DRINKING WATER SOURCE PROTECTION

ACT FOR CLEAN WATER

Thames-Sydenham and Region Watershed Characterization Report

Thames Watershed & Region

(Upper Thames River & Lower Thames Valley Source Protection Areas)

Volume 3

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Prepared by --

Lower Thames Valley Conservation Authority

UPPER THAMES RIVER CONSERVATION AUTHORITY

-- in cooperation with --

St. Clair Conservation

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Conservation Ontario

Watershed Characterization Report
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Thames Watershed & Region Maps

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4 Water Quantity

Many human activities within the Thames Watershed & Region benefit from an abundant supply of water. This section of the Watershed Characterization Report provides a brief outline of current water use.

The Water Budget that is being prepared in parallel to the Watershed Characterization Report will provide more detailed information on the quantities used in the watershed and the future needs of local communities.

4.1 Water Use

Municipalities draw both surface water and groundwater to supply treated water to the public, businesses and industries. Individuals and businesses in rural communities rely on groundwater sources for drinking water. Industries take water directly from groundwater or surface water sources for cooling, washing and other plant operations. Agricultural businesses use water to irrigate crops and nourish livestock. Golf courses, a component of the commercial business sector, are dependent upon a reliable supply of water for irrigation. Each sector has its individual demand on available water supplies.

Water takers have the responsibility to ensure that the amount of water they use does not threaten the environment or existing water users. To enforce this principle, water takings in Ontario are governed by the Ontario Water Resources Act (OWRA) and the Water Taking and Transfer Regulation (ONT. Reg. 387/04), a regulation under the OWRA Act.

Section 34 of the OWRA requires any one taking more than a total of 50,000 litres of water per day to acquire a Permit To Take Water (PTTW). [1] Water takings that are exempt from the requirement to obtain a permit include takings by an individual for ordinary household purposes, water takings for the direct watering of livestock or poultry, and water for firefighting.

Map 16: Permit to Take Water Locations shows the locations of water takers that have water taking permits in the Thames Watershed & Region watershed. The locations shown on the map are colour coded to indicate groundwater, surface water or combined sources. Permit holders draw water for a variety of applications. **Map 17: Permit to Take Water General Purpose of Taking** shows the various types of water takers.

In the upper portion of the watershed, permit holders mainly use groundwater as their source. In the lower portion of the watershed, permit holders mainly draw water from surface water sources.

"The purpose of the PTTW program is to ensure the conservation, protection and wise use and management of waters of the province. Permits are controlled and not issued if the taking of more water in a given area would adversely affect existing users or the environment."

A Ministry of the Environment Director issues permits that establish requirements such as the maximum amount of litres permitted per day and the number of takings allowed per year. Other limits that may be

[1] Ontario Ministry of the Environment. April 2005. Guide to Permit to Take Water Manual.

included in the permit are seasonal restrictions and the time of day in which takings may occur. The permit may also require a monitoring program. Generally, for surface water takings, the user must not take more than 10% of the total flow at the point of taking. Thus, a requirement to know the value of the stream flow at the time of taking is usually included for new and renewed permits. Many agricultural and commercial (golf course) water users store water from spring runoff in ponds for application later in the summer.

The Ministry collects water taking permit information and stores the information in a database. The number of permits for various water taking purposes (as listed in the OMOE database) in the watershed is summarized in **Table 4.1-1: Number of Water Taking Permits by Sector**. For the Thames Watershed & Region watershed, a total of 905 PTTWs are listed in the database. However, many of the permits that are listed in the database have expired dates listed beside them. It is unclear if these permits have been updated or renewed.

In the past, the permits only set limits on the maximum water taking per day and it is difficult to determine how much water was actually used. New requirements have been introduced as of January 1, 2005, that require permit holders to collect, record and submit daily taking volumes to the Ministry on an annual basis. Permit holders, such as large consumptive water users, covered under Phase 1[2] must start on July 1, 2005. Phase 2 and 3 permit holders will also eventually be required to measure, record and submit takings. These phases combined will cover all permit holders. As water taking data is recorded, more representative water use values for the various sectors in the watershed will exist.

[2] OMOE. October 2005. Technical Bulletin: Permit to Take Water – Phase 1 Monitoring and Reporting. Phase 1 permit holders are outlined in this bulletin, and generally include large consumptive takings such as drinking water, beverage manufacturing, certain aggregate processing, plus others.

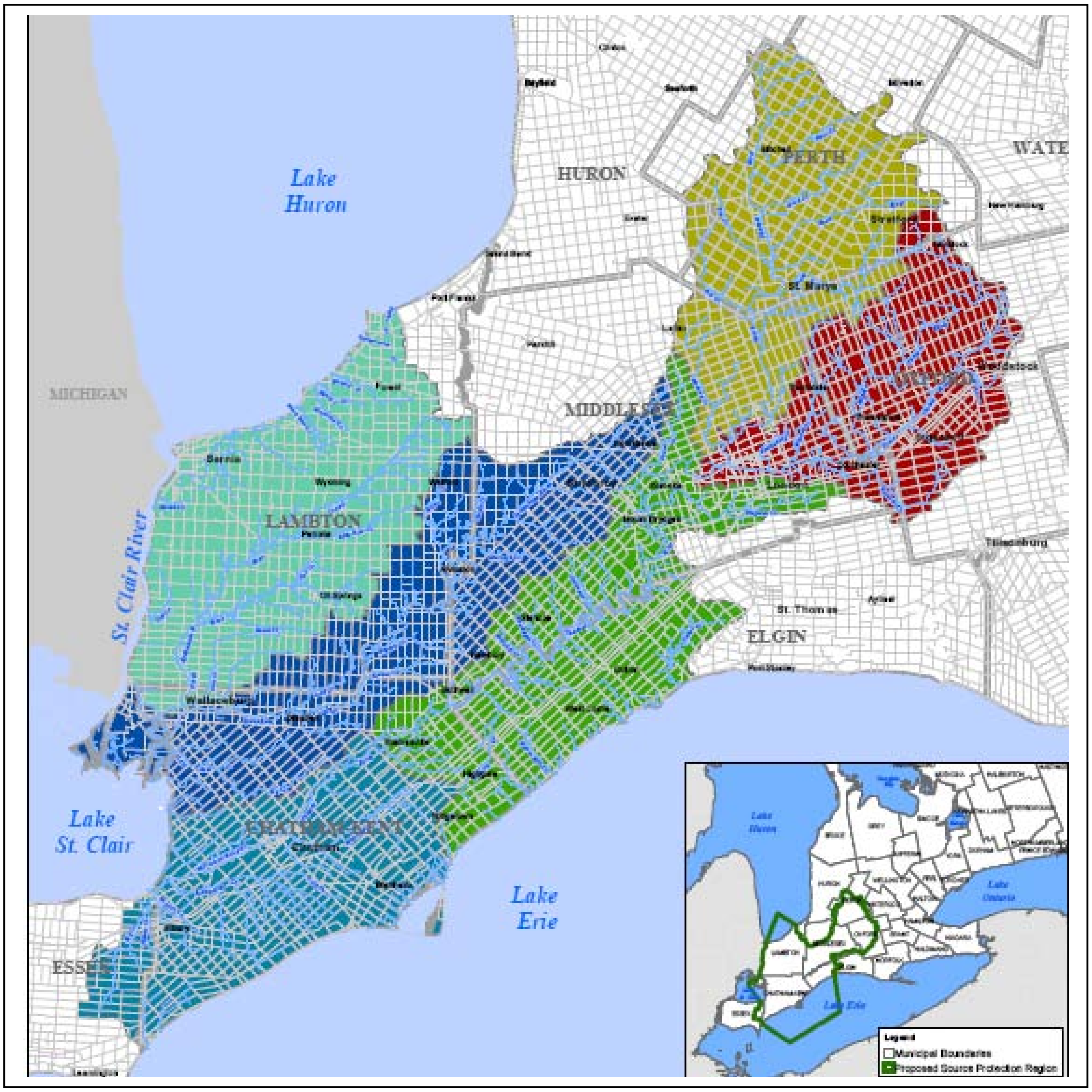
Table 4.1-1: Number of Water Taking Permits by Sector - Thames Watershed & Region[3]

Water Taking Sector	Water Use	Number of Permits	Percent of Total Permits	Total Annual Maximum Permitted Volume ($m^3 x10^6$)	Percent of Total Maximum Volume Permitted
Agricultural	Field and pasture crops, fruit orchards, market gardens/ flowers, nursery, sod farm, tender fruit, tobacco	300	33%	36,043	5%
Commercial	Aquaculture, bottled water, golf course irrigation, mall/ business, snowmaking	158	17%	32,116	4%
Construction	Construction, road building	10	1%	947	0.1%
Dewatering	Construction, pits and quarries	52	6%	241,193	33%
Industrial	Aggregate washing, cooling water, food processing, pipeline testing, power production	92	10%	222,480	30%
Institutional	Hospitals	1	0%	183	0.0%
Miscellaneous	Dams and reservoirs, heat pumps, other - miscellaneous, pumping test, wildlife conservation	57	6%	59,081	8%
Recreational	Aesthetics, other - recreational, wetlands	12	1%	539	0.1%
Remediation	Groundwater, other - remediation	6	1%	51	0.0%
Water Supply	Campgrounds, communal, municipal, water supply	217	24%	148,510	20%
Total		**905**		**741,142**	

The Draft Conceptual Water Budget divided the Thames-Sydenham & Region into six subwatershed catchments as shown in **Figure 4.1-1: Catchment Delineation (Nodes of Interest)**. The Thames Watershed & Region was split into four subwatershed catchments.

The 'North Thames' Catchment Delineation is the North Branch of the upper Thames River. The 'South Thames' Catchment Delineation is the combination of the South Branch and the Middle Branch of the upper Thames River. The 'Central Thames' Catchment Delineation is the lower Thames River from the Forks of the Thames to the Thamesville gauge plus the Lake Erie drainage area south of this part of the river. The 'Lower Thames' Catchment Delineation is the lower Thames River from the Thamesville gauge to the mouth of the Thames River plus the Lake Erie drainage area south of this part of the river and the area draining directly to Lake St. Clair.

[3] OMOE. Permit to Take Water database.



Watershed Catchments

- Bear Creek
- Sydenham
- Central Thames
- Lower Thames
- North Thames
- South Thames

Figure 4.1-1: Catchment Delineation (Nodes of Interest)[4]

[4] Thames-Sydenham & Region Source Protection Region. 2007. June 7, 2007. Draft Conceptual Water Budget, Version 2.0 Final Draft., Map 11: Catchment Delineation (Nodes of Interest).

The two St. Clair Region subwatersheds are included to provide some comparison across the Thames-Sydenham & Region Source Protection Region. The 'Bear Creek' Catchment Delineation is the North Sydenham drainage and the areas that drain to Lake Huron and the St. Clair River. The 'Sydenham' Catchment Delineation is the Main Sydenham River, East Sydenham Branch and the area that drains to Lake St. Clair.

As part of the review of water use undertaken in the Draft Conceptual Water Budget, an estimate of maximum permitted water use was made by multiplying the maximum permitted amount by the maximum number of permitted days. The water volumes were normalized by dividing the total volume by the watershed area from which it could be taken and expressed as depth in mm/year. The comparison of maximum permitted volume in mm per year by source for each subwatershed is shown in **Table 4.1-2: Maximum Permitted Volume by Source** and **Figure 4.1-2: Maximum Permitted Volume by Source.**

Table 4.1-2: Maximum Permitted Volume by Source

Subwatershed	Total Amount of Taking (mm/year)				Total (mm/year)
	Surface	Ground	Both	Undefined	
Bear Creek	28	1	3	0	31
Sydenham	34	16	3	0	53
North Thames	107	49	7	0	162
South Thames	43	197	43	0	283
Central Thames	7	17	3	0	27
Lower Thames	55	2	4	0	60

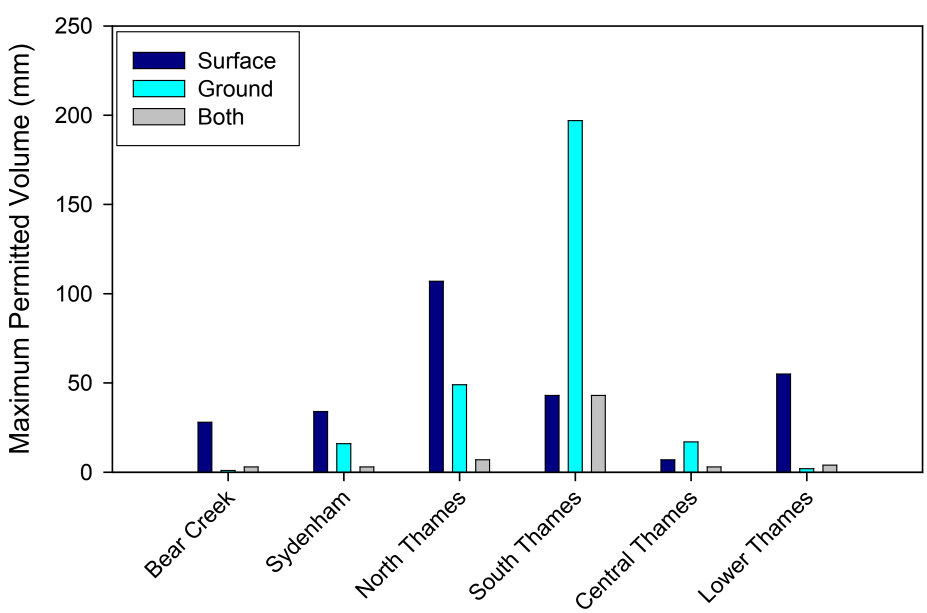


Figure 4.1-2: Maximum Permitted Volume by Source

Agriculture

The region normally receives about 900 mm of precipitation per year. Given the soil types and temperatures in the region, there is usually an adequate amount of rain for a farm operator to produce field crops. Specialized crops such as tobacco, ginseng and market crops including potatoes, beets, carrots and tomatoes are irrigated on a regular basis to maintain yield and quality. While the agricultural sector has 33% of the total permits in **Table 4.1-1,** the percent of total maximum volume permitted is only 5%. This difference probably reflects the seasonal nature of the water taking associated with crop irrigation.

In general, irrigation of cash crops, such as corn and soybeans, is not practiced in the region. However, drought-like conditions can occur and, during a dry year, some farm operators have irrigated field crops. Even with access to bountiful surface water for irrigation in the LTVCA area and a suitable high value crop, it is a borderline economic decision for the farm operator whether to invest in the capital equipment for irrigation of crops such as corn, as there are many years where it is not needed.

The most dependable source of irrigation water is the surface water of the Great Lakes including the lower reaches of the Thames River and creeks which are influenced by the lake levels of Lakes St. Clair and Erie. Due to the topography of the lower Thames watershed, the still water elevation of Lake St. Clair extends up the Thames River to approximately Kent Bridge. Upstream of Kent Bridge on the Thames River the gradient increases to the point where there is no influence from Lake St. Clair. However, there are some farm operations in this area that use the Thames River for irrigation.

Chatham-Kent has recently encouraged the construction of a green house industry. These are relatively high volume users of water and need a secure water supply for crop production. These usually use municipal water supplies.

