Mississippi Valley Conservation

RIDEAU VALLEY CONSERVATION AUTHORITY

Mississippi-Rideau Source Protection Region

Tier 1 Water Budget and Water Quantity Stress Assessment

PRELIMINARY DRAFT
(REVISED)

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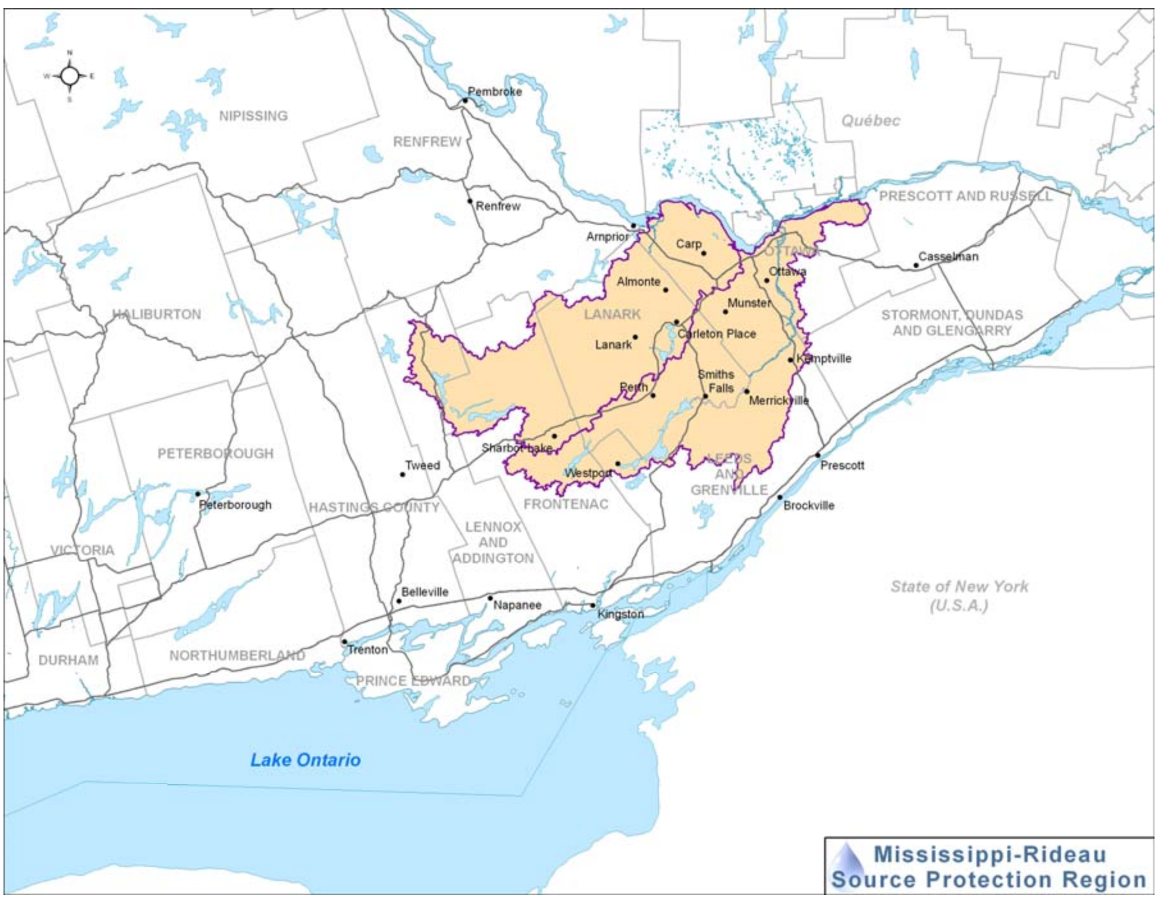

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Acronyms and Abbreviations

AET	Actual Evapotranspiration
CA	Conservation Authority
Conceptual Water Budget	"Conceptual Understanding of the Water Budget" (MRSPR, 2007)
CRCA	Cataraqui Region Conservation Authority
ET	Evapotranspiration
GIS	Geographic Information System
Guidance	"Guidance Module 7: Water Budget and Water Quantity Risk Assessment" (MOEE, March 2007)
GW	Groundwater
Ha.m	hectare metres (volumetric unit)
km	kilometres
L/d	litres per day
m	metres
m^3/s	cubic metres per second
mm	millimeters
MNR	Ministry of Natural Resources
MVC	Mississippi Valley Conservation
OPG	Ontario Power Generation
P	Precipitation
PET	Potential Evapotranspiration
PTTW	Permit To Take Water
SW	Surface water runoff
R	Recharge (to groundwater)
RVCA	Rideau Valley Conservation Authority
SGRA	Significant Groundwater Recharge Area
SPC	Source Protection Committee
SPR	Source Protection Region
SW	Surface Water
T	Temperature
Technical Rules	Technical Rules: Assessment Report (*Clean Water Act, 2006*)
Tier 1	Tier 1 Water Budget and Water Quantity Stress Assessment
Water Surplus	P - ET
WSC	Water Survey of Canada

1.0 Introduction

The Mississippi-Rideau Source Protection Region "Tier 1 Water Budget and Stress Assessment Report" (referred to as Tier 1), was prepared by the Mississippi-Rideau Source Protection Region (SPR) for the Province of Ontario (referred to as the Province). Assistance was provided by Intera Engineering Ltd. and Delcan Corporation. This report is subject to a review from the Province, Conservation Ontario, and a peer review team.

The Tier 1 report follows the requirements outlined in the "Technical Rules: Assessment Report", dated December 12, 2008 (referred to as the Technical Rules). The Technical Rules were created under the *Clean Water Act (2006)*. The methods used are in conformity with the Technical Rules [Part III.2 – Subwatershed Water Budgets and Part III.3 – Subwatershed Stress Levels]. The methods used were further educated by the Ontario Ministry of the Environment (MOE) "Guidance Module 7: Water Budget and Water Quantity Risk Assessment" (MOE, 2007), which is referred to as the Guidance.

