DRINKING WATER SOURCE PROTECTION

ACT FOR CLEAN WATER

Thames-Sydenham and Region Source Protection Committee

Lower Thames Valley Source Protection Area

Proposed

Assessment Report

March 5, 2010

3.0 Water Budget and Water Quantity Stress Assessment

Made possible through the support of the Government of Ontario

Thames – Sydenham and Region
c/o Upper Thames River Conservation Authority
1424 Clarke Road, London, ON, N5V 5B9

March 15, 2010

Dear reader

Re: **Lower Thames Valley Proposed Assessment Report posted for comments**

The Thames-Sydenham and Region Source Protection Committee has posted the enclosed report for review and comment by stakeholders. This report is the second draft of the Proposed Assessment Report for the Lower Thames Valley Source Protection Authority. Comments received through the first posting have been considered by the Source Protection Committee and the report has been revised. Comments received in response to this posting will be forwarded with the Proposed Assessment Report to the Ministry of the Environment.

The Proposed Assessment Report for the Lower Thames Valley Source Protection Area represents a significant milestone in the Source Protection Committee's progress in the completion of the first Source Protection Plans for the Thames-Sydenham and Region. While this Assessment Report contains most of the required information, it is not complete. As a result this Assessment Report identifies the work remaining to complete the Assessment Report for this Source Protection Authority. The Source Protection Committee realizes that this report is a "living document" which will need to be updated and amended. This Assessment Report identifies a number of items which will need to be undertaken before the first Source Protection Plan can be completed. As a result an amended Assessment Report is anticipated prior to completion of the Source Protection Plan for the Lower Thames Valley Source Protection Area.

The Thames-Sydenham and Region Source Protection Committee is also preparing drafts of Assessment Reports for the St. Clair Region and Upper Thames River Source Protection Authorities. These documents will be posted as they reach a point where they can be posted.

We hope that you will take advantage of the open houses being held throughout the region to learn more about this Assessment Report and Source Protection planning. More information on these open houses is available on the web site on the bottom of this letter.

Yours truly,
THAMES-SYDENHAM and REGION

Robert Bedggood, Chair
Source Protection Committee

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3.0 Water Budget and Water Quantity Stress Assessment

The Clean Water Act is intended to reduce the threats to the quality and quantity of drinking water sources. In order to do this, threats within *vulnerable areas* are identified and assessed to determine the relative *risk* to the drinking water source. The Clean Water Act and its regulations identify 21 activities which can be drinking water *threats*. These activities include two which are related to the quantity of drinking water. One is an *activity* that takes water from an aquifer or a surface water body without returning the water taken to the same aquifer or surface water body. The other water quantity threat is an *activity* that reduces the recharge of an aquifer. To determine the risks to drinking water quantity from either of these threats, it is necessary to understand the level of *stress* on a drinking water system's source. The Water Budget is the tool used to understand the level of *stress* on a system or within a *watershed*.

Where there is little potential for *stress*, there are no *threats*. On the other hand, where there is a significant potential for *stress*, activities contributing to the *stress* will be significant threats. The Clean Water Act requires that the *Source Protection Committee* develop a *Source Protection Plan* that reduces the *risk* associated with *significant threats* so that they cease being significant and prevents new *significant threats* from being undertaken in these areas.

The Water Budget looks at the balance of water within an area known as a *watershed*. A Water Budget can be assessed at different scales, but generally this is undertaken on a *watershed* or parts of the *watershed* refered to as a *subwatershed*. It considers inputs or supply to the *watershed* or *subwatershed* which include: precipitation (rain and snow), flow into the watershed from up river, flow into the watershed through groundwater and flow imported into the watershed such as that which is piped water from the Great Lakes. The Water Budget balances these inputs with removals from the *watershed*, or *demand*, which include: discharges into the next *watershed* through stream flow or groundwater, use of water which is consumptive in nature (and therefore does not return the water to the same source from which it was removed), evaporation and transpiration (use of the water by plants). The water budget considers a balance between supply and *demand* that includes a *reserve* quantity that is removed from the supply in the stress calculation. The components of the water budget are described in detail in the Conceptual Water Budget (attached as Appendix 6), the Tier 1 Water Budget and summarized in the following sections.