Livestock numbers vary widely across the area. Livestock is a component of the agricultural industry that requires sufficient water on a daily basis. Many farm operators obtain drinking water from groundwater supplies and large livestock operations can potentially be a stressor on groundwater supply systems. Livestock will naturally gravitate to streams and watercourses to obtain water; farm operators are encouraged to limit livestock access to watercourses.

Agricultural water used for irrigation and in livestock and poultry operations has not been monitored in the region and as a result, the amount of water use required by agriculture is undetermined for the Thames Watershed & Region. However, groundwater studies provide some estimates for agricultural water usage in Lambton County, Middlesex County and the Municipality of Chatham-Kent as summarized in **Table 4.1-3: Agricultural Water Use**. While the table includes areas that are outside the Thames Watershed & Region, it helps to show the differences in agricultural water usage across southwestern Ontario.

Table 4.1-3: Agricultural Water Use (m^3/yr)*

Municipality	Number of Farms	Livestock Watering	Field Crops	Fruit Crops	Vegetable Crops	Specialty Crops	Total
Chatham-Kent	2,299	840,754	927,806	315,456	1,257,748	355,611	3,697,375
Lambton	2,346	1,625,661	79,143	243,621	918,217	172,566	3,039,208
Middlesex	2,515	2,551,461	856,073	347,628	82,723	2,013,392	5,851,278
Elgin	1,323	949,481	1,822,950	390,102	114,189	596,364	3,873,085

*Figures taken from the Essex/Chatham-Kent Region Groundwater Study, Lambton County Groundwater Study and Middlesex-Elgin Groundwater Study.

The volumes of water used for livestock watering and crop irrigation will be reviewed and updated estimates will be provided in the Water Budget Report.

Dewatering

In **Table 4.1-1**, the dewatering sector has 6% of the number of permits but appears to account for 33% of volume. The difference probably reflects the water taking associated with these activities.

Industrial/Commercial

In the commercial sector, water for irrigation of golf courses is a significant water usage. Water sources for golf course irrigation include groundwater, surface water from storage ponds, and water taken directly from local watercourses. In the UTRCA area, large aggregate and quarry operations take water for washing gravel and dewatering the sites. In the LTVCA area of the watershed, the only large industrial user of water is the Ethanol plant in Chatham.

Much of the water for industrial and commercial operations is supplied as part of the municipal water supply system. For example, there used to be numerous agricultural canning plants that were all large water users in Chatham but most of these plants have closed. With the capacity in the system that previously was needed for these industries, the municipality has constructed water pipelines from Chatham to small communities in Chatham-Kent.

Drinking Water Sources

Table 4.1-4: Drinking Water System Sources by Municipality shows a breakdown of the drinking water sources located in the Thames watershed. The percentage of the population served by municipal water ranges from a high of 100% in urban areas to as low as 0% in some rural municipalities. Many rural residents and businesses, especially in Chatham-Kent and Essex, have access to municipal water by a network of pipelines along local roads. **Map 38: Drinking Water Supplies/Intakes** shows the communities that have public water supplies.

Urban residents in the northern part of the Thames watershed (Oxford and Perth Counties) rely on treated groundwater for their drinking water. Some communities in Chatham-Kent and parts of Middlesex County also have municipal systems that use groundwater sources.

Residents in the City of London and some neighbouring Middlesex communities use treated surface water piped from Lake Huron and Lake Erie. Most of the water for residents in Elgin County, Chatham-Kent and Essex County is from Lake Erie. A few communities in Essex have treated water from Lake St. Clair.

Overall, the majority of the people in the Thames Watershed & Region are supplied with treated surface water supplies taken from the Great Lakes. Several of the water intakes and treatment plants that supply this water are located outside the Thames Watershed & Region. For example, the largest urban centre, the City of London, has pipelines providing water from both Lake Huron and Lake Erie. Other smaller communities also receive treated water via these pipelines. In Chatham-Kent and Elgin, several different surface intakes and water treatment plants supply potable water to communities across the Thames Watershed & Region.

Table 4.1-5: First Nation Drinking Water Sources provides a summary of the drinking water sources for First Nations located in the Thames Watershed & Region. Most residents of the First Nation communities rely on groundwater sources for their drinking water. The percentage of the population served by community water ranges from a high of 100% to as low as 0%.

Surface Water Intakes

Surface water is the primary source of drinking water for residents in the Thames Watershed & Region. Pumping stations pump raw water from Lake Huron, Lake St. Clair and Lake Erie to Water Treatment Plants (WTPs) where the water is treated, often stored in reservoirs, and passed through pipelines to residents. The intake locations are shown on **Map 38: Drinking Water Supplies/Intakes**.

The Union Water Treatment Plant is located west of Leamington in Essex County. It takes surface water from Lake Erie and serves the Town of Leamington and parts of the Town of Lakeshore.

The Wheatley WTP derives its surface water from Lake Erie south of Wheatley. This WTP supplies drinking water to the communities of Wheatley and Tilbury in Chatham-Kent. It also supplies water to portions of the Municipalities of Leamington and Lakeshore.

The South Chatham-Kent WTP serves the lower portion of the Municipality of Chatham-Kent. It came into operation in May, 2003 and replaced both the Erie Beach-Erieau Water System and the Blenheim Area Water System. It also serves the communities of Charing Cross, Merlin, Port Alma, Rondeau Bay Estates, Shrewsbury and South Buxton.

Table 4.1-4: Drinking Water System Sources by Municipality

County/ Municipality	Municipality	Water Source	Water Supply System	Percentage* of Population Served by Municipal Water**
MIDDLESEX[5]	City of London	Lake Huron	Lake Huron Primary Water Supply System (LHPWSS)	99%
		Lake Erie	Elgin Area Primary Water Supply System (EAPWSS)	
	Township of Lucan-Biddulph	Lake Huron	LHPWSS	58%
	Township of Thames Centre	Groundwater	Municipal Wells	38%
	Township of Middlesex Centre	Lake Huron	LHPWSS	42%
		Groundwater	Municipal Wells	
	Municipality of Southwest Middlesex	Lake Erie	EAPWSS	41%
OXFORD[6]	City of Woodstock	Groundwater	Municipal Wells	100%
	Town of Ingersoll	Groundwater	Municipal Wells	100%
	Township of Blandford-Blenheim			0%
	Township of East Zorra-Tavistock	Groundwater	Municipal Wells	46%
	Township of Norwich			0%
	Township of South-West Oxford	Groundwater	Municipal Wells	40%
	Township of Zorra	Groundwater	Municipal Wells	38%

[5] Figures taken from Dillon Consulting and Golder Associates. July 2004. Middlesex-Elgin Groundwater Study, Final Report.
[6] Figures from Oxford County. 2005. 2001 population statistics from website. Serviced statistics from Linda Truscott, Water and Wastewater Operations Coordinator.

County/ Municipality	Municipality	Water Source	Water Supply System	Percentage* of Population Served by Municipal Water**
PERTH[7]	City of Stratford	Groundwater	Municipal Wells	100%
	Town of St. Marys	Groundwater	Municipal Wells	100%
	Township of West Perth	Groundwater	Municipal Wells	53%
	Township of Perth East	Groundwater	Municipal Wells	16%
	Township of Perth South	Groundwater	Wells	4%
HURON	Municipality of South Huron			0%
ELGIN[8]	Municipality of Dutton/Dunwich	Lake Erie	EAPWSS	40%
	Township of Southwold	Lake Erie	EAPWSS	50%
	Municipality of West Elgin	Lake Erie	West Elgin Water Treatment Plant	47%
CHATHAM-KENT[9]	Municipality of Chatham-Kent	Lake Erie	South Chatham-Kent, Chatham, and Wheatley Water Treatment Plants	76%
		Groundwater	Municipal Wells (Ridgetown and Highgate)	
ESSEX	Town of Leamington	Lake Erie	Wheatley WTP and Union WTP	100%
	Town of Lakeshore	Lake St. Clair	Stoney Point WTP	74%

* Percentages calculated in this table includes municipal population outside the Thames Watershed & Region
** People that do not have piped public water obtain drinking water from private groundwater wells.

[7] Figures taken from Waterloo Hydrogeologic. April 2003. Perth County Groundwater Study.
[8] Figures taken Dillon Consulting and Golder Associates. July 2004. Middlesex-Elgin Groundwater Study, Final Report.
[9] Figures taken from Dillon Consulting and Golder Associates. December 2004. Essex Region/Chatham-Kent Region Groundwater Study.

Table 4.1-5: First Nations Drinking Water Sources

First Nation	Water Source	Water Supply System	Population Served by Community Water
Caldwell First Nation	Groundwater	Private wells	0%
Chippewas of the Thames First Nation	Groundwater	Chippewas of the Thames WTP	100%
Delaware Nation	Groundwater	Delaware WTP	100%
Munsee-Delaware First Nation	Groundwater	Chippewas of the Thames WTP, private wells	50%
Oneida Nation of the Thames	Groundwater	Oneida Nation of the Thames WTP, private wells	75%

The Chatham WTP receives its raw water from the same raw water pumping station as the South Chatham-Kent WTP at Erie Beach. The Chatham WTP supplies treated water to Chatham and the central parts of Chatham-Kent including the communities of Pain Court, Grande Pointe, Mitchell's Bay, Dresden, Tupperville and Thamesville.

The West Elgin Water Treatment Plant has a Lake Erie intake south of West Lorne at Eagle. The plant services the Municipalities of West Elgin, Dutton Dunwich, and Southwest Middlesex. It also supplies water to the Village of Newbury and the community of Bothwell in Chatham-Kent.

The Elgin Area Primary Water Supply System (EAPWSS) services the communities of London and Southwold in the Region. The WTP is located east of the village of Port Stanley in Central Elgin on Lake Erie. The plant has a current treatment capacity of 90 million litres per day (20 million Imperial gallons per day) and supplies water to a population of approximately 94,400 people.

The Lake Huron Primary Water Supply System (LHPWSS) services the City of London and communities in the Municipalities of Middlesex Centre, Lucan-Biddulph and Strathroy-Caradoc in the region. The WTP is located north of the community of Grand Bend on Lake Huron. The plant has a current treatment capacity of 340 million litres per day (75 million Imperial gallons per day) and serves a population of approximately 325,000 people.

The Stoney Point Water Treatment Plant is located in the Town of Lakeshore in Essex County. It takes surface water from Lake St. Clair and serves the northeastern portion of the Town of Lakeshore.

Groundwater

Map 34: Water Well Record Locations shows an overview of groundwater usage across the Thames Watershed & Region.

Private wells comprise an important source of water for domestic supply and other uses in rural areas. The rural population that is reliant on groundwater varies significantly across the length the of region with the highest numbers in Perth and Oxford Counties. The Thames-Sydenham & Region Draft Conceptual Water Budget[10] has attempted to estimate the private (unserviced domestic water use) based on a number of assumptions. Unserviced populations were determined from county groundwater studies and multiplying by a water use factor. The estimated annual water use by private groundwater users was calculated to be approximately 1,575,000 cubic metres.

[10] Thames-Sydenham & Region. June 7, 2007. Draft Conceptual Water Budget, Version 2.0 Final Draft.

Communal wells usually function to service a cluster of homes such as in a rural subdivision. A small pumping station is used to supply raw water or moderately treated water through pipes to homes in the immediate area. Many of these systems are being replaced where possible with a piped supply from a municipal system. The Rondeau Bay Estate Well System in Chatham-Kent is one example of a communal well system in the Region that has been replaced by piped municipal water.

Municipal wells supply drinking water to residents in many urban centres. Water from municipal well fields is pumped from the aquifer to a local water treatment plant (WTP) where the water is treated and stored in a reservoir or pumped directly to residents via pipeline. Municipal systems using groundwater are shown on **Map 38: Drinking Water Supplies/Intakes** and **Map 35: Municipal Wellhead Protection Areas**.

Groundwater studies have been completed for all of the counties (Oxford, Middlesex, Elgin, Perth, Lambton and Essex) and for the Municipality of Chatham-Kent. These studies address several technical tasks including:

- defining the regional geology,
- evaluating the regional hydrogeology,
- assessing the groundwater use,
- identifying existing and potential sources of groundwater contamination,
- a preliminary groundwater vulnerability definition,
- a brief summary of potential groundwater management and protection activities,
- developing a groundwater model based on the water well information database.

Since the studies were done on a county-wide basis, the groundwater information has been extracted from these reports and presented for each county. The following is a synopsis of information from the individual groundwater studies.

Perth County

Groundwater usage has been assessed using the Permit to Take Water (PTTW) database obtained from the OMOE and information obtained regarding pumping at the different municipal wells. Among the 72 active permits in the UTRCA area, 60 (83%) permits are for groundwater extraction, and four (5%) are for takings from both surface water and groundwater sources. Permits associated with water supplies (both communal and municipal) account for 40 of the 72 current water permits (56%) in the PTTW database. Industrial and agricultural water taking permits account for 18 (25%) of the permits, with commercial, institutional, dewatering and other water use permits accounting for the remainder.

In the UTRCA watershed, six Perth County communities (Mitchell, Sebringville, St. Pauls, St. Marys, Shakespeare and Stratford) are supplied by municipal groundwater supply systems. These municipal systems are serviced by one to 10 wells. Average pumping rates vary depending on the size of the community with Stratford having the highest rate at 14,600 m^3/day and St. Pauls having the lowest rate at approximately 24 m^3/day. The estimated municipal water takings and the residential component of the municipal water use are presented in **Table 4.1-6: Perth Municipal Water Use by Community in the Thames Watershed & Region**. Total municipal groundwater taking is estimated to be 21,233 m^3/day.

Table 4.1-6: Perth Municipal Water Use by Community in the Thames Watershed & Region

Community	Average Pumping Rate (m3/day)	Breakdown of Municipal Water Use
Mitchell	2,660	35% residential, 65% commercial/ industrial
Sebringville	35	100% residential
St. Pauls	24	100% residential
St. Marys*	3,844*	44% residential, 56% commercial/ industrial
Shakespeare	60	80% residential, 20% commercial/ institutional
Stratford	14,610	51% residential, 49% commercial/ industrial
Total	21,233	

* Updated based on comments from St. Marys

To try to determine groundwater used by Perth County rural residents living in the Thames Watershed & Region, several assumptions were made. **Table 4.1-7: Percentage of Municipality in CA Watershed Area** and **Table 4.1-8: Rural Domestic Water Usage by Municipality** help to explain these assumptions.

The rural population was calculated to be approximately 24,000 by subtracting the number of urban residents with municipal water from the overall population. This population was assumed to be evenly distributed in the municipalities. The percentage of each municipality in the UTRCA watershed was used to calculate the number of rural residents using private water supplies to be about 12,800. Using the OMOE standard water usage of 175 litres per day per person, the total rural domestic water usage in the UTRCA area was then estimated to be approximately 2,240 cubic metres per day.

