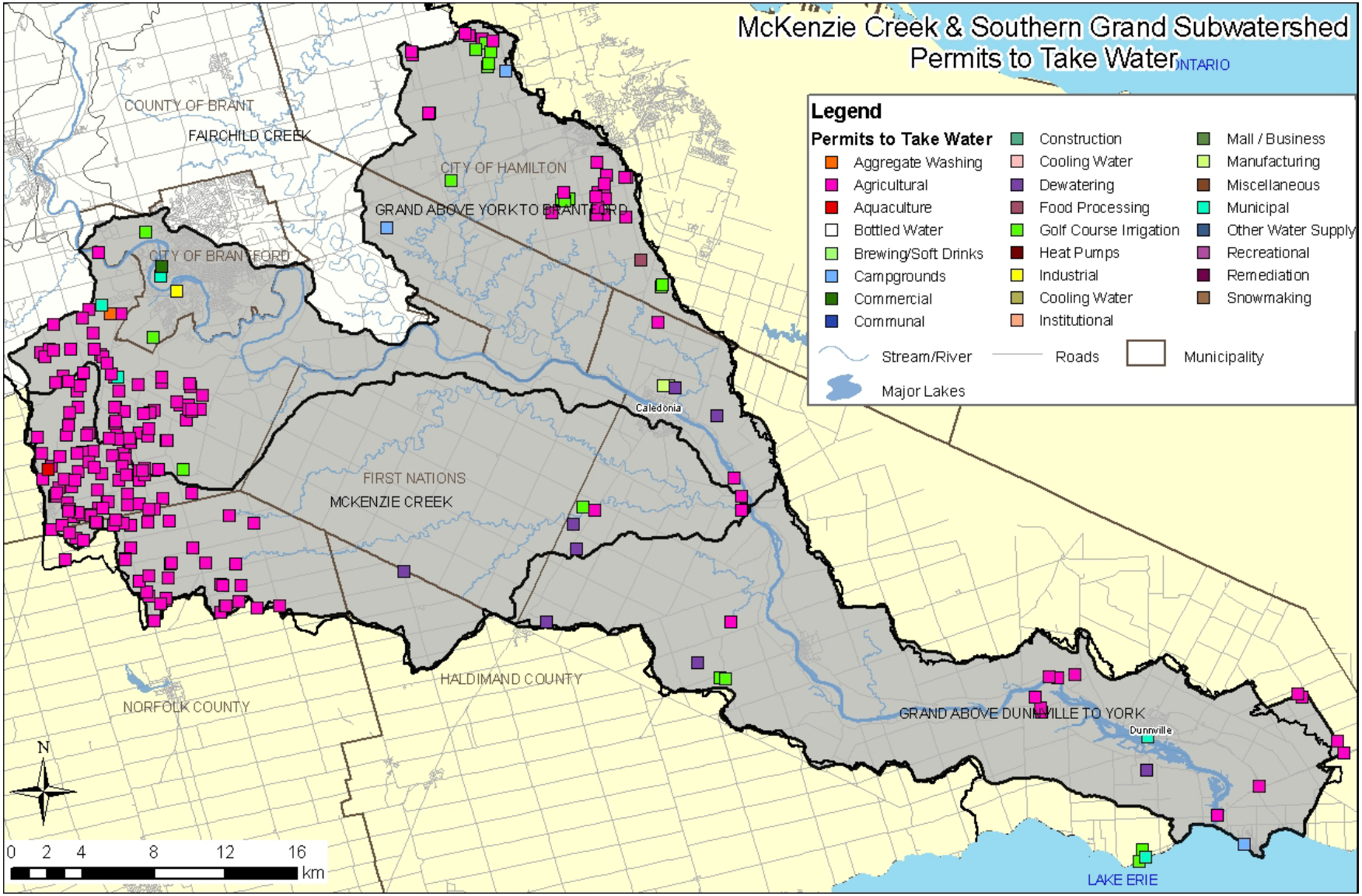