The Water Budget is developed in stages referred to as tiers. These tiers involve more detailed analysis and refined data as they progress. In this manner, only those areas with the potential to be stressed require detailed modelling and analysis; those which appear not to be stressed receive a less detailed screening. Each of these tiers is described in the following sections. *The Lower Thames Valley Source Protection Area* is included with the other Source Protection Areas in the Thames-Sydenham and Region in the Conceptual Water Budget and the Tier 1 Water Budget. Only areas where there is a moderate or significant *potential for stress* on drinking water systems included in the Terms of Reference (only municipal systems in the *LTVSPA*) proceed to a Tier 2 Water Budget. Only those areas which are confirmed to have a significant or moderate stress level in the tier 2 assessment proceed with a Tier 3 Water Budget. It is only through a Tier 3 Water Budget that water quantity threats are assessed. As the potential for *stress* on drinking water sources was determined to be low through the Tier 1 Water Budget, a Tier 2 or Tier 3 Water Budget is not required for the Lower Thames Valley Source Protection Area. As a result, there are no water quantity *threats* to drinking water sources in the Lower Thames Valley Source Protection Area.

3.1 What is a Water Budget?

A water budget quantifies and compares the components of the hydrologic cycle. Much like a bank account, if more water is leaving than is entering, the water in the *watershed* will be depleted over time. If in balance, the water use is sustainable. Each component of the water budget must be quantified so that the *demand* can be compared to the supply. If the *demand* is greater than the supply, the reserves, like the savings in a bank account, will be depleted. Over time this would result in reduced water levels in water bodies and aquifers. Normal and cyclical fluctuations in water level make it necessary to look at the components of the water budget over long periods of time rather than looking at short-term trends in levels. This is especially true in groundwater systems where changes in water levels are more difficult to monitor and analyze.

3.2 Components of the Water Budget

3.2.1. Precipitation

Precipitation, or rain and snow, is the primary component of the supply component of the water budget. Long-term precipitation was analyzed from various meteorological stations around the region. Map 3-2 illustrates the precipitation stations used in the water budget and the spatial variation of the average annual precipitation over the region. Annual average precipitation decreases moving east to west along the LTVSPA from about 950 mm/a at the extreme east to about 850 mm/a at the extreme west. On average, the Lower Thames Valley Source Protection Area receives 900 mm per year of precipitation.

3.2.2. Evapotranspiration

Evapotranspiration (or ET) is the precipitation which either evaporates into the atmosphere or is used by the plants. Water used by plants is also given back to the atmosphere through a process known as transpiration. Together the evaporation and transpiration are known as Evapotranspiration. There is little variation across the region other than as a result of the variation in precipitation. Map 3-3 shows the evapotranspiration across the region. Water which evaporates or is used by the plants is not available as supply and is therefore subtracted from the precipitation in the supply calculations. ET accounts for more than half of the precipitation in the region.

Irrigation, although also used by plants and lost back to the atmosphere through evaporation and transpiration, is considered in the *demand* part of the water budget. Irrigation water is removed from a groundwater or surface water source, and is consumptive to that source. ET, on the other hand, is loss from the precipitation component of the water budget. Another important distinction is that irrigation occurs only in very localized areas where it is required by a crop. ET is directly related to precipitation, temperature and is fairly uniformly distributed across the watershed.

3.2.3. Surface Runoff

Precipitation which falls in the watershed and does not evaporate or get absorbed into the plants either infiltrates into the ground or runs off into streams and rivers. The runoff from the watershed is not available for the supply as it leaves the watershed quickly. Although some of the water which infiltrates into the ground also leaves the watershed relatively quickly, most of the water which seeps deeper into the ground is said to recharge the aquifers which is discussed in the following section.

3.2.4. Recharge

Recharge is the water from precipitation which soaks into the ground and recharges the aquifers in the ground. This is the water which maintains stream flow during periods between runoff events and is referred to as base flow. The water budget assumes that over time the recharge is equivalent to the base flow discharge from the watershed. This relationship is considered more closely in Tier 2 and 3 of the water budget work where calibrated surface and groundwater models are used to describe the components of the water budget including recharge. In the absence of these calibrated models, the average base flow from a watershed is the best indication of the recharge in the watershed.

In order to establish the recharge in a subwatershed the stream flow records are reviewed and runoff is removed from the records to calculate the base flow. Various methods can be used to separate base flow from runoff. In the Tier 1 Water Budget the second pass of the BFLOW filter was applied. This is a method which was developed by Arnold et. al. (1995) and is well accepted in this area. The effects of low flow augmentation reservoirs in the Upper Thames River Source Protection Area, as well as pollution control plant discharges, are taken into account in separating the base flow. This prevents recharge estimates derived from base flow estimation from being artificially elevated from that of natural conditions. In areas where stream flow information was not available, records from a nearby stream flow station (where hydrologic conditions are similar) were used to estimate base flow for the un-gauged *subwatershed*. Monitoring programs in these areas would improve base flow estimates in these *subwatersheds*. However, as with any monitoring program, they must be established sufficiently in advance of undertaking the work to have collected sufficient data for meaningful analysis. This should be considered for future updates to the water budget.