1.1 Background

The Tier 1 report is preceded by the "Conceptual Understanding of the Water Budget" (Mississippi-Rideau Source Protection Region, March 2007), which is referred to as the Conceptual Water Budget. The Conceptual Water Budget received draft approval from the Province in March 2007. The Conceptual Water Budget used the best available data and a simple Geographic Information System (GIS) model to provide long-term (average) estimates of water budget parameters (precipitation (P), evapotranspiration (ET), groundwater recharge (R) and depth of surface water runoff (SW)) summarized on an annual basis for the SPR and its two major watersheds (Mississippi and Rideau). As well, it provided a general understanding of climate, surface water, and groundwater interactions and how water moves throughout the SPR. The water budget estimates from the Conceptual Water Budget only apply on an average-annual regional scale. Average-annual regional values do not apply to individual years or to individual subwatersheds. Actual values will vary temporally and spatially across the Region.

The Tier 1 Water Budget and Stress Assessment builds on the Conceptual Water Budget. It is designed to screen out unstressed subwatersheds using existing information collected for the Conceptual Water Budget. The Tier 1 water budgets are completed using the same simple approach that estimates the various elements of the hydrologic cycle (P, ET, R, and SW) however they are required on a smaller spatial scale (subwatersheds) and shorter temporal scale (monthly and annual). The Tier 1 stress assessments are designed to identify any subwatersheds with municipal drinking water systems that have water quantity stresses. The percent water demand calculations that are required for the Tier 1 stress assessment were not required for the Conceptual Water Budget.

1.2 Scope of Tier 1

The overall objective is to help protect the quantity of drinking water sources in Ontario. The purpose of the Tier 1 is to identify subwatersheds that may be limited in surface water or groundwater supply relative to demand, otherwise called water quantity stress. Subwatersheds that have a MODERATE or SIGNIFICANT stress in Tier 1 and contain a municipal drinking water system will undergo a more refined and complex Tier 2 analysis to confirm water quantity stress. Subwatersheds that show a LOW stress or do not contain a municipal drinking water system will not move forward to Tier 2.

The following items have been completed for Tier 1:

- long-term (average) monthly and annual water budgets on a subwatershed scale
- water quantity stress assessments for surface water and groundwater in all subwatersheds.

The Tier 1 study can be divided into three tasks.

The first task is to estimate the water budget components for each subwatershed (P, ET, R and SW).

The second task is to calculate percent water demand for each subwatershed. Percent water demand is a ratio of the water demand to the water supply (less a reserve). Water demand is determined from consumptive water takings (Section 5.6 and 5.7). Water supply (SW for surface water and R for groundwater) is taken from the water budget (Section 6.1 and 6.2).

The third major task is to assign a stress level to each subwatershed based on the percent water demand (with comparisons to stress level criteria), a sensitivity analysis (if required), and a review of historical issues at the municipal drinking water supplies.

Further details on the contents of this report are given below in Section 1.3.

1.3 Report Structure

Section 1.0 is the background information supporting the Tier 1 report and the scope of work along with how the Tier 1 report was developed and how it is organized.

Section 2.0 describes the study area (the SPR), which is divided into two planning regions, namely, Mississippi Valley Conservation (MVC) and Rideau Valley Conservation Authority (RVCA). Section 2.0 describes how the SPR was divided into subwatersheds for Tier 1. The municipal drinking water systems are listed here as well.

Section 3.0 describes the Tier 1 water budget methodology, the data sources, and results. Long-term (average) annual and monthly are presented for each Tier 1 subwatershed. The water budget is an accounting of inputs and outputs of the water cycle within a control volume (i.e. a subwatershed). For the Tier 1 water budget, estimates are provided for P, ET, and SW on a monthly basis. Estimates of anthropogenic water takings are presented later in Section 5.0 under demand. Estimates of SW and R (Section 3.0) are used to represent the surface water and groundwater supplies for the Tier 1 stress assessments.

Section 4.0 introduces the percent water demand equation for the stress assessments. The percent water demand is the ratio of the water demand to the water supply (less a reserve). Section 4.0 defines the current and future (25-year) demand scenarios, and the time scales (monthly or annual or both depending on whether it’s a surface water or groundwater assessment) that are required for the percent demand calculations (also referred to as the stress calculations).

Section 5.0 presents the methodology and the results for the surface water and groundwater consumptive demands (current and future scenarios).

Section 6.0 presents the methodology and results for the surface water and groundwater supply and reserve. The supply estimates form the denominator of the percent demand equation. The consumptive demand results in Section 5.0 form the numerator. Additionally, the denominator includes a water reserve term, which is estimated differently for surface water and groundwater supplies. The water reserve is a portion of the water supply that is intended to protect water required for other uses (e.g. ecological, dilution for sewage treatment, hydroelectric power, navigation etc) from being considered within the stress calculations. The reserve amounts are also presented in Section 6.0.

Section 7.0 presents the percent water demand results with a comparison to the stress level criteria defined in the Guidance and the Technical Rules. This section also includes requirements for the sensitivity analysis. It also reports on historical performance issues at the municipal drinking water systems. These three elements (percent water demand, the sensitivity analysis, and historical system performance) are all required to assign a final stress level for each subwatershed. Final stress levels are given in section 7.4. The Tier 1 stress assessments and Tier 2 requirements are summarized in Table 7.4-1.

Section 8.0 includes a discussion on uncertainty in the water budget components and the percent demand calculations.

The final section, Section 9.0, summarizes the main conclusions and recommendations.

Tables, graphs, and figures (i.e. maps) are located after the list of references (after the main body of the report). The appendices contain surface water information, precipitation data, evapotranspiration calculations, groundwater recharge and baseflow comparisons, water usage by wildlife conservation permit holders, municipal drinking water surveys, permits to take water information, and a discussion on sewer infiltration. The final appendix contains the Tier 1 peer review record and comments summary.