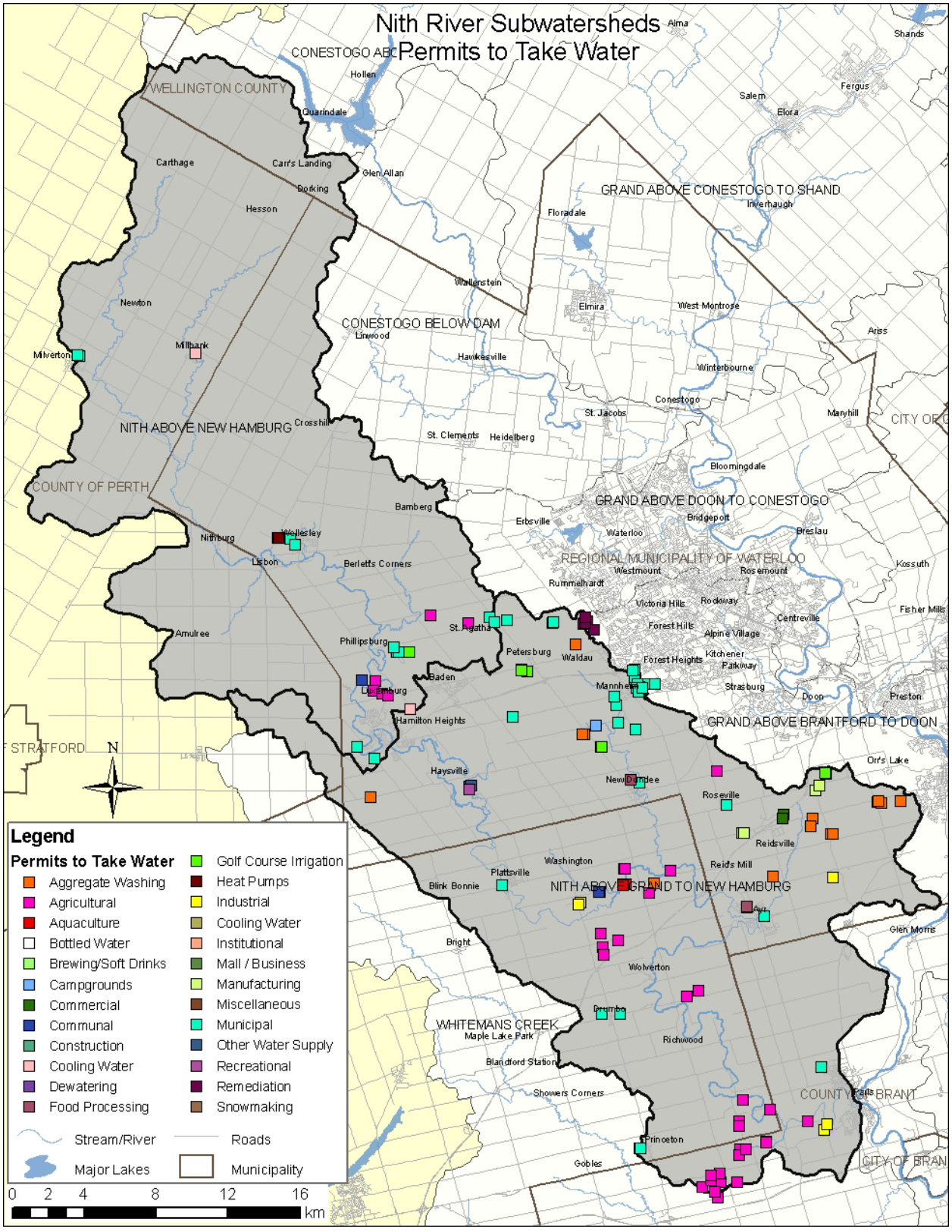
0 2 4 8 12 16
km