Once base flow was determined for each subwatershed being analyzed, the base flow was distributed across the subwatershed using an infiltration model developed by Ministry of Environment and Energy (MOEE, 1995). This method uses soil type, slope and land use to calculate the infiltration factors across the watershed.

In the Tier 2 Water Budget for the Upper Thames River Source Protection Area, recharge is being calculated using surface water and groundwater models. These models use surficial geology and land use characterized in hydrologic response units. Following the completion of the Tier 2 Water Budget for the Upper Thames River Source Protection Area, the MOEE method will be reapplied to the Lower Thames Valley and St Clair Region Source Protection Areas where detailed computer models are not available. In reapplying the MOEE method, surficial geology will be used in place of soils for constancy with the additional work undertaken in the Tier 2 Water Budget and an improved representation of recharge. This will most likely result in an amendment to the Assessment Report.

3.2.5. Water Use (Demand)

Water use in the water balance and stress calculations is referred to as *Demand*. While *demand* would be the simplest of the terms to monitor, records of water use are not required, except where permits for the use are required. Water use of more than 50,000 L/day, other than domestic and livestock watering, requires a Permit to Take Water, however until recently, records of water used were not required to be recorded and submitted. Even where the records are required as part of the permit process, they have only been required for the past few years. This recent record keeping is undertaken by the permit holder with little or no quality control on the data entered. This information is submitted by the permit holder and has only become available to the water budget team near the completion of much of this water budget work. In future revisions to the water budget the actual use records will provide a better estimate of the *demand*. For the Tier 1 Water Budget, estimations of actual use were based on adjusted maximum permitted values, or other sources of estimation in some cases. Large water users were polled to provide a better estimate of water *demand*.

Estimates of water use not requiring a permit to take water (often referred to as *non-permitted* water use) were also included in the calculations of *demand*. While municipal systems require a permit to take water and records of this *demand* is well established through municipal pumping records, an estimate of the water used from private water systems is also required. Generally, this *demand* is minor; however it is important that it not be neglected in the water budget and stress assessment. Non-municipal system domestic *demand* is estimated based on per capita consumption estimations multiplied by population reported in census data.

Livestock watering also does not require a permit. This *demand* was estimated in a similar manner using livestock census data and typical water use by livestock type (Kreutzwiser & de Loë, 1999).

Both of these non-permitted uses are assumed to be distributed evenly across groundwater and surface water sources.

The Permit to Take Water information was analyzed to determine the *demand* in each *subwatershed* and combined with the *non-permitted demand* discussed above. Water use was considered separately for surface water and groundwater as required by the *Technical Rules: Assessment Reports*. Consumptive factors were applied to the surface water *demand* based on the use of the water taken. These factors were recommended by the province in the water budget guidance. The consumptive factors applied to water use are shown in the Tier 1 Water Budget. Consumptive factors were generally not applied to groundwater use as water removed from aquifers is generally not returned to the same aquifers. Groundwater is usually returned to surface water bodies after it is used, resulting in the use being completely consumptive. Water taken for aggregate washing and wildlife conservation are exceptions where consumptive factors were applied. In these cases, permits allow for large quantities to initially fill ponds, but then only a small amount is taken to compensate for evaporation and/or water removed in product in the case of aggregate extraction.

Irrigation *demand* is estimated based on permitted values. As discussed in the section on evapotranspiration, most of the water applied to crops is used by the crops or evaporates back into the atmosphere. This is even truer for irrigation where the amount of water applied is intended to saturate the root zone and not result in any significant runoff or recharge. As such, the consumptive factors for irrigation reflect that little, if any, water is returned to the source from which it was taken.

Table 3-1 summarizes the water *demand* in the area by type and source. It is important to realize that water use by industry and institutions supplied by municipal systems does not require a separate permit and is therefore included in the permitted values for the municipal system.

Table 3-1 Water demand in the LTVSPA (m^3/day)

Groundwater Use	SW Code	Agricultural	Commercial	Construction	Dewatering	Industrial	Institutional	Miscellaneous	Recreational	Remediation	Water Supply	Non-Permitted	**total**
Thames R. between the Forks and Dutton*	11T*	3439	2423	0	0	720	0	0	0	0	1755	2002	**10337**
Central Thames	12T	692	0	0	0	68	0	286	0	0	274	1186	**2506**
Indian-McGregor Creek Area	13T	64	307	0	0	0	0	0	0	0	1544	1716	**3631**
Southwest Thames	14T	460	181	0	0	0	0	0	0	0	0	1471	**2112**
Lake St. Clair	15T	0	0	0	0	0	0	0	0	0	0	756	**756**
Talbot Creek Area	16T	0	0	0	0	0	0	0	0	0	0	307	**307**
Rondeau Bay	17T	0	0	0	0	0	0	0	0	0	42	463	**505**
Central Lake Erie	18T	286	0	0	0	0	0	339	0	0	0	874	**1500**
Total		**17460**	**23568**	**200**	**1117438**	**47872**	**500**	**16051**	**818**	**468**	**66597**	**38612**	**21564**