2.0 Study Area

2.1 Mississippi-Rideau Source Protection Region

The SPR, located in Eastern Ontario, encompasses an area of 8,585 km^2 (Figure 2.1-1). The SPR can be divided into two areas: Mississippi Valley Conservation (MVC) and Rideau Valley Conservation Authority (RVCA). The regional geology in the SPR is generally characterized by fractured Precambrian and Palaeozoic bedrock outcropping at surface or overlain by a thin veneer of overburden sediments, however thick sequences of quaternary deposits also exist in localised areas. This variable overburden thickness results in a complex hydrological system with groundwater/surface water interaction both in bedrock and unconsolidated sediments. For more specific details, including regional maps and cross-sections, please see the Conceptual Water Budget.

2.1.1 Mississippi Valley Conservation (MVC)

MVC (4,352 km^2) includes the Mississippi River watershed (3,765 km^2), the Carp River subwatershed (303 km^2), and an area that drains directly to the Ottawa River named Ottawa MVC (283 km^2). The largest of the rivers in MVC is the Mississippi, which drops 323 m over its 200 km length from Mazinaw Lake to the Ottawa River. Following a southern course through Mazinaw Lake, the Mississippi River flows eastward and runs a direct west-east course to its junction with the Fall River near the Village of Lanark. From this point, it flows north through the towns of Carleton Place, Almonte, Pakenham and Galetta, until it enters the Ottawa River. There are 11 municipalities in MVC and a population of approximately 250,000.

2.1.2 Rideau Valley Conservation Authority (RVCA)

RVCA (4,234 km^2) includes the Rideau River watershed (3,851 km^2) and two subwatersheds that drain directly to the Ottawa River on the west and east side of the Rideau River, namely Ottawa RVCA West (263 km^2) and Ottawa RVCA East (120 km^2). The Rideau River flows north from the headwaters in Upper Rideau Lake near Newboro to the City of Ottawa where it discharges into the Ottawa River. The towns of Perth, Smiths Falls, Merrickville, and Kemptville, and a large part of the City of Ottawa are located in RVCA. There are 18 municipalities in RVCA and approximately 420,000 people.

2.2 Tier 1 Subwatersheds

The Technical Rules require the Tier 1 study to be completed on a subwatershed scale. Furthermore, stress assessments for surface water and groundwater must be completed on the same subwatersheds. Groundwater “subwatersheds” are difficult to delineate without site specific data. Therefore, groundwater stress assessments were completed using the surface water subwatersheds, with the understanding that the groundwater “subwatersheds” likely do not conform to the surface subwatersheds. Therefore, the Tier 1 surface water and groundwater analyses were completed at the same spatial scale, as required by the Technical Rules.

Surface water flow data is an important parameter to the Tier 1 study, as such, the Tier 1 subwatersheds were delineated based on a combination of the CA subwatersheds (delineated by MVC and RVCA for watershed planning purposes) and the location of the hydrometric stations (surface water flow gauges) (Figure 2.2-1).

The final delineation of the Tier 1 subwatersheds is shown in Figure 2.2-2.

The names of the Tier 1 subwatersheds are the same names as the flow gauges where available. Eight of the twelve MVC subwatersheds are gauged (have long-term streamflow records available). Seven of the ten RVCA subwatersheds are gauged. There are seven ungauged subwatersheds (have no long-term streamflow data).

The gauged subwatersheds in MVC are (in order from upstream to downstream):

- Mississippi River At Marble Lake,
- Mississippi River At High Falls,
- Clyde River At Lanark,
- Fall River At Bennett Lake,
- Mississippi River At Fergusons Falls,

- Mississippi River At Appleton,
- Indian River At Blakeney, and
- Carp River At Kinburn.

The gauged subwatersheds in RVCA are (in order from upstream to downstream):

- Tay River At Perth,
- Rideau River Above Smiths Falls,
- Rideau River Below Merrickville,
- Kemptville Creek Near Kemptville,
- Rideau River Below Manotick,
- Jock River Near Richmond, and
- Rideau River At Ottawa.

The ungauged subwatersheds in MVC are:

- Mississippi River At Galetta,
- Mississippi River (Outlet),
- Carp River (Outlet), and
- Ottawa MVC.

The ungauged subwatersheds in RVCA are:

- Rideau River (Outlet),
- Ottawa RVCA (West) and
- Ottawa RVCA (East).

The drainage areas for the Tier 1 subwatersheds are given in Table 2.2-1 and on Figure 2.2-2.

Some of the smaller subwatersheds were combined to form larger subwatersheds when delineating the Tier 1 subwatersheds. For example, downstream of Marble Lake on the Mississippi River, the High Falls subwatershed was extended to further include Buckshot Creek, Upper Mississippi, and Big Gull (Figure 2.2-1 and Figure 2.2-2).

The Tier 1 subwatersheds were extended to natural discharge points. For example, there are two Tier 1 subwatersheds on the Carp River. The Carp River At Kinburn subwatershed extends from the headwaters to the gauge station. The Carp River (Outlet) subwatershed extends further downstream to the outlet at the Ottawa River. The outlet of the Carp River is ungauged.

Ottawa MVC, Ottawa RVCA West, and Ottawa RVCA East were delineated originally by MVC and RVCA for watershed planning purposes. These areas are included in the Tier 1 analysis. They contain tributaries that drain directly to the Ottawa River.

In addition, a Tier 1 subwatershed was delineated at a power generating station at Galetta (Mississippi River At Galetta).

For the purposes of the Tier 1 study, subsequent references to subwatersheds refer to the Tier 1 subwatersheds delineated in Figure 2.2-2 unless otherwise stated.