Table 4.1-7: Percentage of Municipality in CA Watershed Area

Municipality	Watershed
North Perth	100% Maitland Valley
West Perth	28% Ausable-Bayfield, 70% Upper Thames, 2% Maitland Valley
Perth East	50% Grand River, 40% Upper Thames, 10% Maitland Valley
Perth South	100% Upper Thames

Table 4.1-8: Rural Domestic Water Use by Municipality

Municipality	Municipality Population	Estimated Rural Domestic Water Taking (m3/day)
North Perth	5,150	901
West Perth	4,329	758
Perth East	10,298	1,802
Perth South	4,120	721
Total	23,897	4,182
UTRCA Watershed Portion	12,814	2,242

The Perth County Groundwater Study[11] was completed in the spring of 2003 by Waterloo Hydrogeolgic Inc. The final groundwater model encompassed three hydrostratigraphic layers: an upper fine-grained aquitard layer (overburden), a thin middle weathered bedrock aquifer layer, and a thick lower fractured bedrock layer. The overburden includes a succession of fine-grained tills with some surficial glaciofluvial deposits. Tills mapped within the county include Stratford, Rannoch, Mornington, Tavistock, Elma, and Wartburg.

The analysis of well water records from the Water Well Information System (WWIS) concluded that over 80% of the wells in Perth County are completed to bedrock. Static water levels indicated that bedrock groundwater flows from the northeast to the southwest. Some of the important groundwater features in Perth County are discussed in the following paragraphs.

Along the boundary between the Grand River and Thames River watersheds is the Easthope Moraine, which sits on top of a bedrock high. This increase in the bedrock topography acts as the divide for groundwater between the Thames and Grand watersheds.

A buried bedrock channel was also found north of the Thames watershed near Gowanstown, Listowel, Atwood, and Mitchell. Although this channel appeared to have more sand and gravel in comparison to the rest of Perth, it did not appear to affect the overall regional groundwater flow.

Karst (sinkhole) features have been identified in western Perth County (Perth County Groundwater Study, Ausable Bayfield Sinkhole Investigation[12]). Karst may not have an effect on groundwater flow, but may be more important for recharge potential and for contamination potential. At this time, groundwater flow through the system is poorly understood. Due to the lack of information on sinkholes and their location outside of the Thames watershed, these features will not be discussed further in this report.

Detailed groundwater studies were completed for the Town of St. Marys[13] and the City of Stratford[14], in Perth County. These municipalities lie on a sequence of fine-grained glacial till, and the municipal wells are completed in bedrock in both cities. St. Marys groundwater flow is from the northeast to southwest and recharge zones include flat lands north of Otter Creek, sections of the Thames River that flow over bedrock, and areas with outwash deposits, mainly under the south central part of town. The Stratford report concluded that the City's groundwater recharge zone extended beyond the city's limits to the north and east within Perth County.

Usage tends to convert groundwater to surface water when treated municipal sewage is discharged to local watercourses. Similarly, deep aquifer groundwater may be moved to shallow aquifers via private sewage disposal (septic) systems serving rural residents. Overall, the vast majority of the water in Perth County is non-consumptive on a watershed level since it is returned to the respective watershed from which it came. Some uses do result in losses such as irrigation water which can be lost to the atmosphere via evaporation or evapotranspiration.

The total groundwater takings were calculated by adding the takings for large agricultural, domestic (rural and municipal), industrial, institutional and commercial water users. More than half (60%) of groundwater taken within Perth County occurs in the UTRCA watershed and is estimated to be approximately 31,912 m^3/day. Based on the previous calculations for municipal (21,940 m^3/day) and rural (2,242 m^3/day) domestic water usage, the non-domestic water usage appears to be about 7,800 m^3/day.

[11] Waterloo Hydrogeologic. 2003. Perth County Groundwater Study. Unpublished report.
[12] Waterloo Hydrogeologic. 2004. Ausable Bayfield Sinkhole Investigation. Unpublished report.
[13] International Water Consultants. 2002. The Town of St. Marys Ground Water Report.
[14] Golder Associates. 2001. Groundwater Study for the City of Stratford.

Oxford County

The County's 97,510 people (in 2000) are exclusively reliant on groundwater for their drinking water supplies. There are 18 municipal well systems throughout the County that draw on 60 municipal wells to serve 70% of the population. Ten of the well supply systems are in the UTRCA watershed. The County of Oxford became responsible for all of the municipal water supply systems in 2000.

Phase I of the Oxford study included collecting and compiling information on each of the municipal wells. **Table 4.1-9: Municipal Wells Oxford County**, as modified from Phase I, lists each of the communities, the number of municipal wells in each, and the aquifer(s) which they tap.

The rural residents of Oxford County also rely on groundwater for domestic, commercial and most agricultural water supplies. Private wells provide water to the 30 percent of the population (approximately 30,000) not served by a municipal system. Of the close to 6,000 wells listed in a 1987 summary, some 85 per cent were drilled for domestic or stock purposes, 3.7 per cent for municipal or public supply, 3.5 per cent for industrial/commercial use, 2.5 per cent for irrigation and 0.2 per cent for cooling or air conditioning.

The Regional Oxford County Groundwater Study was conducted by Golder and Associates in 2001[15]. The purpose of the County of Oxford Phase II Groundwater Study was to identify areas of significant aquifers and their corresponding recharge areas. Once the areas of these aquifers were identified, the groundwater flow patterns, both vertical and horizontal, were characterized using water level data from the OMOE well record database. This information, together with topographic data from the area, was used to identify areas of high hydraulic head (recharge areas) as well as low head (discharge areas).

[15] Golder and Associates, 2001. Phase II Groundwater Protection Study: County of Oxford. Unpublished report.

Table 4.1-9: Municipal Wells Oxford County

Municipality/Location	Number of Wells	Aquifer(s)
Beachville*	1	bedrock
Bright	2	overburden
Brownsville	2	overburden
Dereham Centre	1	bedrock
Drumbo	3	overburden
Embro*	2	bedrock
Hickson*	1	bedrock
Ingersoll*	8	bedrock
Innerkip*	2	bedrock
Lakeside*	1	bedrock
Mt. Elgin*	2	overburden
Norwich	3	bedrock
Otterville-Springford	4	overburden
Plattsville	2	overburden
Princeton	0	Woodstock
Springford	0	Otterville-Springford
Sweaburg	0	Woodstock
Tavistock*	3	overburden, bedrock
Thamesford*	3	overburden, bedrock
Tillsonburg	10	overburden
Woodstock *	10	overburden

* Located in UTRCA watershed

As shown in **Table 4.1-9: Municipal Wells Oxford County**, municipal systems draw water from both overburden (shallow, intermediate and deep) aquifers and bedrock aquifers within the County. The shallow and intermediate overburden aquifers extend throughout the study area as the County is dominated by glacial deposits and landforms. The bedrock geology of Oxford County consists of a series of subcropping Silurian through Middle Devonian age strata of predominantly limestones, dolostones and shales.

Middlesex County

Dillon Consulting Limited in association with Golder Associates completed the Middlesex-Elgin Groundwater Study in 2004[16]. The study included the City of London, the City of St. Thomas, all of Middlesex County and the majority of Elgin County. The information included in this section is derived from this study.

[16] Dillon Consulting and Golder Associates. 2004. The Middlesex - Elgin Groundwater Study. Unpublished report.

In the Thames Watershed & Region portion of Middlesex-Elgin, three municipalities operate a number of public groundwater supply systems. These include:

- Middlesex Centre (3 systems: Melrose, Komoka-Kilworth, Birr)
- Thames Centre (2 systems: Dorchester, Thorndale)
- Strathroy-Caradoc (Mount Brydges)

A summary of the population that is supplied by municipal systems is shown in **Table 4.1-10: Summary of Potable Water Sources, Middlesex-Elgin**. This table includes systems that are not in the Thames Watershed & Region. The table is based on information for the systems at the time the groundwater study was completed and does not reflect changes in source, such as the conversion of the Strathroy system to surface water.

Based primarily on maximum permitted total volumes, the largest water users are the quarry and mining industry which account for 35% of the groundwater use. Potable water usage (public supply and domestic-residential self supply) makes up approximately 24% of the groundwater use. This percentage has since decreased with the conversion of the Strathroy supply to piped Lake Huron water.

The distribution of groundwater use by category was reported to be:

- Public supply: 12%
- Self supply, domestic (residential) 12%
- Self supply, domestic (commercial/institutional) 12%
- Self supply, irrigation 19%
- Self supply, livestock 9%
- Self supply, industrial (manufacturing) 1%
- Self supply, industrial (mining) 35%
- Self supply, other <1%

Table 4.1-10: Summary of Potable Water Sources, Middlesex-Elgin

Municipality	Population				% Population supplied by Groundwater		
	Total	Municipal Wells	Municipal Surface Water	Private Wells	Total	Private Wells	Municipal Wells
Middlesex County							
Thames Centre	13,125	5,031	8,093	0	100%	62%	38%
Lucan Biddulph	4,388	0	2,538	1,850	42%	42%	0%
Middlesex Centre	14,664	2,863	3,225	8,576	78%	58%	20%
North Middlesex	7,839	0	6,837	1,002	13%	13%	0%
Adelaide-Metacalfe	3,257	0	0	3,257	100%	100%	0%
Southwest Middlesex	7,077	0	2,932	4,145	59%	59%	0%
Strathroy-Caradoc*	20,706	15,707*	0	4,999	100%*	24%	76%*
Newbury	422	0	422	0	0%	0%	0%
Elgin County							
Central Elgin	12,360	1,788	3,913	6,658	68%	54%	14%
Southwold	4,487	0	2,244	2,244	50%	50%	0%
Dutton Dunwich	3,696	0	1,490	2,206	60%	60%	0%
West Elgin	5,464	0	2,571	2,893	53%	53%	0%
Surface Water and Groundwater							
Total - Elgin	41,942	1788	17,659	22,496	58%	54%	4%
Total - Middlesex	71,478	23,601	15,954	31,922	78%	45%	33%
City of London	336,539	0	331,539	5,000	1%	1%	0%

* Information for Strathroy-Caradoc is based on the Groundwater Study and has changed with the conversion of Strathroy to lake water.

Essex & Chatham – Kent

The results and analysis of water use estimates was derived directly from the study[17] completed by Dillon Consulting Ltd. and Golder Associates Ltd.

There are two municipal well supplies identified in Ridgetown and Highgate in the Lower Thames Valley Conservation Authority (LTVCA) watershed. Ridgetown is supplied by two well fields, both completed in the same aquifer system. The well fields are located in an area consisting of 20 to 40 m clay/till aquitard covering the sand and gravel aquifer, which overlies black shale bedrock. The Ridgetown well field supplies 11,900 m^3/day. The region’s low permeability surface clays offer protection from surface spills or hazards. The time of travel for water to move from the ground’s surface through the low permeability soils, which act as an aquitard, is greater than a hundred years. Therefore, emphasis should be placed on maintaining the integrity of the aquitard.

[17] Dillon Consulting and Golder Associates. December 2004. Essex Region/Chatham-Kent Region Groundwater Study.

The Highgate water supply system consists of two wells serving approximately 150 homes in the hamlet of Highgate. The wells are deep (>50 m) and tap a sand and gravel aquifer that is protected by a thick aquitard, consisting of low permeability clay and silt soils. The system demand is approximately 500 m^3/day. The Highgate aquifer is well protected by the overlying clay till aquitard and emphasis for this system should also be on maintaining the integrity of the aquitard.

Based on information from the 1998 MUD survey, the majority of the residents of Essex and Chatham-Kent obtain their domestic water from municipal water systems that take their water from Lake Erie, Lake St. Clair, the St. Clair River, or the Detroit River. The proportion of the population that obtains their domestic water from private or non-municipal communal wells (Domestic Self Supply) accounts for only 9% of total water use.

Groundwater is identified as an important source of agricultural water in Chatham-Kent Groundwater Study. The overall breakdown of agricultural water sources across the Essex Region/Chatham-Kent region study area is roughly 60% groundwater and 40% surface water.

In Chatham-Kent, Ducks Unlimited has a large PTTW for wetland flooding. The actual water used is not recorded and is believed to be far less than these permits allow since the pumps are generally operated for only a few days per year.

Six Conservation Authority Study

As a follow-up to the individual groundwater studies, six conservation authorities (Ausable Bayfield, Maitland Valley, St. Clair Region, Essex Region, Lower Thames Valley and Upper Thames River Conservation Authorities) have commissioned a study to complement the groundwater modelling. Gamma ray geophysical logs were collected throughout the Six Conservation Authority Study area. The numeric model for the report has been finalized and a conceptual model has been drafted.

4.2 Data and Knowledge Gaps for Water Use

Many of the Permits to Take Water still listed in the database have expired dates and it is unclear if these permits have been updated or renewed.

The information presented is based on older Permits To Take Water that only set limits for the maximum water taking per day and the number of days water could be taken. Therefore, it is difficult to determine how much water each sector actually uses.

As of January 1, 2005, new requirements have been introduced that require permit holders to collect and record daily taking volumes for submission to the Ministry on an annual basis. Permit holders, such as large consumptive water users, covered under Phase 1[18] must begin collecting and recording the data starting on July 1, 2005. Phase 2 and 3 permit holders will also eventually be required to measure, record and submit takings. These phases combined will cover all permit holders.

As water taking data is recorded, more representative water use values for the various sectors in the watershed will exist.

[18] OMOE. October 2005. Technical Bulletin: Permit to Take Water – Phase 1 Monitoring and Reporting. Phase 1 permit holders are outlined in this bulletin, and generally include large consumptive takings such as drinking water, beverage manufacturing, certain aggregate processing, plus others.

Estimates of groundwater usage are based on water taking permits and do not include estimates for small domestic wells that do not require a permit. The availability of piped water in rural areas makes it difficult to determine an accurate estimate of the number of domestic wells currently in use.

There are a number of data and knowledge gaps that relate to the understanding of groundwater quantities and availability.

There is no detailed subsurface geology or aquifer definition. Thus, it is difficult to identify groundwater resources such as the extent of aquifers, groundwater flow paths and interaction of aquifers or aquitards. Detailed groundwater discharge and base flow studies are needed.

There is no comprehensive subsurface study based on geophysics and the surficial geology maps only reflect the first few metres. There is no way to derive a map of the lateral extent of aquifers. The assumed parameter based on the grain size or lithology (e.g. hydraulic conductivity) may not represent actual conditions. To obtain additional information, it is recommended that gamma ray logging of domestic wells be undertaken to increase the quality of the well drillers' logs.

The Water Well Information System (WWIS) is a limited resource. There is no data available to map multiple overburden aquifers. Multiple overburden aquifers exist in Oxford and Middlesex Counties. To date, 3D modelling has relied on a conceptual geologic model. The conceptual model cannot be tested for the overburden or bedrock aquifers.

It is difficult to characterize the groundwater resources with the existing knowledge or adequately correlate the PGMN monitoring network and the well attributes. Recommend increasing the number of PGMN monitoring wells in some areas where groundwater is being used.

5 Description of Vulnerable Areas

This section is intended to provide a preliminary description of watershed areas that may be vulnerable, based on information from existing documents. A detailed description and vulnerability analysis will be presented in the Watershed Assessment Report.

5.1 Identification of Source Protection Areas

Intake Protection Zones (IPZ) for surface water sources and Wellhead Protection Areas (WHPA) for groundwater sources identify areas that are considered to be the most vulnerable from a quality and/or quantity perspective.

The majority of residents in the Thames Watershed & Region are supplied with treated surface water taken from Lake Huron, Lake St. Clair or Lake Erie. Seven surface water intakes supply treated drinking water to urban communities in the watershed. In addition, extensive networks of pipelines supply water to rural residents in some areas.