Surface Water Use	SW Code	Agricultural	Commercial	Construction	Industrial	Miscellaneous	Recreational	Water Supply	Non-Permitted	**Total**
Thames R. between the Forks and Dutton*	11T*	3633	2708	0	0	183	44	0	430	**6999**
Central Thames	12T	2355	141	0	0	0	236	0	416	**3148**
Indian-McGregor Creek Area	13T	930	668	0	50	197	0	0	305	**2149**
Southwest Thames	14T	3494	232	375	0	1560	0	1364	157	**7182**
Lake St. Clair	15T	181	217	0	0	6806	0	1363	11	**8579**
Talbot Creek Area	16T	0	0	0	0	0	0	0	108	**108**
Rondeau Bay	17T	395	173	0	0	0	0	0	177	**745**
Central Lake Erie	18T	121	0	0	0	12	12	0	182	**327**
Total		**20324**	**15298**	**375**	**8356**	**23720**	**437**	**2727**	**9475**	**29236**

* Subwatershed 11T crosses over the Upper and Lower Thames boundary, and as such numbers reported are for both source protection authorities in this subwatershed

3.2.6. Water Budget Summary

Each *subwatershed* in the region is examined in terms of the water budget components for both surface and ground water systems on an annual average basis. Components include:

Q_P, precipitation,
$Q_{SW\text{-}in}$, surface water flows in,
$Q_{GW\text{-}in}$, groundwater flows in, (assumed zero in Tier 1)
Q_{ET}, Evapotranspiration,
$Q_{SW\text{-}out}$, surface water flows out,
$Q_{GW\text{-}out}$, groundwater flows out, (assumed zero in Tier 1)
$Q_{GW\text{-}C}$, consumptive groundwater use,
$Q_{SW\text{-}C}$, consumptive surface water use, and
ΔS, change in storage (assumed zero in Tier 1)

The water budget equation can be summarized as:

$$Q_P + Q_{SW-in} + Q_{GW-in} = Q_{ET} + Q_{SW-out} + Q_{GW-out} + Q_{GW-C} + Q_{SW-C} + \Delta S$$

Table 3-2 summarizes the annual water budget in units of annual average m3/day. Water budget balances are compared to the total water supply for each subwatershed (i.e. Precipitation + SW supply), and the error is less than 10% of the estimated supply, which indicates that estimates are reasonable, given the inherent uncertainties in each individual component. Although stress calculations rely on monthly information, average annual water budget components are included as a summary to demonstrate the balance.

Table 3-2 Water budget summary (m^3/day)

Code	Subwatershed	Q_{ET}	Q_P	$Q_{sw\text{-}out}$	$Q_{sw\text{-}in}$	$Q_{gw\text{-}c}$	$Q_{sw\text{-}c}$	ΔS	Balance	%error (of total supply)
11T*	Thames R. between the Forks and Dutton	1167292	1998777	4224578	3402509	10337	6999	0	-7920	-0.1%
12T	Central Thames	998379	1630469	4756196	4224578	2506	3148	0	94819	1.6%
13T	Indian-McGregor Creek Area	641220	1004704	5390464	4756196	3631	2149	0	-276564	-4.8%
14T	Southwest Thames	1352084	2058262	5990752	5390464	2112	7182	0	96595	1.3%
15T	Lake St. Clair	266845	404032	164731	0	756	8579	0	-36879	-9.1%
16T	Talbot Creek Area	246598	421669	172866	0	307	108	0	1791	0.4%
17T	Rondeau Bay	269848	432122	166972	0	505	745	0	-5947	-1.4%
18T	Central Lake Erie	533434	847338	321127	0	1500	327	0	-9049	-1.1%

* Subwatershed 11T crosses over the Upper and Lower Thames boundary, and as such numbers reported are for both source protection authorities in this subwatershed

3.3 Phases of Water Budget Work

3.3.1. Conceptual Water Budget

The Conceptual Water Budget, or conceptual understanding, is the first phase of the water budget development. In this stage, background information is collected on the components of the water budget. The information is analyzed to determine the various components of the water budget based on historical and readily available data on a coarse scale. The conceptual Water Budget was completed for the entire region. The region was divided into 6 *subwatersheds* for the purposes of this analysis. The Conceptual Water Budget is included as Appendix 6 of the Assessment Report.