2.3 Municipal Drinking Water Systems

Subwatersheds that contain municipal drinking water systems and result in MODERATE or SIGNIFICANT water quantity stresses for surface water or groundwater will move on to a Tier 2 analysis.

There are five municipal surface water systems in the SPR. Of the five systems, two (Britannia and Lemieux) draw from the Ottawa River, an inter-provincial waterway that supplies the City of Ottawa, and some of the surrounding communities, with water.

The Ottawa River plants will be excluded from the Tier 1 as per Technical Rule #4 (*Clean Water Act, 2006*), which states “An area represented by a conceptual water budget or water budget prepared in accordance with Rule #3 shall not include any part of a surface water body that is….the Ottawa River.”

Therefore, only the three municipal supply intakes located on inland rivers (inclusive to the Region) are included in Tier 1. The three surface water systems include Carleton Place (MVC), Perth (RVCA) and Smiths Falls (RVCA). The Carleton Place intake draws from the Mississippi River At Appleton subwatershed in MVC. The Perth intake draws from the Tay River At Perth subwatershed. The Smiths Falls intake draws from the Rideau River in the Merrickville subwatershed.

Groundwater municipal systems are located in seven subwatersheds. The Carp municipal water system is located in the Carp River At Kinburn subwatershed (MVC). The system comprises two groundwater wells that draw water from a relatively shallow sand and gravel esker complex that is partially confined by surficial clay.

The Almonte system is located in the Mississippi River At Galetta subwatershed (MVC). The system comprises five groundwater wells at four locations on the northeast side and southeast side of the Mississippi River. The Almonte wells obtain water from the

Nepean Formation (sandstone) Aquifer (referred to as the Nepean Aquifer) that is mostly confined by lower permeability limestone and shale.

The Munster and Kings Park-Richmond (referred to as Kings Park) water systems are located in the Jock River Near Richmond subwatershed (RVCA). Note that Kings Park is a subdivision (approximately 160 homes) located within the Village of Richmond that is serviced by a municipal well. The Munster and Kings Park systems draw water from the same portion of the deep Nepean Aquifer sandstone aquifer that is confined by approximately 30 to 50 m of lower permeability sedimentary bedrock layers.

The Kemptville water system is located in the Rideau River Below Manotick subwatershed (RVCA). The Merrickville system is located in the Rideau Below Merrickville subwatershed (RVCA). Both systems obtain groundwater from the confined Nepean Aquifer sandstone aquifer.

The Westport system is located in the Rideau River Above Smiths Falls subwatershed (RVCA). It obtains water from a relatively shallow portion of the Nepean Aquifer.

Finally, the future Lanark system is a planned groundwater system located in the Clyde River Near Lanark subwatershed (MVC). It is included in the Mississippi Valley Source Protection Area Terms of Reference (MRSPR, February 5, 2009); therefore, it is included in the Tier 1 stress assessment.

3.0 Tier 1 Water Budget

Long-term (average), annual estimates of the water budget were prepared for the SPR and its two major watersheds (Mississippi and Rideau) as part of the Conceptual Water Budget. Existing data and a simple GIS (Geographic Information System) model was used to provide long-term (average) estimates of water budget components summarized on an annual basis for the SPR and its major watersheds. As well, it provided a general understanding of climate, surface water, and groundwater interactions.

The Tier 1 requires data at a smaller scale – the subwatershed scale – and on a monthly basis. The sources of surface water data and climate data required to carry out the Tier 1 are discussed in the following sections.

3.1 Hydrologic Data

3.1.1 Streamflow Data

Streamflow Data for Gauged Subwatersheds

Streamflow (surface water flow) is measured at flow gauges (hydrometric stations). Long-term streamflow data was obtained from Water Survey of Canada's HYDAT database, Parks Canada, MVC and Ontario Power Generation at High Falls. Streamflow data was used to estimate mean monthly and annual flow and depth of runoff (flow per unit area) for each subwatershed. Where there were gaps in gauge records, a correlation exercise using unit monthly flow rates over a common period of record was completed during the Conceptual Water Budget phase to identify the best station for filling in missing data. Missing monthly stream flows were calculated from the linear relationship developed at the station with the best correlation in order to provide a complete set of monthly average stream flows. Outliers were replaced. Rating curves were used for the Fall River At Bennett Lake gauge to calculate streamflows from water level data. An inventory of streamflow data and data infilling approaches is given in Appendix A.

The streamflow data for all subwatersheds with stream flow gauges was treated as described above, except for the Tay River At Perth subwatershed. The Tay River At Perth subwatershed requires special attention because there is no single source of long-term accurate stream flow records. The method developed to estimate representative long-term average monthly stream flows for the Tay River at Perth subwatershed is described in Appendix A**.**

The streamflow data from WSC (HYDAT) is measured with a relatively high degree of certainty. A 5% error is often accepted for WSC data (Conceptual Water Budget). Data at the High Falls gauge is from OPG (power generating station). The uncertainty in the streamflow data from OPG is unknown.

Streamflow Estimates for Ungauged Subwatersheds

The subwatersheds that do not have a flow gauge (or no long-term streamflow records) are referred to as ungauged. Streamflows for ungauged subwatersheds were estimated by pro-rating to gauges with similar climate, land cover, surficial geology, and degree of regulation (e.g. whether or not the river is controlled by dams). Flows are estimated by multiplying the gauge flows by the ratio of the subwatershed areas (gauged/ungauged). Methodologies for each of the ungauged subwatersheds are described below.

Streamflows for the Mississippi River At Galetta subwatershed were estimated by pro-rating flows averaged between the Carp River At Kinburn gauge and Indian River At Blakeney gauge. Pro-rated flows were added to flows for the Mississippi River At

Appleton gauge and the Indian River At Blakeney gauge. Streamflows for the Mississippi River (Outlet) subwatershed were estimated using the same method.