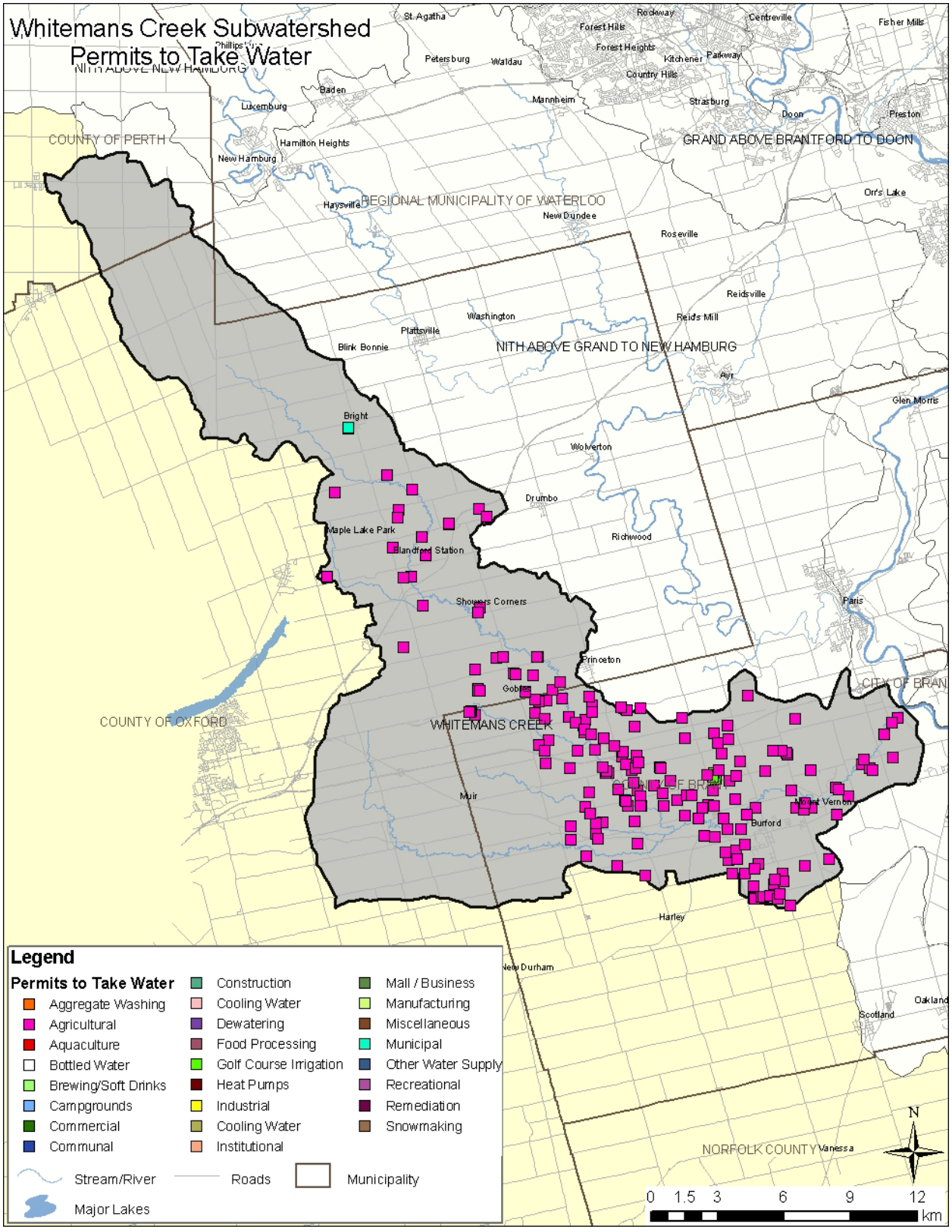

Grand Conestogo to Shand Subwatershed
Permits to Take Water
Legend
Permits to Take Water
Aggregate Washing
Agricultural
Aquaculture
Bottled Water
Brewing/Soft Drinks
Campgrounds
Commercial
Communal
Construction
Cooling Water
Dewatering
Food Processing
Golf Course Irrigation
Heat Pumps
Industrial
Cooling Water
Institutional
Mall / Business
Manufacturing
Miscellaneous
Municipal
Other Water Supply
Recreational
Remediation
Snowmaking
Stream/River
Roads
Major Lakes
Municipality
Kenilworth
Grand Valley
Waldemar
DUFFERIN COUNTY
GRAND ABOVE SHAND TO LEGATT
WELLINGTON COUNTY
Alma
Shands
Fergus
SPEED ABOVE DAM
Salem
Elora
GRAND ABOVE CONESTOGO TO SHAND
Inverhaugh
Floradale
Wallenstein
Elmira
West Montrose
REGIONAL MUNICIPALITY OF WATERLOO
Ariss
GRAND ABOVE DOON TO CONESTOGO
CONESTOGO BELOW DAM
Hawkesville
Winterbourne
CITY OF GUELPH
SPEED ABOVE GRAND TO ARMSTRONG
Conestogo
St. Jacobs
N
0 1.5 3 6 9 12
km


Central Grand River Subwatersheds
Permits to Take Water
GRAND ABOVE CONESTOGO TO SHAND
CONESTOGO BELOW DAM
GRAND ABOVE DOON TO CONESTOGO
SPEED ABOVE GRAND TO ARMSTRONG
REGIONAL MUNICIPALITY OF WATERLOO
WELLINGTON COUNTY
CITY OF GUELPH
GRAND ABOVE BRANTFORD TO DOON
COUNTY OF BRANT
FAIRCHILD CREEK
CITY OF BRANTFORD
Legend
Permits to Take Water
Aggregate Washing
Agricultural
Aquaculture
Bottled Water
Brewing/Soft Drinks
Campgrounds
Commercial
Communal
Construction
Cooling Water
Dewatering
Food Processing
Golf Course Irrigation
Heat Pumps
Industrial
Cooling Water
Institutional
Mall / Business
Manufacturing
Miscellaneous
Municipal
Other Water Supply
Recreational
Remediation
Snowmaking
Stream/River
Roads
Major Lakes
Municipality
0 1.5 3 6 9 12
km
N