3.3.2. Tier 1 Water Budget

The Tier 1 Water Budget utilizes the information collected and analyzed in the Conceptual Water Budget. In Tier 1, the potential for stress is assessed in *subwatersheds* within the region. As with the Conceptual Water Budget, the Tier 1 Water Budget was documented in one report for the entire Thames-Sydenham and Region. For the purposes of the Tier 1 Water Budget, the region was subdivided into 32 *subwatersheds*, as shown in Map 3-1. A water budget and stress assessment was calculated for each of these *subwatersheds*. Map 3-5 indicates the potential for stress on surface water sources, while Map 3-6 illustrates the potential for stress on the groundwater sources.

3.3.3. Tier 2 Water Budget

Although a Tier 2 Water Budget is required for the Upper Thames River Source Protection Area, one is not necessary for the Lower Thames Valley Source Protection Area as no municipal systems are in *subwatersheds* which have a moderate or significant potential for stress.

3.3.4. Tier 3 Water Budget

The Tier 3 Water Budget is a local area water balance undertaken on the scale of a single water supply system and is intended to examine the reliability of that supply. As no *subwatersheds* in the Lower Thames Valley Source Protection Area advanced to a Tier 2 Water Budget, a Tier 3 Water Budget is not required.

3.3.5. Peer Review of the Water Budget

Each phase of the water budget is subject to a peer review process. The project team and consultants work closely with the peer reviewers to ensure that the work undertaken is technically sound and meets the requirements of the *technical rules* and relevant provincial guidance. As work on the project progresses, the materials are presented to the peer review committee for their comments. Those comments are considered by the peer review team and consultants and are generally incorporated into the final report. The comments, along with their responses, are also incorporated into a peer review record which becomes part of the water budget report. Following completion of the peer review, the draft water budget document is submitted to the Ministry of Natural Resources for acceptance.

The Conceptual Water Budget successfully completed the peer review process and the draft has been accepted by the MNR. However, work on the Tier 1 Water Budget was not completed in time to complete the peer review process prior to posting of this draft of the Assessment Report for the Lower Thames Valley Source Protection Area. The material included in this draft of the Assessment Report is based on a final draft submitted to the peer reviewers for their review and comment. Peer review of the work included in this Assessment Report is not a requirement of the *technical rules*; however the Source Protection Committee relies on the technical experts on the peer review committee to ensure that the work is suitable for the purposes of developing a Source Protection Plan for the area. Due to the peer reviewers having reviewed much of the material as the work progressed, it is not anticipated that changes resulting from the review will have a substantial effect on the stress assessment, the delineation of SGRAs, or the other information presented in this draft of the Assessment Report. It is, however, anticipated that the comments will continue to improve the documentation and interpretation of the work undertaken. Minor changes may be incorporated into the report prior to posting the proposed Assessment Report for consultation. If, however, significant changes are required, the need for these changes will be acknowledged in the next version (the proposed Assessment Report), and dealt with through the amended Assessment Report discussed in other sections.

3.4 Water Quantity Stress Assessment

The level of potential for stress is calculated based on the following formula as defined in the *Technical Rules: Assessment Reports*:

$$\%\ \text{Water Demand} = \frac{Demand}{Supply - Reserve} x100$$

Percent Water Demand is calculated separately for groundwater and surface water as are the other terms in the above *percent water demand* equation.

For surface water, *Demand* is the monthly estimated *demand* of all surface water sources, *Supply* is the monthly estimated median daily flow, and *Reserve* is the 90^{th} percentile monthly flow, or the flow that is exceeded 90 percent of the time for the month being analyzed.

For groundwater, supply includes a number of components as discussed above. For the Tier 1 Water Budget, supply is simplified to include recharge and groundwater flow into the watershed. As discussed above, recharge is estimated using base flow. Groundwater flow into the watershed can be calculated through the use of a calibrated groundwater model. Developing and calibrating a groundwater model is however not part of the scope of the Tier 1 Water Budget. As a large scale regional groundwater model was available for the region, it was planned to use it for this purpose. It was, however, determined that it was not adequate for the purposes of describing flows between *subwatersheds* at the scale required for the Tier 1 Water Budget. In the absence of a good estimate for groundwater flow into the subwatershed, it is possible to neglect the inflow of groundwater in the supply term. This results in a conservative estimate of the percent water *demand*. It was felt that in *subwatersheds* where there is considerable *demand* and the *subwatersheds* are relatively small, a large portion of the supply could be coming from adjacent *subwatersheds* as groundwater flows in and, therefore, the *percent water demand* could be overly conservative. As there were no *subwatersheds* which indicated a moderate or significant potential for stress, an estimation of groundwater inflow is not necessary.