Streamflows from the Carp River At Kinburn gauge were pro-rated to estimate flows on the Carp River (Outlet) and Ottawa MVC subwatershed.

Flows at the Rideau River At Ottawa gauge were pro-rated to estimate flows downstream at the outlet for the Rideau River (Outlet) subwatershed.

The Ottawa RVCA West and Ottawa RVCA East subwatersheds were treated differently. These subwatersheds are relatively impervious compared to the other subwatersheds in the SPR therefore flows from the Ottawa RVCA areas were estimated by pro-rating to a gauge in Toronto (Black Creek). Adjustments were made for differences in precipitation and percent connected imperviousness area. The streamflow estimation technique is given in Appendix A.

3.1.2 Climate Data and Evapotranspiration Calculations

Precipitation and Temperature Data

Average monthly precipitation (P) and temperature (T) values were obtained from spatial models of 1971-2000 climate 'normals' developed by the Canadian Forest Service (McKenney et al. 2006) with data from the Meteorological Service of Canada. Average monthly P and T values were weighted over the SPR. Precipitation data is shown on Figure 3.1-1.

Precipitation is measured with a fairly high level of certainty. An uncertainty of 10% for the precipitation can be assumed (Conceptual Water Budget).

Based on analyses done for Mekis and Hogg (1999), the 1971-2000 period appears to be the wettest of the 20th century (B.Hogg, 2009). This may affect water budget results.

Evapotranspiration Calculations

ET is not measured. Rather it is calculated (or derived). Potential evapotranspiration (PET), or lake evaporation, was calculated using the Thornwaite and Mather (1957) method using the P and T data described above.

PET was converted to actual evapotranspiration (AET) using land cover, topography (slope), and soil data (Conceptual Water Budget). The land cover data was obtained from MNR for the period from 1991 to 1998 (MNR, 1998). Root depth for different types of vegetation was estimated from Table 3-1 of the Stormwater Management Planning and

Design Manual (MOE, 2003). The soil property data was obtained from CanSIS (Agriculture and Agri-Food Canada, 2002).

The ET values were revised for Tier 1. The sunlight duration factors used to calculate ET for the Conceptual Water Budget were from the original Thornthwaite and Mather tables (1949). These tables were revised in 1957. The revised ET values reflect the revised ET tables (1957) and are about 10% lower than the ET values shown in the Conceptual Water Budget. Revised AET is shown on Figure 3.1-2.

AET is a difficult parameter to measure, even at the site scale. Rosenberry et al. (2007) quantified the uncertainties associated with multiple techniques to calculate PET in New Hampshire, U.S.A. Additionally, a comment by Szilagyi (2007) on the Rosenberry et al. (2007) article describes potentially significant differences in the calculated PET when using data from the middle of a small lake compared to using data from the shoreline of a lake only 200 m away. This example highlights the uncertainty associated with extrapolating AET from point measurements to regional estimates, which is the case for calculating AET in the SPR using data from McKenney et al. (2006). Despite these uncertainties, the McKenny et al (2006) data set and the Thornthwaite and Mather (1957) techniques produce the best estimate of AET for the SPR with the available data.

PET and AET calculations (from above) were carried out in a GIS program at a 25 m x 25 m grid-scale. Subsequent calculations for water surplus (P – ET) and groundwater recharge (R) were also carried out in a GIS program using the same grid size.

P and AET values for individual subwatersheds were calculated by taking an average of the values over the subwatershed. P and AET was calculated for each subwatershed for water budgeting purposes by taking an average over the cumulative drainage area (including upstream subwatersheds). P and AET values for individual subwatersheds (and cumulative drainage areas) are given in Appendix B. The results for individual subwatersheds are discussed below.

Within the MVC subwatersheds there is some variation in precipitation with approximately 8% difference between the lowest average, annual precipitation (851 mm for Indian River Near Blakeney) and the highest (928 mm for Mississippi River At High Falls). Calculated actual evapotranspiration was lowest in the Mississippi River Below Marble Lake subwatershed (540 mm) and highest in both the Mississippi River (Outlet) subwatershed and Ottawa MVC (573 mm) subwatersheds.

Within the RVCA subwatersheds there is about 5% difference in precipitation between the lowest average, annual precipitation (906 mm for the Tay River At Perth subwatershed) and the highest average, annual precipitation (949 mm for Kemptville

Creek near Kemptville subwatershed). Evapotranspiration was calculated to be lowest in the Rideau River (Outlet) subwatershed (539 mm) and highest in the Kemptville Creek Near Kemptville subwatershed (586 mm).

3.1.3 Groundwater Recharge Calculations

Groundwater recharge (R) was calculated using Ontario's Ministry of Environment and Energy (MOEE) (1995) methodology. The MOEE (1995) method uses the water surplus (P – ET), which is calculated by subtracting the actual evapotranspiration (AET) from the precipitation (P). Surficial geology (soils), topography (slope) and land cover are considered using infiltration coefficients. Parameters in the MOEE 1995 methodology were modified to suit the SPR. The final methodology used for the groundwater recharge estimates in the SPR is described in Appendix C. Limitations and uncertainty with respect to the methodology are given in Section 5.3 of the Conceptual Water Budget.

The MOEE (1995) method was originally intended to estimate groundwater recharge capacity for septic system tile drains to dilute nitrate from septic system effluent. The infiltration coefficients outlined by the MOEE (1995) method were designed to slightly underestimate groundwater recharge in order to be conservative for assessing the impact of septic systems. The infiltration coefficients in the MOEE (1995) method were developed for basic soil types including sandy loam, clay loam and impervious clay.

The SPR contains numerous "soil types", including organic deposits, a range of tills and bedrock. These "soil types" were included in the groundwater recharge calculations. Professional judgment was used to estimate the infiltration coefficients for the soil types that were not published in the MOEE (1995) method. The estimated infiltration coefficients for the additional soil types used in this report were interpolated based on the published values for sandy loam, clay loam and tight clay published in the MOEE (1995) method, and soil property data from textbooks and the Storm Water Management Planning and Design Manual (MOE, 2003).