McKenzie Creek & Southern Grand Subwatershed
Permits to Take Water
ONTARIO
COUNTY OF BRANT
FAIRCHILD CREEK
CITY OF HAMILTON
GRAND ABOVE YORK TO BRANTFORD
CITY OF BRANTFORD
Caledonia
FIRST NATIONS
MCKENZIE CREEK
HALDIMAND COUNTY
NORFOLK COUNTY
GRAND ABOVE DUNNVILLE TO YORK
Dunnville
LAKE ERIE
N
0 2 4 8 12 16
km
Legend
Permits to Take Water
Aggregate Washing
Agricultural
Aquaculture
Bottled Water
Brewing/Soft Drinks
Campgrounds
Commercial
Communal
Construction
Cooling Water
Dewatering
Food Processing
Golf Course Irrigation
Heat Pumps
Industrial
Cooling Water
Institutional
Mall / Business
Manufacturing
Miscellaneous
Municipal
Other Water Supply
Recreational
Remediation
Snowmaking
Stream/River
Roads
Municipality
Major Lakes

Appendix B: Maps of PTTW by Subwatershed




Whitemans Creek Subwatershed
Permits to Take Water
COUNTY OF PERTH
REGIONAL MUNICIPALITY OF WATERLOO
GRAND ABOVE BRANTFORD TO DOON
NITH ABOVE GRAND TO NEW HAMBURG
COUNTY OF OXFORD
WHITEMANS CREEK
NORFOLK COUNTY
St. Agatha
Rockway
Centreville
Fisher Mills
Forest Hills
Forest Heights
Kitchener
Parkway
Country Hills
Petersburg
Waldau
Baden
Lukenburg
Mannheim
Strasburg
Doon
Preston
Hamilton Heights
New Hamburg
Haysville
New Dundee
Roseville
Orr's Lake
Reidsville
Washington
Reids Mill
Plattsville
Blink Bonnie
Ayr
Glen Morris
Bright
Wolverton
Drumbo
Maple Lake Park
Richwood
Showers Corners
Paris
Princeton
Gobles
Muir
Mount Vernon
Burford
Harley
New Durham
Oakland
Scotland
Vanessa
Legend
Permits to Take Water
Aggregate Washing
Agricultural
Aquaculture
Bottled Water
Brewing/Soft Drinks
Campgrounds
Commercial
Communal
Construction
Cooling Water
Dewatering
Food Processing
Golf Course Irrigation
Heat Pumps
Industrial
Cooling Water
Institutional
Mall / Business
Manufacturing
Miscellaneous
Municipal
Other Water Supply
Recreational
Remediation
Snowmaking
Stream/River
Roads
Municipality
Major Lakes
N
0 1.5 3 6 9 12
km

Appendix C: Livestock Water Demand by Subwatershed

Subwatershed	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
	m^3/month x 1000												m^3/yr*1000
Conestogo River	165.47	149.46	165.47	160.13	165.47	160.13	165.47	165.47	160.13	165.47	160.13	165.47	**1,948.29**
Eramosa River	9.37	8.47	9.37	9.07	9.37	9.07	9.37	9.37	9.07	9.37	9.07	9.37	**110.35**
Speed River	23.67	21.38	23.67	22.91	23.67	22.91	23.67	23.67	22.91	23.67	22.91	23.67	**278.69**
Mill Creek	1.92	1.73	1.92	1.85	1.92	1.85	1.92	1.92	1.85	1.92	1.85	1.92	**22.56**
Fairchild Creek	29.20	26.37	29.20	28.25	29.20	28.25	29.20	29.20	28.25	29.20	28.25	29.20	**343.77**
Grand - Headwaters	39.04	35.27	39.04	37.78	39.04	37.78	39.04	39.04	37.78	39.04	37.78	39.04	**459.71**
Grand - Conestogo to Shand	117.15	105.82	117.15	113.37	117.15	113.37	117.15	117.15	113.37	117.15	113.37	117.15	**1,379.39**
Grand - Central	31.38	28.34	31.38	30.37	31.38	30.37	31.38	31.38	30.37	31.38	30.37	31.38	**369.46**
Grand - Southern	20.37	18.40	20.37	19.71	20.37	19.71	20.37	20.37	19.71	20.37	19.71	20.37	**239.85**
McKenzie Creek	8.55	7.72	8.55	8.27	8.55	8.27	8.55	8.55	8.27	8.55	8.27	8.55	**100.65**
Nith River	156.80	141.62	156.80	151.74	156.80	151.74	156.80	156.80	151.74	156.80	151.74	156.80	**1,846.17**
Whitemans Creek	33.75	30.49	33.75	32.66	33.75	32.66	33.75	33.75	32.66	33.75	32.66	33.75	**397.41**
TOTAL	**636.67**	**575.06**	**636.67**	**616.14**	**636.67**	**616.14**	**636.67**	**636.67**	**616.14**	**636.67**	**616.14**	**636.67**	**7,496.33**