Groundwater is also an important source in the Thames Watershed & Region. Most groundwater supply systems are located in the eastern portion of the watershed in Perth (6), Oxford (10), and Middlesex (7) Counties, where there are 23 municipal and three First Nation systems using groundwater sources. There are only two municipal groundwater source systems in Chatham-Kent. There are no municipal groundwater source systems in the parts of Elgin and Essex Counties within the Thames Watershed & Region.

The locations of the surface water intakes and the groundwater source areas are shown on **Map 38: Drinking Water Supplies/Intakes**. The urban areas that receive treated surface water are also shown.

5.2 Groundwater: Aquifer Vulnerability, Wellhead Protection Areas (WHPA) & Potential Drinking Water Sources

The use of groundwater as a source is often determined by the capability of the local aquifers and groundwater quality.

East of the London area, the bedrock aquifers are carbonate in nature and generally have low mineral content, making them more aesthetically acceptable. Also, they have a capacity that can maintain small to large communities. Most of the municipal wells in Perth and Oxford Counties are developed in these bedrock aquifers.

To the west of London, the bedrock groundwater carries more minerals, such as sulphur and iron, making it less desirable as a drinking water source. The groundwater drinking water sources are primarily from surficial unconfined overburden aquifers associated with sand plains or till moraines.

5.2.1 Aquifer Vulnerability

The groundwater quality vulnerability analysis addresses the intrinsic vulnerability of the groundwater aquifers. This includes:

- Identifying vulnerable areas
- Mapping the relative vulnerability of the aquifers within each vulnerable area
- Identifying highly vulnerable aquifers, significant groundwater recharge areas and future municipal supply areas

The relative vulnerability will be characterized as high, medium and low.

Map 18: Intrinsic Susceptibility Index (ISI) provides an overview of ISI values from the studies done in the Thames Watershed & Region. Information was interpreted differently in some areas and potential differences are shown along the county boundaries. The Southwestern Edge-matching Project[19] explains where areas of differences occur.

In general, the areas of highest susceptibility are in the sand plains and moraines across the watershed. The areas of low susceptibility are in the silt and clay plains. Several maps including **Map 6: Surficial Geology**, **Map 7: Physiography**, **Map 8: Soils Information** and **Map 9: Ground Surface Elevation** show some of the features that affect the groundwater susceptibility.

5.2.2 Wellhead Protection

Information on the number of wells in each municipal drinking water system in the Thames Watershed & Region has been provided in **Section 3.3: Groundwater Quality** and summarized in **Table 3.3.1.1-1: Municipal Well Supply Systems in Thames Watershed & Region.**

Wellhead Protection Areas have been completed for all operating municipal systems and the backup wells in the City of London. **Map 35: Municipal Wellhead Protection Areas** shows the areas of most concern based on the estimated time of travel from two to 25 years.

The groundwater quality assessment is focused on the physical characteristics of the groundwater resource. It includes:

- Assessing and mapping the vulnerabilities of Wellhead Protection Areas (WHPA) and other designated systems
- Assessing highly vulnerable areas and aquifers on the broader geographic landscape including potential impacts from outside the WHPAs
- Evaluating and mapping the vulnerability for specific areas within the watershed including: Significant Groundwater Recharge Areas (SGRA), Highly Vulnerable Aquifers (HVA), and Future Municipal Supply Areas (FMSA)
- Identifying sensitivity areas and the assignment of vulnerability scores to these sensitivity areas

This assessment is based on the following studies:

- Perth County Groundwater Study, Waterloo Hydrogeologic Inc., Final Report, 2003[20]
- Perth County Vulnerability (SWAT) Pilot Study, WHI, 2005[21]
- Phase II, County of Oxford Groundwater Protection Study, Golder Associates, 2002[22]
- County of Oxford Vulnerability (SWAT) Pilot Study, Golder Associates, 2005[23]

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[19] Waterloo Hydrogeologic. 2005. Southwestern Region Edge-Matching Study.
[20] Waterloo Hydrogeologic. April 2003. Perth County Groundwater Study, Final Report.
[21] Waterloo Hydrogeologic. 2005. Perth County Vulnerability (SWAT) Pilot Study.
[22] Golder Associates. 2002. Phase II, County of Oxford Groundwater Protection Study.

- Middlesex-Elgin Groundwater Study Final Report, Dillon Consulting and Golder Associates, July 2004[24]
- Strathroy-Caradoc Groundwater Management Study, International Water Consultants Ltd., 2001[25]
- Essex Region/Chatham-Kent Groundwater Study, Dillon Consulting and Golder Associates, December, 2004[26]

In Oxford County, small communities, villages, towns and cities rely completely on groundwater for their potable water supply[23]. The wells supplying 10 of these municipal drinking water systems are in the Upper Thames River Conservation Authority watershed. All of the municipal drinking water systems are administered by the county government. The County of Oxford has completed both aquifer vulnerability (AVI) vulnerability and intrinsic susceptibility index (ISI) analysis for groundwater sources. Also, SWAT (surface to well advection time) for Woodstock, Ingersoll, Tillsonburg and Norwich are done.

Perth County relies on groundwater to supply nearly all of its drinking water needs[20]. There are 10 municipal systems and the wells for six of the systems are located in the UTRCA watershed. Each system is administered by the local municipality. The intrinsic susceptibility index (ISI) vulnerability analysis is complete for the County of Perth.

In Middlesex County, there are currently six active municipal systems and a stand-by system of several backup well fields that are maintained by the City of London[24]. The wells for all seven of the municipal systems are in the UTRCA watershed. Each system is administered by the local municipality. The intrinsic susceptibility index (ISI) vulnerability analysis is complete for the County of Middlesex.

It should be noted that while the northern portion of the community of Mount Brydges in Middlesex is in the St. Clair Region Conservation Authority watershed, part of the community is in the Thames Watershed & Region and the wells supplying Mount Brydges are in the UTRCA watershed. Thus, the Mount Brydges system is included in both this report and the St. Clair Region Report.

There are also three First Nation systems that utilize groundwater sources in Middlesex County. These are located in the Lower Thames Valley Conservation Authority part of the watershed. It is unknown if ISI or other vulnerability analysis has been done for the First Nation systems.

In Chatham-Kent, there are only two groundwater-based municipal water systems[26], both in the LTVCA watershed. The systems are administrated by Chatham-Kent. The intrinsic susceptibility index (ISI) vulnerability analysis has been completed.

Additional WHPA vulnerability scoring and threats assessment are at or near completion for all municipal systems in Perth, Oxford and Middlesex Counties. These should be complete in 2007. It is anticipated that the additional Chatham-Kent vulnerability analysis will be funded and completed in 2007.

5.2.3 Potential Future Drinking Water Sources

The Middlesex-Elgin Groundwater Study[24] identified two major bedrock aquifers as potential sources. A shale aquifer near the western border of Middlesex was described that is “more marginal and typically produces less water with poorer water quality”. The other bedrock aquifer was a limestone aquifer in the northeastern part of the Study area. The study indicates that the water quality for this aquifer is generally good with high hardness. However, high iron concentrations and sulphide odours also occur.

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[23] Golder Associates. 2005. County of Oxford Vulnerability (SWAT) Pilot Study.
[24] Dillon Consulting and Golder Associates. July 2004. Middlesex-Elgin Groundwater Study, Final Report.
[25] International Water Consultants Ltd. 2001. Strathroy-Caradoc Groundwater Management Study.
[26] Dillon Consulting and Golder Associates. December 2004. Essex Region/Chatham-Kent Region Groundwater Study.

The Middlesex-Elgin Study noted that the overburden aquifers had limitations on their usefulness for drinking water sources. The surficial unconfined sand and gravel overburden aquifers associated with the Caradoc, Bothwell and Norfolk Sand Plains were identified as being "most vulnerable to impacts" (from contamination). The other overburden aquifers were described as "relatively local in nature and cannot be mapped on a regional basis". Thus, the limitations on quality, quantity or vulnerability reduce the potential usefulness of the overburden aquifers that were identified in Middlesex.

The Essex Region/Chatham-Kent Region Groundwater Study[26] did not identify any significant potential groundwater aquifers that are located in the Thames Watershed & Region watershed. While the contact aquifer used by Ridgetown and Highgate appears to have significant production potential, the aquifer unit is quite variable in thickness and composition making the prediction of aquifer presence difficult. The study also indicates that the water generally has concentrations of natural trace elements and chemical compounds (i.e. iron, sodium, fluoride, copper, lead, etc.) that can be generally very near limits set by the Ontario Safe Drinking Water Act.

In the Oxford County Study[22], Section 6.0 Aquifer Characterization provides aquifer mapping vulnerability and water quality mapping.

The shallow and intermediate overburden aquifers were identified as being quite extensive. The deep overburden aquifer was least extensive. In the order of 80% of the shallow aquifer was reported as having high vulnerability. The intermediate aquifer contains significant area of moderate vulnerability and only small areas are considered to be highly vulnerable. The vulnerability of these aquifers limited their potential for drinking water sources.

The western two thirds of Oxford County are underlain with out-cropping carbonate (limestone and dolostone) rocks that generally provide good bedrock water supplies. The eastern third of the County is underlain by the Salina Formation which consists of shales with interbeds of salt and gypsum that do not produce the good quantity or quality of the carbonate rock formations.

The bedrock aquifers and the deep overburden aquifer have only very few local areas of high vulnerability, primarily along the Thames River where the overburden is considerably thinner.

In general, groundwater in Oxford County was considered to be of good quality. However, sample results for the shallow overburden aquifer have an average of 5.34 mg/L of nitrate and the ODWS criteria of 10 mg/L was exceeded in 12% of the samples. Also, 55% of the samples had detectable total coliform bacteria, showing the vulnerable nature of the shallow aquifer.

The Perth County Groundwater Study[20] indicated that upper, intermediate and deep overburden aquifers are difficult to characterize. Also, in the Thames River watershed they are sparse and limited to alluvial sands and gravels deposited along rivers and streams.

For bedrock aquifers, the specific capacity was reported to be highly variable across the County. Overall, the bedrock groundwater quality in Perth County was reported to be excellent, from both a bacteriological as well as chemical standpoint. However, the report did identify several issues related to the bedrock water quality.

The groundwater is naturally fluoridated to levels up to 4 mg/L and can exceed the Ontario Drinking Water Standard of 1.5 mg/L. Several parameters such as hardness, iron, colour and total dissolved solids can exceed the Ontario Drinking Water Standard Aesthetic Objectives. For example, the report indicates that all of the municipal wells in the County exceed the guideline of 80 to 100 mg/L for hardness. Nineteen out of 30 wells recorded iron above the recommended objective of 0.3 mg/L. Nine out of 30 municipal wells had elevated levels of total dissolved solids.

Data Gap – Potential Future Groundwater Sources

The guidance for preparing the Watershed Characterization Report recommends developing a map that shows potential future groundwater sources. However, given the limitations on potential groundwater sources, a map identifying potential future groundwater drinking water source aquifers has not been produced for the Thames Watershed & Region.

5.3 Surface Water: Intake Protection Zones (IPZs)

The use of surface water as a drinking water source is determined by the quality of the water and the capability of the local watercourses to supply the quantity of water needed by the community.

5.3.1 Small River and Inland Systems

There are no inland surface water or small river intakes in the Thames Watershed & Region.

5.3.2 Great Lakes and Interconnecting Large River Systems

There are eight municipal water treatment facilities that take water from Lake Huron, Lake St. Clair or Lake Erie to supply drinking water to communities in the Thames Watershed & Region. The Chatham and the South Chatham-Kent Water Treatment Plants share a common intake, making the total number of intakes seven. A summary of the facilities and their intake sources is provided in **Table 5.3.2-1: Intakes Servicing Thames Watershed & Region**.

Table 5.3.2-1: Intakes Servicing Thames Watershed & Region

System	Intake Source
Chatham Water Treatment Plant* South Chatham-Kent Water Treatment Plant* West Elgin Water Treatment Plant Wheatley Water Treatment Plant Elgin Primary Area Water Supply** Union Water Supply System**	Lake Erie
Lake Huron Primary Area Water Supply**	Lake Huron
Stoney Point Water Treatment Plant**	Lake St. Clair

* Combined Intake
**Located outside of the SWP area

Map 38: Drinking Water Systems/Intakes shows the location of these Great Lakes drinking water intakes and the urban areas that receive treated water from them. Four of the intakes and treatment plants are located outside the watershed but supply water to systems that service communities in the Thames Watershed & Region.

Lake Huron: The Lake Huron Primary Water Supply System (LHPWSS) intake is located to the north of the Region near Grand Bend. As shown on **Map 2: Major Subwatershed Delineations**, none of the Thames Watershed & Region drains to Lake Huron.

Lake St. Clair: Most of the Thames Watershed & Region drains into Lake St. Clair via the Thames River. The Stoney Point Water Treatment Plant intake is located on Lake St. Clair west of the mouth of the Thames which discharges into the lake at Lighthouse Cove.

Lake Erie: The southern part of the Lower Thames Valley Conservation Authority watershed drains to Lake Erie. Six water treatment plants in the Thames Watershed & Region take water from Lake Erie between Port Stanley in the east and Union in the west. Between these two intakes, the West Elgin Water Supply System has an intake along the shoreline south of West Lorne; the Chatham-Kent intake supplies raw water to both the Chatham WTP and the South Chatham-Kent WTP; and an intake south of Wheatley feeds the Wheatley WTP.

5.3.3 Intake Protection Zones (IPZs)

As part of the evaluation of surface water threats, a minimum radius of 1 km is recommended for an initial Intake Protection Zone (IPZ-1). The radius of the IPZ-1 can be extended based on local conditions and professional judgment.

A second, larger Intake Protection Zone (IPZ-2) will be delineated by taking into consideration the magnitude of the threat delivery vectors and time for intake shutdown. Delivery vectors include factors such as current, wave action, stream flow and drift.

The zones will be established in the Intake Protection Zone Delineation Studies as the first phase of the Surface Water Threats Studies. Studies are underway for all of the municipal surface water intakes supplying communities in the Thames Watershed & Region. The lead organization for each is summarized in **Table 5.3.3-1: Drinking Water Surface Water Threats Studies**. The IPZ studies are at various stages of development.

Table 5.3.3-1: Drinking Water Surface Water Threats Studies

Intake	Lead Agency
Lake Huron Primary Water Supply System	City of London
Stoney Point Water Treatment Plant	Essex Region Conservation Authority
Union Water Supply System	Essex Region Conservation Authority
Wheatley Water Treatment Plant	Essex Region Conservation Authority
South Chatham-Kent & Chatham Water Treatment Plants	Essex Region Conservation Authority
West Elgin Water Treatment Plant	Municipality of West Elgin
Elgin Primary Area Water Supply	City of London

To consolidate work for several intakes, study efforts have been combined for nine water treatment plants that take water from the St. Clair River, Lake St. Clair, the Detroit River and western Lake Erie. This study includes the intakes for the Stoney Point WTP, the Union WSS, Wheatley WTP and the Chatham/South Chatham-Kent WTPs. The study also includes the Belle River, Windsor East & West, Amherstburg and Colchester water treatment plant intakes. A draft report[27] by Stantec on these intakes is available. The figures showing the Preliminary In-Lake IPZs for the Stoney Point, Union, Wheatley and Chatham intakes are provided below, together with a brief description extracted from the draft report.