Groundwater reserve is 10% of the supply, as required in the *Technical Rules: Assessment Reports*. A water reserve estimate is intended to protect a portion of water from being considered within the stress calculations, adding a conservative element to this calculation. This water is removed from the supply in the stress assessment.

The *Percent Water Demand* is used as an indication of the stress level in the *watershed* or *subwatershed*. This stress level is described in this document as the "potential for stress" as it better describes the situation given the *uncertainty* associated with the calculations. Generally, a tier 1 *stress assessment* is understood to have considerable *uncertainty* associated with the *percent water demand* calculations which would be reduced through subsequent analysis in the Tier 2 or 3 Water Budgets, where warranted. At the completion of the Tier 1 Water Budget, it is important to understand that conclusions drawn from this analysis are indicative of whether more analysis is required; not an absolute determination that there is *stress*. Given the level of conservatism, as discussed above, this is especially important when considering the *subwatersheds* which are being described as having a significant potential for *stress*. However, for the *subwatersheds* which are described as having a low potential for *stress*, this conservatism clearly indicates that they do not have a significant level of *stress*. The sensitivity analysis required for *subwatersheds* which are almost moderate gives even more confidence in this conclusion. *Subwatersheds* with a moderate potential for *stress* also advance to the next stage of analysis, along with those identified with a significant potential for *stress*. At the next stage, additional analysis is required to determine the *percent water demand* and, therefore the *stress* level, with a higher level of confidence. If this moderate or significant potential for *stress* affects a municipal water supply, additional analysis would be undertaken through the Source Protection program. However, in the Lower Thames Valley Source Protection Area, *subwatersheds* which show a significant or moderate potential for *stress* do not contain municipal drinking water sources. Therefore, additional analysis is recommended to adequately determine the potential for *stress* in these *subwatersheds*. This work will need to be undertaken through other programs before the water budget and, specifically, the *percent water demand* can be used in the implementation of other programs such as the Permit to Take Water program.

In assessing the potential for *stress*, various scenarios as identified in the *technical rules* must be considered. These scenarios consider current and future municipal *demand* under both average and drought scenarios. Drought scenarios are not considered in the Tier 1 Water Budget. Scenario A and B discussed in Table 3-3 below relate to the current and future municipal *demand* (respectively). As there are no additional planned systems in the Lower Thames Valley Source Protection Area, the scenario related to planned systems (scenario C) is not applicable and therefore not included in Table 3-3. Table 3-4 describes the potential for *stress* based on the *percent water demand* for the applicable scenarios which must be compared to the ranges shown in Table 3-3. Additional criteria as described in Rule 32 and 33 are also considered in the stress assessment. If the intake or well was not able to operate due to insufficient quantity of water or a low water level, the potential for *stress* is described as moderate and the *subwatershed* would advance to the next tier.

Table 3-3 potential for stress based on *percent water demand* under current and future municipal water demand

Potential for Stress	Surface Water % Water Demand	Groundwater % Water Demand	
Based on	Max'm monthly	Max'm monthly	Avg annual
Significant	Greater than or equal to 50%	Greater than or equal to 50%	Greater than or equal to 25%
Moderate	Less than 50% but greater than 20% (or between 18 and 20%, inclusive, but under sensitivity analysis increases to greater than 20%)	Less than 50% but greater than 25%	Less than 25% but greater than10% (or between 8 and 10%, inclusive, but under sensitivity analysis increases to greater than 10%)
Low	Less than or equal to 20% (after sensitivity analysis if between 18 and 20%, inclusive)	Less than or equal to 25%	Less than or equal to 10% (after sensitivity analysis if between 8 and 10%, inclusive)

Table 3-4 Surface water potential for stress based on Tier 1 stress assessment

Subwatershed	Code	Supply (Q_{50})	Reserve (Q_{90})	Demand	Potential for stress
Thames River between the Forks and Dutton	11T*	933120	606874	29659	low
Central Thames	12T	1010880	630720	15039	low
Indian-McGregor Creek Area	13T	1122854	736214	7838	low
Southwest Thames	14T	1161259	754713	22853	low
Lake St. Clair	15T	7690	2851	9823	Significant
Talbot Creek Area	16T	10454	4709	108	low
Rondeau Bay	17T	7776	2938	2759	Significant
Central Lake Erie	18T	19354	8770	941	low

* Subwatershed 11T crosses over the Upper and Lower Thames boundary, and as such numbers reported are for both source protection authorities in this subwatershed