Groundwater recharge was calculated in 25 m × 25 m cells across the SPR in a GIS program by taking the sum of the infiltration coefficients, multiplied by the water surplus. The result is an estimation of annual groundwater recharge (Figure 3.1-3). However, the MOEE (1995) method adds uncertainty into the calculation of R by assuming the infiltration coefficients accurately represent the physical controls on groundwater recharge. Therefore, the groundwater recharge estimates from the MOEE (1995) method were compared to the groundwater recharge estimated by the following methods.

Groundwater recharge was estimated by Novakowski et al. (2007) at a site scale by examining daily changes in the water levels in a small number of wells in the shallow groundwater system in the Tay River At Perth subwatershed. This study showed groundwater recharge at the study site was approximately 2% of precipitation, and that recharge was dependent on fracture location and spacing and may change significantly within a subwatershed. The study also showed a rapid response of groundwater level to precipitation, but the response is at least partially controlled by the number of fractures. Using 2% of precipitation in the Tay River At Perth subwatershed (906 mm, Table B.1 in Appendix B) estimates groundwater recharge for the study site to be 18 mm.

The MOEE (1995) method calculated groundwater recharge as low as 40 mm per year (Figure 3.1-3) in some of the 25 m × 25 m cells in the Tay River At Perth subwatershed. Groundwater recharge of 40 mm per year is similar to the 18 mm calculated by Novakowski et al. (2007) and suggests the MOEE (1995) method produces acceptable estimates of groundwater recharge. However, recharge in other cells in the Tay River At Perth subwatershed were calculated by the MOEE (1995) method to be 300 mm per year. Overall the calculated average annual groundwater recharge rate for the Tay River At Perth subwatershed using the MOEE (1995) method was 121 mm, which is higher than some of the 25 m × 25 m cells that had calculated recharge rates of 40 mm per year. The Novakowski et al. (2007) study suggested groundwater recharge in the Tay River At Perth subwatershed varies both spatially and temporally, which highlights the difficulty of estimating groundwater recharge at a regional scale.

Groundwater recharge was also estimated by examining groundwater discharge to rivers, which is also called baseflow. The idea is that the baseflow to streams is equivalent to groundwater recharge. Baseflow methods for estimating groundwater recharge use changes in river water level to estimate the long-term, relatively steady, addition of baseflow to the river. The drawback to using the baseflow methods is that the method is not applicable for subwatersheds where the river is controlled by anthropogenic means (i.e. dams and weirs). The rivers in many of the subwatersheds in the SPR are anthropogenically controlled.

Baseflow was estimated on a subwatershed scale using the USGS BFLOW model (Neff et al. 2006). This is a separate method than the MOEE (1995) that is not based on water surplus, soil type, land cover, or land topography. The BFLOW model examines changes in surface water level and provides three estimates of baseflow to the river, a low, medium and high estimate. The selection of the final baseflow estimate is left up to the discretion of the model user.

Appendix C shows the BFLOW results for three subwatersheds that are not anthropogenically controlled. In addition, the results for the Tay At Perth suwbatershed were included despite the anthropogenic controls in order to allow a comparison of the three methods. Due to the small amount groundwater recharge estimated by Novakowski et al. (2007) described above, the low estimates of groundwater recharge from the BFLOW model were used.

A comparison of the BFLOW results to the MOEE (1995) results for the Lanark, Kinburn and Fall River subwatersheds showed the MOEE (1995) recharge values were approximately 10% lower on average than the baseflow results (Appendix C). The BFLOW estimate for recharge in the Tay River At Perth subwatershed was higher than the MOEE (1995) and Novakowski et al. (2007) estimates.

The similarity between the subwatershed scale recharge estimates from the MOEE (1995) and BFLOW methods suggests the MOEE (1995) method produced adequate estimates of groundwater recharge at a regional scale for the purpose of this study. However, without accurate field data it is difficult to address the level of uncertainty. The Novakowski et al. (2007) study showed the local spatial scale and small temporal scale (weeks to months) variability of groundwater recharge will add uncertainty to any groundwater recharge estimate.

There are many other methods for estimating groundwater recharge at a regional scale. However, these methods have complex data requirements, and the data required for these methods is not often available at a regional scale. For example the Water Table Fluctuation Method used by Healy and Cook (2002) requires knowledge of the specific yield and temporal changes in water table level. This data is limited in the SPR due to the few number of wells that are completed solely in an unconfined aquifer and the absence of water table level monitoring data.

3.2 Methodology for Tier 1 Water Budgets

Following the principle of conservation of mass, inputs must balance with changes in storage and outputs over a time period. The water budget for a given control volume (e.g. a subwatershed) can be expressed as the following mathematical expression:

$$P + SW_{in} + GW_{in} + ANTH_{in} = AET + SW_{out} + GW_{out} + ANTH_{out} + \Delta S + Diversions$$

Here
- P = precipitation (rainfall + snowmelt), an input to the system
- SW_{in} = surface water flow into the control volume
- GW_{in} = groundwater flow into the control volume
- $ANTH_{in}$ = anthropogenic flow into the control volume (e.g. wastewater discharges)

AET = actual evapotranspiration (evaporation and transpiration), an output from the control volume
SW_{out} = surface water flow out of the control volume
GW_{out} = groundwater flow out the control volume
$ANTH_{out}$ = anthropogenic flow out of the control volume (e.g. drinking water takings)
ΔS = delta storage (i.e. changes in storage in surface water and groundwater such as in the aquifers, snowpack, and reservoirs)
Diversions = water taken out of the control volume

The above equation can be reduced to:

$$P = AET + SW_{out} + GW_{net} + \Delta S$$

following these simplifications:

- All subwatersheds considered in the water budget are treated as headwater subwatersheds (e.g. extend to the headwaters) resulting in no stream flow coming into the subwatershed at the boundary therefore SW_{in} is reduced to zero.
- The groundwater flux into and out of the control volume is considered to be negligible (i.e. the volume of groundwater flowing into the control volume at the up-gradient boundary is assumed to equal the volume of groundwater flowing out of the control volume at the down-gradient boundary). Therefore, the net groundwater flux or GW_{net} (GW_{out} minus GW_{in}) for the purpose of the Tier 1 water budget is reduced to zero. Detailed groundwater models would be needed to more accurately define groundwater movement. These models are not available for the SPR.
- The water budget addresses movement of water into and out of the subwatershed. Therefore, other fluxes of water that occur in each subwatershed (e.g. storage, canopy interception, overland flow) are considered negligible.
- Most anthropogenic fluxes are internal fluxes and are not reported in this section.
- There are no known major diversions in the SPR so this term can be ignored.

Groundwater Flux

The majority of the Mississippi Valley contains Precambrian rock. Lateral groundwater flow in Precambrian rock is limited, and is difficult to quantify because groundwater travels primarily in discrete fractures. The eastern part of the Mississippi Valley and the Rideau Valley contains the Nepean Formation, which is a laterally extensive sandstone in these areas. The Nepean Formation outcrops near the eastern boundary of the Mississippi

Valley and the western and southern boundaries of the Rideau Valley (Conceptual Water Budget). For areas with the Nepean Formation, lateral groundwater flow is conceptualized to be focused through the Nepean Formation (Conceptual Water Budget).

The regional groundwater flow direction in the Nepean is generally west to east (Conceptual Water Budget). Groundwater is recharged in the Nepean aquifer in the Mississippi Valley and is transported through the Rideau Valley into the neighbouring South-Nation Valley to the east of the M-R SPR. The Conceptual Water Budget suggested a field campaign to collect water samples to estimate the age of the water in the Nepean Formation. However, many of the wells that penetrate the Nepean Formation are open holes that cross several formations and it was determined that it would be difficult to obtain reliable results from this work.

The transmissivity of the Nepean Aquifer is at least two orders of magnitude greater than other regional bedrock aquifers (Conceptual Water Budget), which is why it is commonly used for supplying water where it is readily accessible for private well construction, or when a municipal source is developed. Six of the seven municipal groundwater systems obtain water from the Nepean Aquifer, which is an indication of the significance of this aquifer in the SPR.

One municipal groundwater system obtains water from a sand and gravel esker. Sand and gravel aquifers are present in many areas of the SPR, but these aquifers are not continuous and are not considered to move water through the SPR on a regional scale.

The volumetric groundwater flow rate in the Nepean Aquifer was estimated for the Conceptual Water Budget. The Conceptual Water Budget used an estimated hydraulic conductivity for the Nepean Aquifer of 1×10^{-4} m/s and an estimated aquifer thickness of 40 m. Groundwater levels obtained from the MOE water well record database from bedrock wells completed greater than 30 m below ground surface indicated a horizontal hydraulic gradient of 0.001 m/m across the Rideau Valley, where the Nepean Formation aquifer is present. This small hydraulic gradient is expected for aquifers with a high hydraulic conductivity, such as the Nepean Aquifer.

The product of the hydraulic conductivity, hydraulic gradient and aquifer thickness was used to estimate a volumetric flow rate of 4×10^{-6} m^3/s per m length of the Nepean Formation aquifer. The product of this unit length volumetric flow rate and the length of the northern border along the Ottawa River and eastern border of the Rideau watershed (~ 150 km), is approximately 0.6 m^3/s. This flow rate is a regional estimate of lateral groundwater flow in the Nepean Formation aquifer.

Assuming the regional lateral groundwater flow in the Nepean Formation aquifer is evenly distributed throughout the aquifer, we can prorate the flow from the regional scale to the subwatershed scale for subwatersheds where the Nepean Formation aquifer is present. The maximum width of each of the subwatersheds in the SPR was estimated by drawing a north-south line through the widest section of each subwatershed in a GIS program. This line represents the largest width that groundwater may travel through in each subwatershed. The maximum widths for the subwatersheds ranged from a low of 10 km for the Ottawa RVCA West subwatershed to a high of 33 km for the Rideau River Below Merrickville subwatershed.

The lateral groundwater flow for each subwatershed that contains the Nepean Formation Aquifer was prorated by the product of the hydraulic conductivity of the aquifer (1×10^{-4} m/s), the aquifer thickness (40 m), hydraulic gradient (0.001 m/m) and the estimated maximum widths. The resulting calculated flows ranged from 0.04 m^3/s for the Ottawa RVCA West subwatershed, up to 0.132 m^3/s for the Rideau River Below Merrickville subwatershed. These calculated flow rates represent (on average) approximately 5% of the calculated groundwater recharge into each subwatershed (see Section 6.2). Therefore, due to the relatively small lateral groundwater flow entering subwatersheds through the Nepean Formation compared to the total groundwater recharge into each subwatershed, lateral groundwater flow into subwatersheds was assumed to be negligible.

Lateral groundwater flow in the Precambrian is considered to be less than the flow in the Nepean Formation aquifer. Since lateral flow in the Nepean Formation is assumed to be negligible, lateral flow in the Precambrian is also assumed to be negligible.

Since GW_{net} is effectively reduced to zero, the water budget equation can be reduced to:

$$P = AET + SW_{out} + \Delta S$$

3.3 Annual Water Budgets for Subwatersheds

Building on the equations described in Section 3.2, long-term (average) annual water budgets were calculated over a 30-year period (1971-2000). Changes to groundwater and surface water storage over long-term periods (e.g. 30-years) are considered minor compared to the fluxes in and out of catchments. Therefore, for the long-term annual water budget, changes in water storage (ΔS) (e.g. groundwater storage and surface water reservoirs), can be assumed to be zero.