[27] Stantec. March 2008. Essex, Chatham-Kent Source Protection Technical Study, Intake Protection Zone and Vulnerability Assessment Study (Wallaceburg), Draft.

Stoney Point

The Preliminary IPZs for the Stoney Point intake are shown in **Figure 3.3.3-1: Stoney Point Intake Preliminary In-Lake IPZ-2**. The intake is located approximately 1.2 km off the southern shore of Lake St. Clair at a depth of 3.1 m. The current patterns around the intake are generally parallel to the shoreline. The IPZ-2 extends approximately 2.4 km to the east, 5 km to the west and 3.6 km north of the intake. There are no tributaries that fall within the boundaries of the IPZ-2. The mouth of the Thames River is located 8.5 km east of the intake.

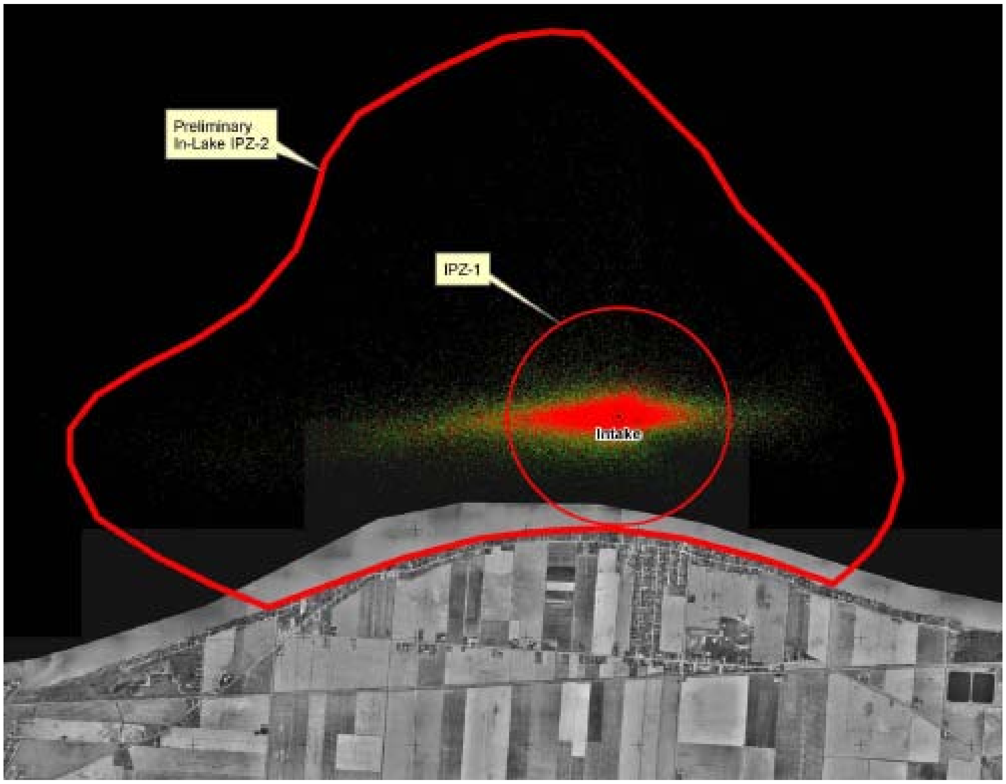

Figure 5.3.3-1: Stoney Point Intake Preliminary In-Lake IPZ-2

Union

The preliminary IPZs for the Union Water Supply System are shown in **Figure 5.3.3-2: Union Intake Preliminary In-Lake IPZ-2.** There are two intakes for this WTP, located 400 m from shore at a depth of 3.9 m and 1100 m from shore at a depth of 5.5 m. The IPZ-2 extends approximately 2 km east, 3.5 km west and 3 km south of the intake. There are no gauged tributaries within the IPZ-2.

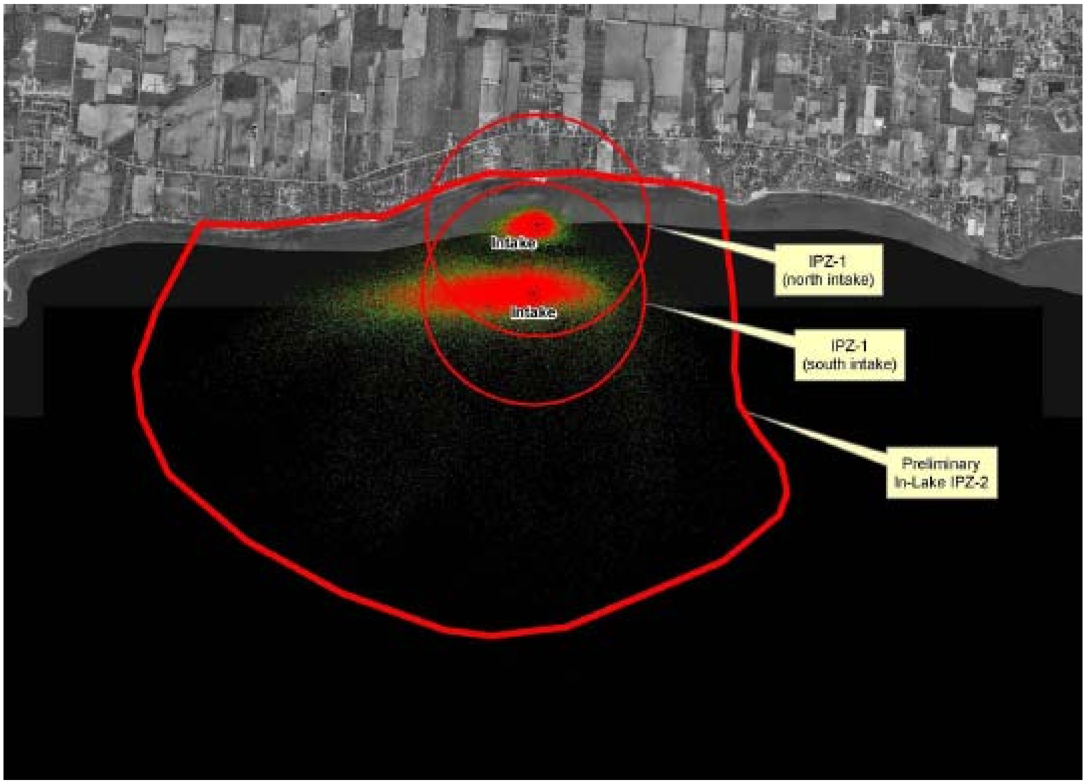

Figure 5.3.3-2: Union Intake Preliminary In-Lake IPZ-2

Wheatley

The preliminary IPZs for the Wheatley Water Supply System are shown in **Figure 5.3.3-3: Wheatley Intake Preliminary In-Lake IPZ-2**. There are two intakes for this WTP, located approximately 150 m from shore at a depth of 3.0 m and 600 m from shore at a depth of 4.4 m. The IPZ-2 extends approximately 2 km east, 3.5 km west and 3 km south of the intake. There are no gauged tributaries within the IPZ-2.

Chatham/South Chatham-Kent

The preliminary IPZs for the Chatham/South Chatham-Kent WTPs are shown in **Figure 5.3.3-4: Chatham/Chatham-Kent Intake Preliminary In-Lake IPZ-2**. The intake is located approximately 500 m from the shore at a depth of 5.5 m. The preliminary IPZ-2 extends 4 km west and 2 km east of the intake. There are no gauged tributaries within the IPZ-2.

Data and Knowledge Gaps - Intake Protection Zones (IPZs)

There is a lack of detailed monitoring information for the small watercourses and municipal drains that discharge in or near the Intake Protection Zones. Flow monitoring information is needed to confirm time of travel estimates. Water quality monitoring information is needed to help assess the potential impact of the discharges.

Figure 5.3.3-3: Wheatley Intake Preliminary In-Lake IPZ-2

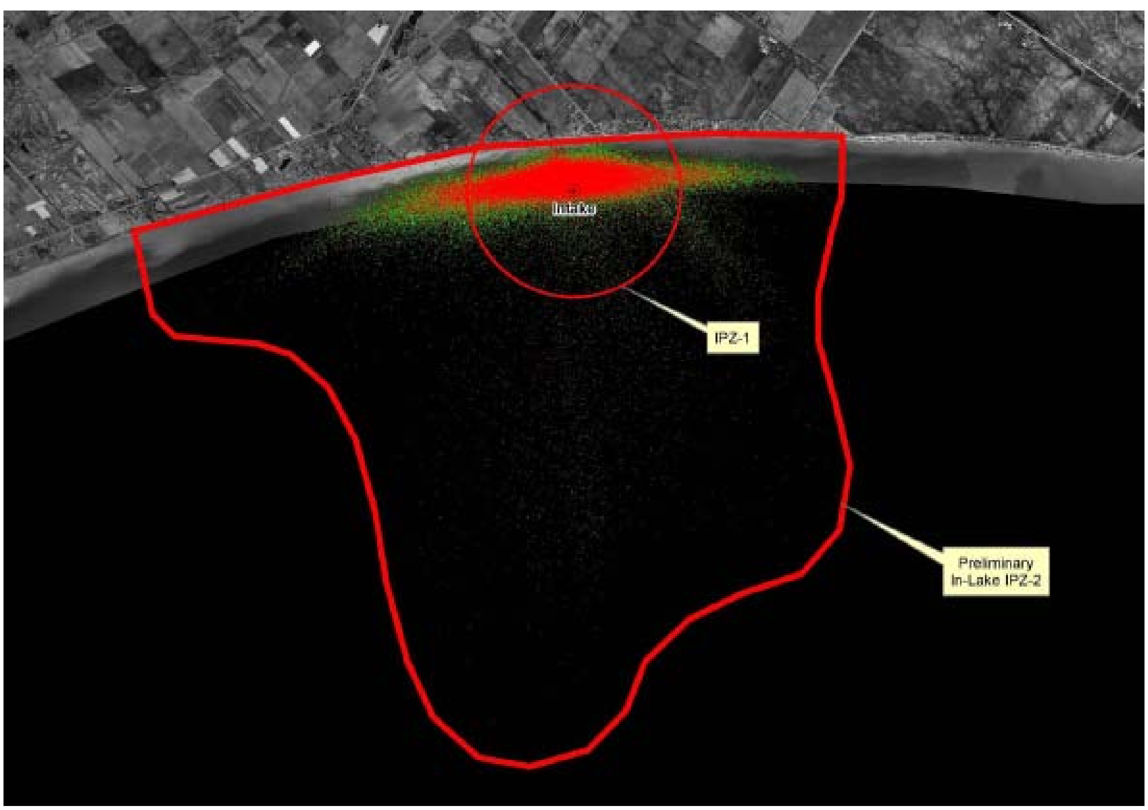

Figure 5.3.3-4: Chatham/Chatham-Kent Intake Preliminary In-Lake IPZ-2

6 Existing Drinking Water Threats Inventories

A "drinking water threat" can be defined as an activity or condition (existing or future) that affects or has the potential to affect the quality or quantity of a drinking water source.

This section of the report is intended to identify existing drinking water quality threats that have been inventoried as part of previous studies, reports and monitoring. Water quantity threats are being identified as part of the work on the Water Budget.

The evaluation of these existing threats and the identification of new threats will be done as part of the ongoing work for Source Protection.

6.1 Threats to Water Quality

Water quality threats have contaminants associated with them. Chemical or pathogen contaminants have the capacity to degrade present or future drinking water supplies if they are released and enter the drinking water source. Potential contaminant releases can be from individual point source locations or from non-point source land use activities.

Work is underway to establish an inventory of land uses and human activities that have the potential to impact surface water sources near existing water intakes. This work is summarized in **Section 6.1.1: Surface Water Quality Threats**. A brief summary of known surface water quality issues is provided in **Section 6.1.2: Known Surface Water Issues**.

Both surface water and groundwater sources are used for drinking water supplies. Many potential threats are common to both sources. An overview of potential source water threats for both surface water and groundwater is given in **Section 6.2: Groundwater**. The potential threats inventory is based on information summarized from several groundwater studies that have been completed for the Thames Watershed & Region.

6.1.1 Surface Water Quality Threats

Map 38: Drinking Water Supplies/Intakes shows the locations of various intakes and the communities that receive treated surface water. Surface water can be endangered by a wide variety of potential threats such as direct discharges from municipal or industrial wastewater treatment plants, runoff from urban, industrial and rural lands, or spills from storage or transportation of materials.

The need to assess vulnerability and establish an inventory of threats as part of Source Protection has been recognized and there are several studies of intake protection zones being conducted for surface water intakes supplying drinking water to communities in the proposed Thames Watershed & Region. These studies are summarized below.

Lake Huron Primary Water Supply System (LHPWSS)

This plant supplies drinking water to the City of London and other municipalities in Middlesex County. It is located outside the Thames Watershed & Region watershed. The intake is located in Lake Huron north of the community of Grand Bend. The potential impacts for the LHPWSS intake will be evaluated as part of the work being co-ordinated by the City of London.

Stoney Point, Union, Wheatley and Chatham/South Chatham-Kent Water Intakes

The potential impacts for the Stoney Point Intake will be evaluated as part of the Lake Erie, Detroit River, Lake St. Clair and St. Clair River Intake Protection Zone Delineation. Three municipal intakes on the Great Lakes connecting channels of the Detroit and St. Clair Rivers, two municipal intakes on Lake St. Clair, and three on Lake Erie have been grouped. This approach recognizes that these particular intake studies will involve similar science, expertise, and data, related to coastal processes in the lakes and river hydraulics of the connecting channels. The Essex Region Conservation Authority is the project lead.

West Elgin (Lorne) Water Supply System

The West Elgin plant supplies drinking water from Lake Erie to several communities including Rodney, Port Glasgow, West Lorne and Eagle. The Municipality of West Elgin is the lead for the threats study.

Elgin Area Primary Water Supply System (EAPWSS)

This plant supplies water to the City of London and several other communities in the Thames Watershed & Region. The intake is located in Lake Erie south of Port Stanley. The potential impacts for the EAPWSS intake will be evaluated as part of the work being co-ordinated by the City of London.

6.1.2 Groundwater Threats

Potential threats to groundwater are usually associated with the transmission of contaminants down through over burden to the groundwater aquifer. Once contaminants reach the aquifer, they can migrate along the aquifer for great distances. Since groundwater is a source of base flow in watercourses, the contamination can potentially affect both groundwater and surface water.

The groundwater system represents a complex recharge and discharge relationship between groundwater and surface water systems, regional and local precipitation, plant transpiration and human consumption. Potential threats can include specific point sources, widespread land use or recharge from contaminated surface water.

Several existing groundwater studies examine groundwater resources on a regional level, and identify potential risks or issues related to groundwater resources. These reports were done for study areas defined by municipal boundaries and the potential threats inventories do not correspond to watershed boundaries. However, the reports provide a preliminary list of threats that can be evaluated further in the Issues Evaluation/Threats Inventory component of the Assessment Report. **Map 2: Major Subwatershed Delineations** shows the parts of each municipality that are in the watershed of the Thames Watershed & Region.

The following groundwater studies provide summaries of the potential threats.