Table 3-5 Groundwater potential for stress based on Tier 1 stress assessment (Average Annual Conditions)

Subwatershed	Code	Q_{supply}	$Q_{reserve}$	Q_{demand}	Potential for stress
Thames River between the Forks and Dutton	11T*	232027	23203	5384	low
Central Thames	12T	291274	29127	2506	low
Indian-McGregor Creek Area	13T	79825	7982	3631	low
Southwest Thames	14T	141855	14186	2112	low
Lake St. Clair	15T	41577	4158	756	low
Talbot Creek Area	16T	51712	5171	307	low
Rondeau Bay	17T	42880	4288	505	low
Central Lake Erie	18T	95967	9597	1500	low

* Subwatershed 11T crosses over the Upper and Lower Thames boundary, and as such numbers reported are for both source protection authorities in this subwatershed

Table 3-6 Groundwater potential for stress based on Tier 1 stress assessment (Maximum Monthly Conditions)

Subwatershed	Code	Q_{supply}	$Q_{reserve}$	Q_{demand}	Potential for stress
Thames River between the Forks and Dutton	11T*	445491	44549	34032	low
Central Thames	12T	291274	29127	5556	low
Indian-McGregor Creek Area	13T	79825	7982	4896	low
Southwest Thames	14T	141855	14186	4740	low
Lake St. Clair	15T	41577	4158	756	low
Talbot Creek Area	16T	51712	5171	307	low
Rondeau Bay	17T	42880	4288	563	low
Central Lake Erie	18T	95967	9597	2931	low

* Subwatershed 11T crosses over the Upper and Lower Thames boundary, and as such numbers reported are for both source protection authorities in this subwatershed

Although some *subwatersheds* in the Lower Thames Valley Source Protection Area have potential to be stressed, that *stress* does not affect any municipal drinking water systems. Map 3-5 shows the potential for *stress* in surface water of the *subwatersheds* within the Lower Thames Valley Source Protection Area. Map 3-6 shows that there are no *subwatersheds* with more than a low level of groundwater stress in the Lower Thames Valley Source Protection Area.

Thus, for the purposes of the Clean Water Act, the potential for *stress* on municipal drinking water systems in the Lower Thames Valley Source Protection Area is LOW.

3.4.1. Uncertainty in the Stress Assessment

As the *stress* assessment for the Lower Thames Valley Source Protection Area was completed as part of a Tier 1 Water Budget, some uncertainty in the data and analysis is expected. Surface water stress assessments for the *subwatersheds*, which include direct tributaries to the Great Lakes or Lake St. Clair, are likely over estimating the percent water demand, and therefore the potential for stress. This is expected as some of the water takings near the Great Lakes are likely drawing their water from the Great Lakes rather than drawing water from the subwatershed being assessed. Although permits where this is likely to be the case have been removed from the *demand* used in the *stress* calculations, it is suspected that more, especially in areas with little topographic relief from the lake level, are also effectively drawing water from the lake. Unfortunately, the permit to take water database coordinates are not reliable enough to make further judgments as to whether the permit reflects a *demand* from the subwatershed being assessed or from the Great Lake which is beyond the study area. Although a full Tier 2 Water Budget would not be required to reduce the uncertainty in these *subwatersheds*, further analysis would be necessary to gain a better understanding of the *demand* in these areas and whether they rely on water from the lake rather than the subwatershed being considered. In these *subwatersheds*, the potential for *stress* does not affect municipal drinking water systems, thus this work must rely upon other programs to undertake a more detailed assessment of the potential for *stress*.

Although this *uncertainty* has little effect on the Source Protection Plan it is of considerable importance in interpreting this analysis for use in other programs such as the Permit to Take

Water Program. Therefore there are no water quantity *threats* in the Lower Thames Valley Source Protection Area.

3.5 Significant Groundwater Recharge Areas

Significant Groundwater Recharge Areas (SGRA) are delineated through the water budget work. These areas are determined through the use of the recharge calculated in the Tier 1 Water Budget and discussed in Section 3.3 above. Recharge is compared to both the average recharge of the area and to the effective precipitation (precipitation less evaporation) of the area to determine if the recharge at that location is significant. Rule 44 identifies the criteria for determining whether a recharge area is significant:

- the area annually recharges water to the underlying aquifer at a rate that is greater than the rate of recharge across the whole of the related groundwater recharge area by a factor of 1.15 or more; or
- the area annually recharges a volume of water to the underlying aquifer that is 55% or more of the volume determined by subtracting the annual evapotranspiration for the whole of the related groundwater recharge area from the annual precipitation for the whole of the related groundwater recharge area.