- Essex Region/Chatham-Kent Region Groundwater Study[28]
- Middlesex-Elgin Groundwater Study[29]
- Strathroy-Caradoc Groundwater Management Study[30]
- Phase II Groundwater Protection Study, County of Oxford[31]
- Vulnerability (SWAT) Pilot Study, County of Oxford[32]
- Perth County Groundwater Study[33]

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[28] Dillon Consulting and Golder Associates. December 2004. Essex Region/Chatham-Kent Region Groundwater Study.
[29] Dillon Consulting and Golder Associates. July 2004. Middlesex-Elgin Groundwater Study, Final Report.
[30] International Water Consultants Ltd. June 2001. Strathroy-Caradoc Groundwater Management Study.
[31] Golder Associates Ltd. 2001. Phase II, County Oxford Groundwater Protection Study.
[32] Golder Associates Ltd. September 2005. County of Oxford Vulnerability (SWAT) Pilot Study.
[33] Waterloo Hydrogeologic. April 2003. Perth County Groundwater Study, Final Report.

The reports identified several land uses and human activities that have the potential to impact groundwater quality.

Abandoned Water Wells

Map 34: Water Well Record Locations shows the wells in the watershed based on the OMOE database. While many are actively in use, improperly abandoned wells and active wells that are not properly maintained can provide easy and quick access for contaminants, surface water and water from other groundwater aquifers into an aquifer being used as a source of drinking water.

Oil and Gas Wells and Pipelines

Oil and gas exploration and production are important activities in parts of southwestern Ontario. **Map 31: Oil and Gas Wells** shows the extent of oil and gas drilling in the watershed. Oil and gas wells extend much deeper underground than water wells and must be drilled through the freshwater bearing aquifer zones. Since they intersect these aquifers, they can represent a threat. Also, production processes or brine disposal can threaten shallow groundwater quality. Modern drilling practices are aimed at reducing the potential threat level. However, there were many wells drilled in the early 1900s that had little or no protection for groundwater resources. In-ground pipelines are used to transport both crude oil and petroleum products throughout the province. Leakage from these lines is a potential threat to both groundwater and surface water.

Private Sewage Disposal Systems (Septic Tanks)

Septic tanks and new private disposal systems are a method for collection and treatment of small quantities of sewage. Potential groundwater problems can occur when sewage percolates too rapidly into the water table. Even properly constructed and maintained systems have the potential to impact groundwater if they are located too closely together in multi-lot developments.

Underground Storage Tanks

Underground storage tanks have been used throughout Ontario for liquid chemical storage, primarily to reduce the potential for fires or fire exposure of petroleum products such as gasoline and oil. The potential for a leak threatening groundwater is high since underground tanks cannot be easily inspected. Modern tank design and installation requirements have reduced the potential but contamination from old tanks is still a risk.

Use of Nutrients, Land Application and Storage

Nutrients of various kinds are applied to farm lands, recreation areas such as golf courses, and private lawns. When handled properly and applied in reasonable amounts, nutrients do not normally pose a threat to groundwater resources. However, inappropriate handling, improper storage or application of excessive amounts can represent a threat to groundwater. In addition to the potential for chemical contamination, some nutrient sources such as livestock manure or sewage sludge can include the potential for micro-organism contamination.

Application of Pesticides and Herbicides

Pesticides and herbicides are widely used in both urban and rural areas. Similar to the use of nutrients, inappropriate handling, improper storage or application of excessive amounts can represent a threat to groundwater.

Use and Storage of Road Salt

Road salt contamination is a potential threat to groundwater quality especially in areas where major roads cross regions with surficial sand and gravel deposits. In general, salt storage facilities have been improved over the years but past storage practices have resulted in contamination of groundwater aquifers.

Spills

Despite the best precautionary efforts, chemical spills can occur and potentially harm groundwater quality. In addition to locations where chemicals are manufactured or stored, there is a potential for release along main transportation corridors such as Highway 402 and rail lines.

Aggregate Extraction and Quarry Operation

Activities associated with aggregate extraction or quarry operations increase the potential for contamination of aquifers.

Landfills

Modern landfills now have a range of features and components designed to prevent impacts and ongoing monitoring is also required to identify any potential concerns. However, closed (abandoned) landfills and older landfills approved before more stringent requirements were in place have the potential for the escape of contaminants into the groundwater. Lists of known closed (abandoned) landfills and of active landfills are provided in Section 2.6 of the Watershed Characterization Report.

Stormwater Retention/Detention Facilities

Stormwater control facilities are now a common part of municipal development. Facilities built in low permeability soils or with a liner are not likely to affect groundwater quality. However, there is a potential for dissolved contaminants such as salts entering the groundwater from an unlined pond in permeable soil types.

Industrial Facilities and Brownfield Sites

Industrial operations that manufacture, utilize and store chemicals have the potential to affect groundwater both by spills and by the accumulation of low levels of contamination in the soils at the plant site. Brownfield sites of former manufacturing or industrial sites can be of particular concern. Modern industrial operations usually have better controls and are subject to inspection by government officials.

Databases and Other Sources Used to Identify Locations of Potential Threats

The groundwater studies researched and assembled information of potential contaminant sources from a variety of public and private databases and other sources. For example, some of the databases and sources used for various groundwater studies include:

- OMOE Database containing information on fuel storage tanks and PCB storage sites.
- OMOE Waste Disposal Site Inventory containing information on known landfill sites (active and closed) up to October 30, 1990.
- OMOE Spills Database.
- Anderson's Waste Disposal Sites (1930-2000) uses historical documentation to locate and characterize former waste disposal sites.
- National BCB Inventory (1988-1998) includes information on in-use BCB containing equipment and federal out-of-service equipment or PCB waste.
- Inventory of Coal Gasification Plants (to 1988) information on known and historic sites that produced or use coal tar and other related tars.
- Chemical Register (1992, 1999-2002) including information from a one time study in 1992 and private sources with a listing of facilities that manufacture and distribute chemicals.
- Pesticide Register (1988-1998) containing OMOE database of manufacturers and vendors of registered pesticides.
- Ministry of Natural Resources Records (by Cairnlins Resources Limited) and other studies (underground Resource management Inc. and Gartner Lee Associates Ltd., 1984) providing information on the locations of oilfield brine injection wells, cavern-washing brine injection wells, and industrial waste injection wells.

- Oil and Gas Pools and Pipelines of Southern Ontario Petroleum Resources Map (June 1, 2001) prepared by Ministry of Natural Resources and the Ontario Oil, Gas & Salt Resources Library.
- Municipal Survey information on salt storage and winter maintenance practices from various government sources.

Geographic Distribution of Potential Contaminant Sources

The distribution of potential threats varies across the proposed Thames Watershed & Region. The majority of point source contaminant sources such as fuel tanks, manufacturing facilities and PCB storage sites are located in and around urban areas while waste disposal sites and salt storage locations are more broadly distributed.

Information on the locations of potential threats was provided in several maps and tables that were prepared as part of the Groundwater Study Reports. In some cases, the consultants also tried to assign geographic coordinates if possible for many of the potential sources with unique locations. Some of the information available from the studies is summarized below.

Middlesex-Elgin Groundwater Study

The study collected assessed and summarized information on several potential groundwater threats. Electronic copies of the information are available. Some of the maps in the study that will be of interest are listed below:

- Regional Potential Contaminant Source Inventory
- Regional Potential Contaminant Source Inventory (London Area)
- Regional Potential Contaminant Source Inventory (St. Thomas Area)

Essex Region/Chatham-Kent Region Groundwater Study

The study collected assessed and summarized information on potential groundwater threats. Potential Contaminant Sources are illustrated on a map of the area that is provided in the study.

- Regional Potential Contaminant Source Inventory

Oxford County Groundwater Study

The study collected assessed and summarized information on potential groundwater threats. Potential Contaminant Sources are provided in the report and illustrated on maps in the study as listed below:

- Contaminant Inventory Map
- Contaminant Inventory Map Woodstock
- Contaminant Inventory Map Ingersoll
- Contaminant Inventory Map Tillsonburg

County of Oxford Vulnerability (SWAT) Pilot Study

The objective of the study was to further assess and delineate existing Wellhead Protection Areas for the Ingersoll, Norwich and Woodstock water supply systems. Based on the type of land use and the surface to well advection time (SWAT), the relative risks were evaluated and illustrated in figures in the study as listed below:

- Relative Risk of Existing Land Uses within the Ingersoll WHPA
- Relative Risk of Existing Land Uses within the Norwich WHPA
- Relative Risk of Existing Land Uses within the Woodstock WHPA

Perth County Groundwater Management Study

The Perth County Groundwater Management Study was initiated to develop an improved understanding of local groundwater conditions within the context of larger regional groundwater flow systems. Two of the objectives of the study were to compile a contaminant source inventory and to conduct a contaminant source assessment in the wellhead protection areas. The potential contaminant sources and the capture zones for the municipal wells are illustrated in figures that are part of the Perth Study as listed below:

- Atwood Integration of Study Results
- Listowel Integration of Study Results
- Gowanstown Integration of Study Results
- Milverton Integration of Study Results
- Shakespeare Integration of Study Results
- Sebringville Integration of Study Results
- Mitchell Integration of Study Results
- St. Pauls Integration of Study Results
- Stratford Integration of Study Results
- St. Marys Integration of Study Results

The study indicated that, based on the low susceptibility throughout Perth County, the most likely route through which a contaminant could migrate to the bedrock aquifer is through a poorly constructed or improperly abandoned borehole[33].

6.2 Known Water Quality Issues

The Strathroy-Caradoc Groundwater Management Study[30] identified the nitrate content of the groundwater in the Caradoc Aquifer as a significant concern. Nitrates are usually considered to be associated with septic systems or agricultural activities. Elevated levels of nitrate were reported in the community of Mt. Brydges with observed nitrate levels ranging from a low of 3.2 mg/L in 1989 to a high of 7.1 mg/L in 1998.

The Perth District Health Unit (PDHU) completed a rural water quality study[34] in 1991/1992 examining the bacterial, nitrate and fluoride levels in private wells in Perth County. 38% of the 142 wells sampled in the study were found to contain some form of contamination in the water, with the majority of the contamination being bacterial in nature[33].

A regional groundwater study[35] completed by the UTRCA, ABCA and MVCA in 2001 included a groundwater quality assessment. This study concluded groundwater throughout Perth County tends to be good[33]. Naturally-occurring levels of fluoride in high concentrations were identified as a health related concern. Several other parameters including hardness, iron, colour and total dissolved solids were also found to exceed aesthetic objectives.

Fluoride is often associated with sodium bicarbonate groundwater[36] and can occur naturally in groundwater at levels that exceed the drinking water standard[37]. Boron, iron, manganese, sodium and selenium, like fluoride, can occur naturally in groundwater. The concentrations[38] tend to be greater in reducing environments, such as deeper bedrock aquifers. Thick clay and clayey till overburden increases

[34] Perth District Health Unit, 1994. Perth County Rural Water Quality Survey, 1991/92

[35] Upper Thames River Conservation Authority, Ausable-Bayfield CA, Maitland Valley CA. 2001. Perth County Groundwater Study, Final Report. Submitted to the County of Perth.

[36] Griffioen, J., R. Brunt, S. Vasak and J. Van der Gun. 2005. A global inventory of groundwater quality: first results. In Bringing groundwater quality research to the watershed scale (Proceedings of GQ2004, the 4th International Groundwater Quality Conference, held at Waterloo, Canada July 2004. p 2-10.)

[37] Lesage, S. Groundwater quality in Canada: a national overview. In Bringing groundwater quality research to the watershed scale (Proceedings of GQ2004, the 4th International Groundwater Quality Conference, held at Waterloo, Canada July 2004. p 2-10.)

[38] Minnesota Pollution Control Agency. 1998. Boron in Minnesota's Ground Water. In Groundwater/ November 1998. 2 p. www.seagrant.umn.edu/groundwater/pdfs/MPCA-Boron.pdf

residence times and the likelihood of a reducing environment. As residence times increase (older groundwater), groundwater tends to become more reducing and the amounts of these constituents released from the rock materials that comprise these aquifers may increase.

The Oxford County Groundwater Study[31] assessed general groundwater quality by sampling 84 shallow overburden wells and 83 bedrock aquifer wells. Bacteriological results showed a higher incidence of total coliform and *E. coli* present in the shallow wells. Moderate levels of nitrate were found with some wells having levels over 10 mg/L. The groundwater quality was mapped for nitrate, TDS and sodium.

6.3 Data and Knowledge Gaps for Existing Drinking Threats Inventories

Data Gap Groundwater: Information on private well water quality may be available from the Ministry of Health and local health units. This information might help in identifying groundwater contamination issues.

Data Gap Groundwater Studies: The success of the geocoding for potential sources was variable and depended on the quality of location data in the original databases. **Table 6.3-1: Geocoding Summary Essex Region/Chatham-Kent Region Groundwater Study** and **Table 6.3-2: Geocoding Summary Middlesex-Elgin Groundwater Study** show the limitations reported by the consultant. Similar limitations on identifying the sites of potential contamination were reported in the Perth County Groundwater Study as shown in **Table 6.3-3: Summary of Potential Contaminant Sites Perth Groundwater Study**.

Table 6.3-1: Geocoding Summary Essex Region/Chatham-Kent Region Groundwater Study

Database	Very Good	Good	Poor	Not Geocoded	Total
TSSA Fuel Storage Sites	257		190	22	469
Provincial PCB Storage Sites	73		16	93	182
OMOE Spills Database				383	383

Table 6.3-2: Geocoding Summary Middlesex-Elgin Groundwater Study

Database	Very Good	Good	Poor	Not Geocoded	Total
TSSA Fuel Storage Sites	340		110	24	474
Provincial PCB Storage Sites	69		6	104	179
OMOE Spills Database				358	358
WSIS Landfills	191			172	363

Table 6.3-3: Summary of Potential Contaminant Sites Perth Groundwater Study

Potential Contaminant Source	Number of Sites Mapped	Number of Sites Impossible to Map
Fuel Storage	85	37
Spills	59	18
PCB Storage	16	2
Landfill/Certificates of Approval	13	216
Coal Gasification Plants	1	0
Oil and Gas Wells	24	?
Abandoned WWIS wells	121	?

7 Summary of Identified Issues and Concerns

An "issue" is the realization of a threat within a drinking water source. For water quality, it is represented by exceedences of water quality standards or increasing trends in water quality parameters. For water quantity, the term "stress" can be equated to the term "issue" for water quality.

"Concerns" are different from issues in that they may not be supported by scientific information such as monitoring results. Concerns may represent potential problems for drinking water sources but need further evaluation to determine if they are significant. Concerns are expected to be identified as part of the public and stakeholder consultation process.

7.1 Identified Issues

Inland Surface Water Quality

Section 3.2: Raw Water Characterization for Inland Surface Water provides a review of inland water quality across the region. In general, the following summarizes stream water quality issues that were identified as part of the review and are potential issues for drinking water quality:

- Phosphorus levels are above the Interim Water Quality Objective (for streams) of 0.03 mg/L to prevent algae growth that can result in taste and odour problems.
- Nitrate levels appear to be increasing and in some cases are above the Ontario Drinking Water Standard of 10 mg/L.
- Bacteria can be present at high levels above the Provincial Water Quality Objective of 100 counts per 100 mL for Recreational Water Use.

Great Lakes Water Quality

Section 3.4: Raw Water Characterization for Drinking Water Intakes provides a review of water quality for water treatment plants supplying water to communities in the Thames Watershed and Region. In general, the following briefly summarizes raw (untreated) water quality issues that were identified as part of the review and are potential issues for drinking water quality:

- Phosphorus levels in Lake Erie and Lake St. Clair can be above the Interim Water Quality Objective (for lakes) of 0.02 mg/L to prevent algae growth that can result in taste and odour problems.
- Turbidity which can affect treatment plant performance can be above the Ontario Drinking Water Standard (Aesthetic Objective) of 5 NTU.
- Temperature which can affect plant performance can be above the Ontario Drinking Water Objective of 15ºC.
- Bacteria can be present at high levels.
- Hardness levels which can affect treatment plant performance is above the Ontario Drinking Water Standard (operational Guideline) of 100 mg/L in Lake Erie.

Nitrates in Overburden Source Groundwater

The Strathroy-Caradoc Groundwater Management Study[39] identified the nitrate content of the groundwater in the Caradoc Aquifer as a significant concern. Levels of nitrate over 10 mg/L have been identified as being an issue in the wells supplying the community of Mount Brydges.

The Oxford County Groundwater Study assessed general groundwater quality by sampling 84 shallow overburden wells and 83 bedrock aquifer wells. Moderate levels of nitrate were found with some wells having levels over 10 mg/L. The groundwater quality was mapped for nitrate, TDS and sodium.

[39] International Water Consultants Ltd. June 2001. Strathroy-Caradoc Groundwater Management Study.

Bacteria in Groundwater Sources

The Perth District Health Unit (PDHU) completed a rural water quality study[40] in 1991/1992 that examined the bacterial, nitrate and fluoride levels in private wells in Perth County. 38% of the 142 wells sampled in the study were found to contain some form of contamination in the water, with the majority of the contamination being bacterial in nature.

The Oxford County Groundwater Study assessed general groundwater quality by sampling 84 shallow overburden wells and 83 bedrock aquifer wells. Bacteriological results showed a higher incidence of total coliform and *E. coli* present in the shallow wells.

As summarized in **Section 3.3: Groundwater Quality** bacteria levels that exceeded Provincial Drinking Water Objectives were found at a number of source water locations.

Chemical Parameters in Groundwater

A regional groundwater study[41] completed by the UTRCA, ABCA and MVCA in 2001 included a groundwater quality assessment. This study concluded groundwater throughout Perth County tends to be good. Naturally-occurring levels of fluoride in high concentrations were identified as a health related concern. Several other parameters including hardness, iron, colour and total dissolved solids were also found to be above aesthetic objectives.

Some Provincial Groundwater Monitoring Network (PGMN) wells have been found to have concentrations of fluoride (>1.5 mg/L), boron (>5 mg/L), selenium (>.01 mg/L) and sodium (200 mg/L) that are above health related standards. Two other parameters, iron and manganese, are above the aesthetic levels.

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[40] Perth District Health Unit. 1994. Perth County Rural Water Quality Survey, 1991/92.

[41] Upper Thames River Conservation Authority, Ausable-Bayfield CA, Maitland Valley CA. 2001. Perth County Groundwater Study, Final Report. Submitted to the County of Perth.

7.2 Identified Concerns

Scientists from the National Water Research Institute met with colleagues from other government departments and research facilities to discuss the major threats to water quality in Canada.[42] These are listed in **Table 7.2-1: Threats to Drinking Water Quality**.

Table 7.2-1: Threats to Drinking Water Quality

1. Waterborne pathogens
2. Algal toxins and taste and odour problems
3. Pesticides
4. Persistent organic pollutants and mercury
5. Endocrine disrupting substances
6. Nutrients - nitrogen and phosphorus
7. Aquatic acidification
8. Ecosystem effects of genetically-modified organisms
9. Municipal wastewater effluents
10. Industrial point source discharges
11. Urban runoff
12. Landfills and waste disposal
13. Agricultural and forestry land use impacts
14. Natural sources of trace element contaminants
15. Impacts of dams/diversions and climate change

7.3 Data and Knowledge Gaps for Identified Issues and Concerns

Issues of concern to the general public have not been identified. Additional concerns will be identified as part of public consultation and stakeholder involvement in the source protection process.

Mapping of the identified issues and concerns has not been done as part of the Watershed Characterization Report.

[42] Environment Canada. 2001. Threats to Sources of Drinking Water and Aquatic Ecosystem Health in Canada.

Appendix A: Data Gap Reporting

WC Deliverable	Data Set Name	Data Gap Problem	Comment
Section 2.5 Aquatic Ecology			
Fisheries Evaluation	Fisheries Data	Current Knowledge on cold water community location based on municipal drains almost exclusively	Work needs to be extended to natural systems to seek out cold water refuges
		Fish sampling data obtained from DFO and OMNR Lake Erie Management Unit needs to be incorporated into database	
		MNR data stored in hard copies should be made available	
		Application of indices such as the Index of Biological Integrity (IBI) to existing fish data	Help identify areas of high quality habitat and identify areas where further sampling may be required
		GIS analysis could aid in targeting sampling	Examining features (physiography, groundwater, land use, etc.) at the better quality known cold water sites and searching out similar conditions
		Historic evidence of cold water streams has not been investigated	Identify areas of protection, conservation, preservation or restoration potential

WC Deliverable	Data Set Name	Data Gap Problem	Comment
Section 2.5 Aquatic Ecology			
Aquatic Macroinvertebrates	Habitat Conditions & Water Quality	Use of additional indices to provide more information	Simpson's Diversity Index should be considered
		Analysis of physiography & land use	Identify potential communities and groundwater quality/quantity stressors and impacts
Reptile	Survival habitat and population dynamics	Extent, abundance and population demographics of prey	Needed for some species
		Lack of data for LTVCA (Thames River) watershed	Recent sampling efforts have concentrated on UTRCA watershed
		Lack of species information, habitat identification, seasonal dispersal, population isolation, reproductive success, past distribution	Regular surveys needed to maintain consistent long-term data
Species At Risk	Range and numbers of fish species at risk	Sections of the Thames River have little or no sampling	LTVCA section especially
		Limited information and data on the biology and ecology of many species	Population, abundance, distribution or status unknown for some species
Section 2.6 Human Characterization			
Landfills	Active, closed & expansions	Data missing	Information for UTRCA watershed is not included in report

WC Deliverable	Data Set Name	Data Gap Problem	Comment
Section 3.0 Water Quality			
Inland surface water quality – physical and chemical	PWQMN data	Does not exist for 1997 to 2001 and partially populated at other times/locations	Data gap for most PWQMN stations See Tables 3.2.3-2 and 3.2.3-3
UTRCA Inland surface water quality – microbial	PWQMN data for 1996 to present	Does not exist	Data gap for most PWQMN stations
LTVCA Inland surface water quality – microbial	PWQMN data for 1996 to 2002	Does not exist	Data gap for all PWQMN stations
Inland surface water quality	Other sources of information	Missing data	COA, Health Unit, Strathroy Reservoir, sediment analysis and Research data has not been reviewed
Intakes surface raw water quality – physical and chemical	DWSP data for West Elgin WTP and Wheatley WTP	Does not exist	Alternate sources of data have been found but they are not as 'complete'
Intakes surface raw water quality – microbial	DWIS data for Wheatley WTP, Elgin WSS, Lake Huron WSS, Stoney Point WTP and Union WSS	Missing data	Missing data from the DWIS; have let CO know; alternate sources of data have been found
Inland and intakes surface water quality – emerging pollutants		Partially populated, too sparse	Not enough data on emerging contaminants (fire retardants, pharmaceuticals, algae toxins, etc.)
Inland and intakes surface water quality	Municipal and Industrial Sewage Treatment	Missing data	Data sets not available
Intakes and inland surface water quality	Other sources of information	Missing data	Sources such as Great lakes monitoring data has not been reviewed
	Pesticides, DNAPLs, Pharmaceuticals, parasites and other contaminants	Limited data	Technical Expert Committee recommendations
	Pathways of Contamination	No review at this time	

WC Deliverable	Data Set Name	Data Gap Problem	Comment
	Sediment Analysis	No review at this time	Sediment data may help identify contaminant locations
	Bio-accumulation	No review at this time, limited information	Guide to Eating Ontario Sport Fish provides some information
	Cyanobacteria (blue-green algae)	Missing data	Comprehensive data lacking at this time
Groundwater Quality & Characterization	Groundwater Data	Missing data	Evaluation and characterization not complete Additional work is underway
	Municipal Groundwater Sources	Does not exist or partially populated	Data gap for many wells See Tables 3.3.3.3-1 to 3.3.3.3-26
	PGMN - microbial	Missing data, limited data	No total coliform, no *E. coli* for many wells, detection limited 10 per 100 mL
	Historic data	Missing data	Old sporadic reports in hard copy difficult to find and review
	Private Wells Water Quality Data	Missing data	Health Unit data

WC Deliverable	Data Set Name	Data Gap Problem	Comment
Section 4.0 Water Quantity			
Water Usage	Permit To Take Water Data	Data out of date	Many permits in database have expired dates and it is unclear if they have been renewed
	Water uses	Data Incomplete	Older permits only have maximum water taking per day. Difficult to determine actual usage.
Section 5.0 Description of Vulnerable Areas			
Map of Potential Future Drinking Water Groundwater Sources	Groundwater aquifers	Limitations on water quality and quantity	Overburden aquifers vulnerable to contamination Bedrock aquifers have aesthetic water quality issues
Section 6.0 Existing Drinking Water Threats Inventories			
Water Quality Threats	Location Identification	Data incomplete	Geocoding of potential sources variable See Tables 6.3-1, 6.3-2 and 6.3-3
Section 7.0 Summary of Identified Issues and Concerns			
Identified Concerns	List of Concerns	Missing Data	Concerns will be identified as part of public consultation and review of previous public discussions.

Appendix B: List of Acronyms

ABCA - Ausable Bayfield Conservation Authority
AO - Aesthetic Objective
AOC - Area of Concern
ARDA - Agricultural and Rural Development Act
BUI - Beneficial Use Impairment
CA - Conservation Authority
CCME - Canadian Council of Ministries of the Environment
CDW - Committee on Drinking Water
CEQG - Canadian Environmental Quality Guidelines
CN - Canadian National
CNR - Canadian National Railways
CO - Conservation Ontario
CoAs - Certificates of Approvals
COA - Canada-Ontario Agreement
C & O - Chesapeake and Ohio
COSEWIC - Committee on the Status of Endangered Wildlife in Canada
CPR - Canadian Pacific Railway
CSO - Combined Sewer Overflow
CURB - Clean Up Rural Beaches
DAR - Development Assessment Report
DFO - Department of Fisheries and Oceans
DNAPLs - Dense Non-Aqueous Phase Liquids
DOC - Dissolved Organic Carbon
DWIS - Drinking Water Information System
DWS - Drinking Water Systems
DWSP - Drinking Water Surveillance Program
EIS - Environmental Impact Statement
EMRB - Environmental Monitoring and Reporting Branch
END - Endangered
ERCA - Essex Region Conservation Authority
FBI - Family Biotic Index
FN - First Nation
FTU - Formazin Turbidity Unit
GLWQA - Great Lakes Water Quality Agreement
HPC - Heterotrophic Plate Count
IAP - Initiative Action Plan
IAP - Infrared Aerial Photography
IAS - Invasive Alien Species
IC - Implementation Committee
IJC - International Joint Commission
IMAC - Interim MAC
IPWQO - Interim Provincial Water Quality Objectives
IPZ - Intake Protection Zones
ISI - Intrinsic Susceptibility Index
IRS - Indian Research Satellite
LaMP - Lakewide Management Plan
LAWSS - Lambton Area Water Supply System
LHPWSS - Lake Huron Primary Water Supply System
LTVCA - Lower Thames Valley Conservation Authority

MAC - Maximum Acceptable Concentration
MCL - Maximum Concentration Level
MDL - Method Detection Limit
MISA - Municipal Industrial Strategy for Abatement
NAR - Not At Risk
NHIC - Natural Heritage Information Centre
NIS - Non-native Invasive Species
NPDWRs - National Primary Drinking Water Regulations
NTU - Nephelometric Turbidity Unit
OBBN - Ontario Benthic Biomonitoring Network
ODWS - Ontario Drinking Water Standard
OG - Operational Guideline
OMOE - Ontario Ministry of Environment
OMNR - Ontario Ministry of Natural Resources
OMAF - Ontario Ministry of Agriculture and Food
OMAFRA - Ontario Ministry of Agriculture, Food and Rural Affairs
OMMAH - Ontario Ministry of Municipal Affairs and Housing
OMNDM - Ontario Ministry of Northern Development and Mining
OWRA - Ontario Water Resources Act
PAHs - Polynuclear Aromatic Hydrocarbons
PCBs - Polychlorinated Biphenyls
PGMIS - Provincial Groundwater Monitoring Information System
PTTW - Permit To Take Water
PWQMN - Provincial Water Quality Monitoring Network
PWQO - Provincial Water Quality Objective
PWSS - Primary Water Supply System
RAP - Remedial Action Plan
ROM - Royal Ontario Museum
SAR - Species at Risk
SC - Special Concern
SCRCA - St. Clair Region Conservation Authority
SOLRIS - Southern Ontario Land Resources Information System
SOLEC - State of the Great Lakes Ecosystem Conference
SOWAQ - Southern Ontario Water Quality
SVCA - Sydenham Valley Conservation Authority
SWIG - Source Water Implementation Group
TDS - Total Dissolved Solids
TEC - Technical Experts Committee
THMs - Trihalomethanes
THR - Threatened
USEPA - United States Environmental Protection Agency
UTRCA - Upper Thames River Conservation Authority
WHI - Waterloo Hydrogeologic, Inc
WHPA - Wellhead Protection Area
WSS - Water Supply System
WTP - Water Treatment Plant
WWTP - Wastewater Treatment Plant

Appendix C: Significant Natural Areas and Wetlands (UTRCA)

	Site Name	Designations	Wetland Code	Size (ha)	Source
Avon River					
	Gads Hill South Swamp	Class 2 Wetland	NE5Aa	129	OMNR and UTRCA
	Little Lakes Swamp Complex	Class 3 Wetland; ESA	NE4D	135	OMNR and UTRCA; Hoffman 1981
	Shakespeare Hills/Avon Banks	Class 5 Wetland	NE6Ac	77	OMNR and UTRCA
	Stratford Wetland Complex	Class 6 Wetland	DO5D	186	OMNR and UTRCA
	Avonbank Woods	Prelim ESA		70	Hoffman 1981
Black Creek					
	Ellice Swamp	Class 2 Wetland	EL13A	866	OMNR and UTRCA
	Gads Hill South Swamp and Agreement Forest	Class 2 Wetland; ESA	NE5Aa	405	OMNR and UTRCA
	Gads Hill North Swamp	Class 4 Wetland	NE5AB	26	OMNR and UTRCA
	Sebringville Woods	Class 6 Wetland, ESA	DO12E	90	OMNR and UTRCA; Hoffman 1981
	Carlingford Spillway	Earth Science ANSI			OMNR
	Seebach Hill Spillway	Earth Science ANSI			OMNR
	Warburg Road Cut	Earth Science ANSI			OMNR
Cedar Creek					
	Cedar Creek/Sweaburg Swamp	Class 1 Wetland; SNA	NO5A	184	OMNR and UTRCA; Hilts 1976
	Brick Ponds Wetlands Complex	Class 2 Wetland	WC1C	32	OMNR and UTRCA
	Oxford Centre Swamp	Class 3 Wetland; SNA	NO6B, NO7E	96	OMNR and URCA; Hilts 1976
	NO3B "Jack Griffin's Wetland"	Class 6 Wetland	NO3B	38	OMNR and UTRCA
	Cedar Creek Source Complex	Class 6 Wetland	SW24E	21	OMNR and UTRCA
	TRT5	Class 7 Wetland	TRT5	25	OMNR and UTRCA
	Trillium Woods	Provincial Nature Reserve		10	OMNR 1984