Table 3-7 below summarizes the recharge and the conditions which must be met for an area within a particular subwatershed to be deemed significant. It is worth noting that in most cases rule 44(1) provides a more conservative criterion for SGRA declaration than does rule 44(2).

Table 3-7 Criteria for Significant Groundwater Recharge Areas

Subwatershed		Annual Average recharge (mm/a)	Effective Precipitation (mm/a)	SGRA Criteria Rule 44(1) (based on annual recharge)	SGRA Criteria Rule 44(2) (based on effective precipitation) mm/a
Thames River between the Forks and Dutton	11T	198	404		
Central Thames	12T	173	351		
Talbot Creek Area	16T	120	388		
Central Lake Erie	18T	103	336		
Central Thames Valley		**165**	**352**	**190**	**194**
Indian McGregor Creek Area	13T	70	331		
Southwest Thames	14T	61	304		
Lake St. Clair	15T	84	305		
Rondeau Bay	17T	84	344		
Lower Thames Valley		**69**	**301**	**79**	**166**

Rule 45 indicates that the area must have "a hydrological connection to a surface water body or aquifer that is a source of drinking water for a drinking water system". For the purposes of this rule it is important to realize that a drinking water system can be single residential water well. Map 34 in Thames Watershed Characterization Report summary included as Appendix 5 illustrates that wells are located throughout the region. In areas where shallow sandy deposits provide for recharge areas, well installation is simple through the use of sand points driven to a modest depth. These types of water wells are, in most cases, installed without a permit and therefore not included in the water well information system used to produce Map 34. Further, it is not intended by the *technical rules* that the connection be direct or immediate, but rather that there is a "hydrologic connection". This recognizes that water not only flows vertically through the ground but also flows laterally from areas of higher levels to areas of lower water levels. Thus, it is generally accepted that aquifers are recharged from areas up gradient from the aquifer as well as directly above. Although through Tier 2 and 3 Water Budget a much better interpretation of the extent of aquifers will be understood, currently in the Lower Thames Valley Source Protection Area there is little information on a localized scale on the extent of the aquifers. Thus, a precautionary, conservative approach is warranted and all areas which meet the criteria for significance are included as *SGRA*.

Map 4-8 illustrates the *Significant Groundwater Recharge Areas* in the Lower Thames Valley Source Protection Area. The vulnerability of the *SRGAs* is considered in the Vulnerability Assessment section of the Assessment Report. It is, however, important to point out that the *SGRAs* which are coincident with *Highly Vulnerable Aquifers* (*HVA*), will receive a vulnerability score of 6 which can result in a moderate threat, while activities in the other *SGRAs* cannot result in water quality *threats* due to the *vulnerability* score being 4 or less.

3.6 Data Gaps and Next Steps

Table 3-8 summarizes data gaps identified through the Tier 1 Water Budget and Water Quality Stress Assessment. As the *stress* assessment was completed through a Tier 1 Water Budget, it is expected that there would be data gaps. If work was to proceed to a Tier 2 Water Budget, many of these gaps would need to be addressed at that time. As the potential for *stress* has no effect on municipal water systems, additional work is not required through Source Protection Planning. These gaps become more of a problem for other programs, such as the Permit to Take Water Program, which would benefit from results with a lower level of uncertainty.

These gaps do not affect the reliability of the analysis for use in the development of the Source Protection Plan.

Table 3-8 Data gaps related to Water Budget and Water Quantity Stress Assessment

Gap	Description
Determine Inland takings drawing from great lakes	• Confirm location and watercourse conditions related to water takings near Lake Erie and Lake St. Clair • Recalculate percent water demand • Reassess potential for stress in these areas • Update Assessment Report only if warranted
Improved understanding of water use	• Obtain actual water use data from all significant water users through the PTTW reporting system • Requires reassessment after sufficient data has been reported, perhaps when Assessment Report requires future update
Revise SGRAs for consistency with T2 work	• Revise infiltration and recharge modelling to utilize surficial geology rather than soils • Undertake edge matching with T2WB recharge estimates from advanced GW/SW models in the UTRSPA • Reassess vulnerability based on updated delineation • Update Assessment Report with revised SGRA delineation and vulnerability assessment
Completion of the peer review of the T1WB	• Receive and consider comments of the peer reviewers prior to submission of the T1WB report to MNR for acceptance • Finalize the peer review record
Un-gauged Areas	• Temporary stream gauging on small lake draining tributaries to improve understanding of how these behave • Surface Water Model to better understand distribution of flows in un-gauged subwatersheds
Climate Change	• Consider the impact of Climate change on the water budget and the stress assessment
Refine ET	• Improve calculation of ET to include consideration of soil types and land use at a local level