	Site Name	Designations	Wetland Code	Size (ha)	Source
Dingman Creek					
	Dingman Cr / N. Dorchester Wetland Complex	Class 1 Wetland	ND15A	118	OMNR and UTRCA
	Regina Mundi Kirk-Cousins Wetland	Class 2 Wetland	WE9A	15	OMNR and UTRCA
	Westminster Wetland or Tenants Pond	Class 3 Wetland	WE10A	110	OMNR and UTRCA: City of London 1996
	Hearns Wetland	Class 3 Wetland	ND14C	5	OMNR and UTRCA
	Dingman Wetland and Fen	Class 3 Wetland	LO013	10	OMNR and UTRCA
	Elliot Laidlaw - Westminster Complex	Class 7 Wetland; Pot. ESA; SNA	WE18	152	OMNR and UTRCA; City of London 1996; Hilts and Cook 1982
	Delaware East Woodlot + Delaware Woodlot #11	SNA		178	Hilts and Cook 1982
	Delaware Northeast Woodlot	SNA		89	Hilts and Cook 1982
	East Lambeth - Talbot Road Corridor Extension	ESA		153	City of London 1996
	East Lambeth Forest (ESA 10088)	ESA		15	City of London 1996
	Foster Ponds	SNA		41	Hilts and Cook 1982
	Silver Swamp ESA	Potential ESA		27	City of London 1996
	Lower Dingman Corridor	Potential ESA		775	City of London 1996
	Mud Lakes	Candidate Nature Reserve		73	OMNR 1984
	Kilworth - Lake Maumee II and II	Earth Science ANSI			OMNR
	Kilworth Shoreline	Earth Science ANSI			OMNR

Site Name		Designations	Wetland Code	Size (ha)	Source
Dorchester					
	Dorchester Swamp	Class 1 Wetland; Car Can; ANSI; SNA	ND11A	500	OMNR and UTRCA; Hilts and Cook 1982
	Putnam Track Swamp	Class 1 Wetland	Nd29A	130	OMNR and UTRCA
	Meadowlily Woods ESA	Class 3 Wetland; ESA; SNA	WE17A	300	City of London 1996; Hilts and Cook 1982
	North Dorchester Swamp	Class 3 Wetland	ND6A	275	OMNR and UTRCA
	WN2D "Banner Swamp"	Class 6 Wetland	WN2D	7	OMNR and UTRCA
	ND32E or West Dorchester Wetland	Class 7 Wetland	ND32E	15	OMNR and UTRCA
	Thamesford Woodlot	SNA		121	Hilts and Cook 1982
Fish Creek					
	Kikton-Woodham	Earth Science ANSI			OMNR
	Lucan Moraine	Earth Science ANSI			OMNR
Flat Creek					
	McGrath Swamp	Class 6 Wetland	HI184	48	OMNR and UTRCA
	Staffa Kame Complex	Earth Science ANSI			OMNR
	North Thames Valley (Milverton + Mitchell Moraine)	Earth Science ANSI			OMNR
Forks of the Thames					
	Westminster Ponds - Pond Mills ESA (part of)	Class 1 Wetland, ESA	LC3A LC5D WE14D	300	OMNR and UTRCA; City of London 1996
	Arva Moraine Wetlands Complex	Class 3 Wetland		64	OMNR and UTRCA
	Highbury Wetland	Class 7 Wetland		2	OMNR and UTRCA
	Kilally Forest ESA	ESA		176	City of London 1996
	The Coves	ESA		43	City of London 1996

Site Name		Designations	Wetland Code	Size (ha)	Source
Glengowan					
	Motherwell Blue Heron Swamp	Class 6 Wetland	FU2D, FU14D	10	OMNR and UTRCA
	Fullarton Area	Earth Science ANSI			OMNR
	North Thames Valley	Earth Science ANSI			OMNR
Gregory Creek					
	Wetland Southwest of Uniondale	Class 2 Wetland	ZO34BE	4	OMNR and UTRCA
	DeBoer Wetlands	Class 2 Wetland	ZO34BH	23	OMNR and UTRCA
	St. Ives Floodplain	SNA		81	Hilts and Cook 1982
Komoka Creek					
	Komoka Creek Swamp + Campbellville Swamp Complex	Class 1 Wetland	LB2A	75	OMNR and UTRCA
	Komoka Bluff	SNA		34	Hilts and Cook 1982
	Camp Kee-Mo-Kee	SNA		22	Hilts and Cook 1982
	Komoka Shoreline	Earth Science ANSI			OMNR
Medway Creek					
	Arva Moraine Wetlands Complex	Class 3 Wetland		64	OMNR and UTRCA
	Elginfield Swamp	Class 6 Wetland	LD52A	2	OMNR and UTRCA
	Maple Grove Swamp	Class 7 Wetland	LD33D	17	OMNR and UTRCA
	WN18D "West Nissouri Wetland"	Class 7 Wetland	WN18D	6	OMNR and UTRCA
	Arva ESA or ESA 03040	Potential ESA		76	City of London 1996
	DeVizes Woodlot	SNA		41	Hilts and Cook 1982
	Medway Valley Heritage Forest	ESA		300	City of London 1996
	Elginfield Area Moraine	Earth Science ANSI			OMNR

Site Name		Designations	Wetland Code	Size (ha)	Source
Middle Thames					
	Unopened 12th Woodlots	Class 2 Wetland; Can. Nat. Res.; SNA	ZO37C	21	OMNR and UTRCA; Hilts 1976; OMNR 1984
	Lakeside Dump Swamp	Class 2 Wetland	ZO34CA	33	OMNR and UTRCA
	Medina Bush	Class 2 Wetland	ZO26B	32	OMNR and UTRCA
	ZO10D "Great Blue Heronry"	Class 2 Wetland; WWC	ZO10D	11	OMNR and UTRCA
	Kintore Swamp	Class 4 Wetland; WWC	ZO28A	157	OMNR and UTRCA
	Banner Swamp	Class 7 Wetland	ZO48B	10	OMNR and UTRCA
	Thamesford Meltwater Channel	Earth Science ANSI			OMNR
Mud Creek					
	Matheson's Bush	Class 2 Wetland	ZO33B	7	OMNR and UTRCA
	Mud Creek Banks	Class 4 Wetland	ZT24A	50	OMNR and UTRCA
	Youngsville Forest	Class 7 Wetland;SNA	ZO31B	21	Hilts 1976; UTRCA
	Mud Creek Meltwater Channel	Earth Science ANSI			OMNR
	Brooksdae Glacial Complex	Earth Science ANSI			OMNR
North Mitchell					
	Kuhrville Complex	Class 6 Wetland	EL5D	89	OMNR and UTRCA

Site Name		Designations	Wetland Code	Size (ha)	Source
North Woodstock					
	Pittock Reservoir	Class 1 Wetland	BB7C, ZT1C		OMNR and UTRCA
	Trotters Lake/ Vansittart Woods Complex	Class 1 Wetland	BB5A, BB6B	29	OMNR and UTRCA
	Zorra Swamp	Class 5 Wetland; SNA;	ZT23A	85	OMNR and UTRCA; Hilts 1976
	Eastwood Wetland	Class 6 Wetland	BB1C, NO8D	7	OMNR and UTRCA
	Wetland ZT26B	Class 7 Wetland	ZT26B	4	OMNR and UTRCA
	Wetland BB2D	Class 7 Wetland	BB2D	7	OMNR and UTRCA
	County Forest	SNA			Hilts 1976
	Fowlers Pond	SNA			Hilts, 1976
	Maple Woodlot	SNA			Hilts 1976
	Thames River Valley	SNA			Hilts 1976
	Innerkip Quarry	Earth Science ANSI			OMNR
Otter Creek					
	Conroy Woods	Class 3 Wetland, ESA	DO13D DO9B	120	OMNR and UTRCA; Hilts 1981
Oxbow Creek					
	LD50B "Oxbow Creek Wetland"	Class 6 Wetland	LD50B	14	OMNR and UTRCA
	Springers Creek Woodlot	SNA		61	Hilts and Cook 1982
	Elginfield Area Moraine				OMNR
Plover Mills Corridor					
	Thorndale River Valley	SNA		162	Hilts and Cook 1982
	Rannock Road Cut	Earth Science ANSI			OMNR
Pottersburg Creek					
	Airport Wetland	Class 7 Wetland	WD11D	5	OMNR and UTRCA

	Site Name	Designations	Wetland Code	Size (ha)	Source
Reynolds Creek					
	Five Point Woods	Class 1 Wetland	SW7A SW5C SW8C	160	OMNR and UTRCA
	Dereham Wetlands	Class 1 Wetland	SW29e	5	OMNR and UTRCA
	Mud Lake and Area	Class 2 Wetland, SNA	SW13B	81	OMNR and UTRCA; Hilts 1976
	ND17E	Class 3 Wetland	ND17E	8	OMNR and UTRCA
	SW14C	Class 3 Wetland	SW14C	18	OMNR and UTRCA
	Verschoyle Wetland	Class 6 Wetland	SW16D	17	OMNR and UTRCA
	Northwest Crampton Wetland	Class 7 Wetland	ND27B ND28C	18	OMNR and UTRCA
	Salford Woods	SNA			Hilts 1976
River Bend					
	Komoka Creek Swamp + Campbellville Swamp Complex	Class 1 Wetland	LB2A	74	OMNR and UTRCA
	Sifton Bog	Class 2 Wetland, ESA	LC2A	28	OMNR and UTRCA; City of London 1996; Hilts and Cook 1982
	Komoka Park Reserve or Kilworth ESA	Class 6 Wetland, ANSI, PP	DE4B, DE5B	200	OMNR and UTRCA; City of London 1996; OMNR 1984
	Kilworth Tuffa Deposits	SNA		5	Hilts and Cook 1982
	Kilworth Bluff	SNA		16	Hilts and Cook 1982
	Komoka Bridge Woodlot	SNA		47	Hilts and Cook 1982
	Kains Woods ESA	ESA; SNA		500	City of London 1996; Hilts and Cook 1982
	Warbler Woods	ESA; ANSI; SNA		63	City of London 1996; Hilts and Cook 1982
	Hyde Park ESA	Potential ESA		29	City of London 1996
	Kilworth - Lake Maumee II and II	Earth Science ANSI			OMNR

Site Name	Designations	Wetland Code	Size (ha)	Source
South Thames				
Five Point Woods	Class 1 Wetland, SNA	SW7A SW5C SW8C	161	OMNR and UTRCA; Hilts 1976
Golspie Swamp	Class 2 Wetland	ZO44A	296	OMNR and UTRCA
Foldens Swamp Complex	Class 4 Wetland	SW25B SW23D	108	OMNR and UTRCA; Hilts 1976
Rayside Swamp	Class 6 Wetland	ZO47	18	OMNR and UTRCA
Heslop Swamp	Class 7 Wetland	SW11B SW12D	19	OMNR and UTRCA
Ingersoll Wetland	Class 7 Wetland	SW10C	9	OMNR and UTRCA
Stelco Quarry	Earth Science ANSI			OMNR
Stoney Creek				
Arva Moraine Wetlands Complex	Class 3 Wetland		64	OMNR and UTRCA
Fanshawe Wetlands ESA, Fanshawe Complex	Class 3 Wetland; ESA	LD53A	133	OMNR and UTRCA; City of London 1996
Ballymote Wetland	Class 7 Wetland	LD51B	7	OMNR and UTRCA

Site Name		Designations	Wetland Code	Size (ha)	Source
Trout Creek					
	Wildwood Lake Wetland	Class 1 Wetland; CA; IBA	ZO38c	1257	OMNR and UTRCA
	Trout Creek Swamp or Wetland	Class 2 Wetland	ZO39B DO10B	34	OMNR and UTRCA
	ZO34cbc	Class 2 Wetland	ZO34cbc	51	OMNR and UTRCA
	ZO34cfg	Class 2 Wetland	ZO34cfg	80	OMNR and UTRCA
	ZO34Bd	Class 2 Wetland	ZO34Bd	15	OMNR and UTRCA
	Brooksdale Forest	Class 2 Wetland; SNA	ZO32B	42	OMNR and UTRCA; Hilts 1976
	Trout Creek Floodplain	ESA		75	Hoffman 1981
	Fairview Woods	ESA		70	Hoffman 1981
	Trout Creek Valley	SNA			Hilts 1976
	Shagbark Hickory Woods	ESA		48	Hoffman 1981
	Happy Hills	SNA			Hilts 1976
	Lost Concession	SNA			Hilts 1976
	Harmony Woods	ESA		37	Hoffman 1981
	Harmony Cut	Earth Science ANSI			OMNR
	Wildwood Silts	Earth Science ANSI			OMNR
	St. Marys Cement Co., South Quarry	Earth Science ANSI			OMNR
Waubuno Creek					
	Lakeside/Sunova Area Dump	Class 2 Wetland	ZO34ca	35	OMNR and UTRCA
	Wetland Southwest of Uniondale	Class 4 Wetland	ZO34BE	34	OMNR and UTRCA
	Medina Bush	Class 6 Wetland; SNA	ZO26b	32	OMNR and UTRCA; Hilts 1976
	WN2D	Class 7 Wetland	WN2D	7	OMNR and UTRCA
	Cobble Hills	SNA		70	Hilts 1976

Site Name		Designations	Wetland Code	Size (ha)	Source
Whirl Creek					
	Whirl Creek Woods	Class 5 Wetland	FU20E	34	OMNR and UTRCA
	Brunner Complex	Class 6 Wetland	MO175	32	OMNR and UTRCA
	Seabach Hill Woods	Class 7 Wetland; ESA	EL11D	12	OMNR and UTRCA; Hoffman 1981
	Seebach Hill Spillway	Earth Science ANSI			OMNR
Wye Creek					
	Belton Swamp	Class 7 Wetland	WN10D	4	OMNR and UTRCA
	Wyton Station Woods	SNA		65	Hilts and Cook 1982

Short Forms:

ESA - Environmentally Sensitive Area
SNA - Significant Natural Area
CA - Conservation Area
Car Can - Carolinian Canada Site
PP - Provincial Park
UTRCA - Upper Thames River Conservation Authority
WWC - Wildwood Wetland Complex
OMNR – Ontario Ministry of Natural Resources
Can. Nat. Res. - Candidate Nature Reserve
IBA - Important Bird Area

Notes:

Size of site is approximate only.

Sources:

OMNR and UTRCA = Wetland Files are available from the Ontario Ministry of Natural Resources and Upper Thames River Conservation Authority.
OMNR = Earth Science and Life Science ANSI (Areas of Natural and Scientific Interest) files are available from the OMNR.
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