For the annual water budget, the difference between the inputs and the outputs in the water budget lies in the inherent error associated with estimation of each component (P, AET, and SW) and the uncertainty in assuming that the change in storage over the year is zero. These errors and uncertainty are lumped into an amount referred to as the "Residual" and are presented as an additional component. The "Residual" term also includes any withdrawals from the system. The long-term annual water budget equation becomes:

$$P - AET - SW_{out} = Residual$$

The results of the long-term, annual water budget for the gauged and ungauged subwatersheds in MVC and RVCA are in Table 3.3-1. Note that the values for P and AET that are shown in Table 3.3-1 are based on the cumulative drainage area (the subwatershed is extended to the headwaters).

Table 3.3-1 shows good agreement between the hydrologic components amongst the MVC subwatersheds. For example, the highest stream flow volume is in the subwatershed (Marble Lake) with the second highest precipitation (919 mm) and lowest evapotranspiration (540 mm). Also, the subwatershed (Carp River) with the lowest stream flow (326 mm) also has the second highest rate of evapotranspiration (571 mm). The long-term annual average measured stream flow (SW_{out}) varies between 326 mm for Carp River At Kinburn to 420 mm at Marble Lake.

Average, annual precipitation and evapotranspiration are generally higher in the Rideau River watershed (924 mm for P and 573 mm for ET) than in the Mississippi River watershed (898 mm for P and 557 mm for ET). The measured streamflows in the Rideau River however are similar in magnitude to those in the Mississippi River, but show less variation. The average, annual depth of runoff measured for the Rideau River is 367 mm per year (Ottawa). The average, annual depth of runoff for the Mississippi River is 358 mm per year (Appleton). The average, annual depth of runoff at the outlet of the Mississippi River (ungauged) is estimated as 331 mm (367 mm for the Rideau). The annual, average measured streamflow in RVCA varies from 355 mm for the Tay River at Perth gauge to 386 mm for the Jock River Near Richmond gauge (or 477 mm for the ungauged Ottawa RVCA West subwatershed).

The majority of the residual amounts in Table 3.3-1 are negative for the MVC subwatersheds. Negative residual values suggest that precipitation could be underestimated or AET and Q could be overestimated. The subwatersheds with positive residuals are Mississippi River At High Falls, Mississippi River At Galetta, Mississippi River (Outlet), and Carp River At Kinburn. The Ottawa RVCA (West) subwatershed (ungauged) has the highest residual amount of all the subwatersheds suggesting that the surface water flow estimated for this ungauged subwatershed may be overestimated.

3.4 Long-term Monthly Water Budgets for Subwatersheds

Long-term (average) monthly water budgets were completed for Tier 1 subwatersheds. The methodology is described in Section 3.2. As opposed to the annual water budget, the storage term needs to be considered in a monthly water budget. Several water storages are at work in a typical year, including winter precipitation storage in the snow pack, spring runoff storage in regulated surface reservoirs, unregulated lakes and wetlands, and spring / fall underground water storage in the aquifers. Fluxes among all of these are included in the ΔS (delta storage) term. Because most storage components cannot be accurately quantified, their lumped effects will be calculated as the difference between the monthly inputs and outputs. As with the annual water budget, a residual amount is associated with each component estimate and is combined with the ΔS (delta storage) calculations. The monthly water budget equation used is:

$$P - AET - SW_{out} = \Delta S + Residual$$

Long-term monthly water budgets for the subwatersheds in MVC are presented in Table 3.4-1 and Graphs 3.4-1 to 3.4-12. Long-term monthly water budgets for RVCA are presented in Table 3.4-2 and Graphs 3.4-13 to 3.4-22.

Regulation affects surface water flows. Four subwatersheds within the SPR are not affected by dam operations, generating stations or canal lockstations and are therefore referred to as “unregulated” (e.g. natural) subwatersheds. The unregulated subwatersheds include three in MVC (Clyde River, Fall River and Carp River) and one in RVCA (Jock River). The remaining subwatersheds in the SPR are affected by controls. They are referred to as regulated subwatersheds.

The unregulated subwatersheds in MVC have similar water budget characteristics, with the highest release of stored water in the month of April as expressed by a larger negative ΔS term. July, August and September have the lowest stream flow volumes for these unregulated subwatersheds. There is generally more variation in monthly flows in unregulated subwatersheds than in regulated subwatersheds.

Flows on the Mississippi River at Marble Lake, High Falls, Fergusons Falls and Appleton, and on the Indian River at Blakeney, are all affected by dam operations and generating stations. This results in less variation in average monthly flows.

The Mississippi River At Marble Lake subwatershed is affected by regulation but differs from others because of the effect of lake level regulation. Marble Lake levels and flows are impacted by operations at Mazinaw Lake Dam. This water storage effect, combined with other surface reservoirs located between Marble Lake and the Appleton gauge, also influences the water budget for Appleton.

For the RVCA subwatersheds, again, monthly water budgets for unregulated subwatersheds differ from those that have controlled water levels. Flows measured at the Tay River At Perth, Rideau River At Smiths Falls, and Rideau River At Manotick are affected by dams. The gauge on Kemptville Creek Near Kemptville is 4 km downstream of a dam at Oxford Mills, which affects flows. Flows measured on the Rideau River At Merrickville gauge and Rideau River At Ottawa gauge are less affected by regulation.

The Jock River Near Richmond subwatershed (unregulated) had the highest release of stored water in April and the highest April stream flows as expressed by the negative ΔS term at 103 mm. Depth of runoff (stream flow divided by drainage area) for the Jock River Near Richmond gauge is 6-7 mm per month for July, August and September. Comparatively, depth of runoff is 16-18 mm for the Tay River Near Perth gauge and 22-26 mm at the Rideau River Above Smiths Falls gauge. The effect of spring runoff storage in reservoir lakes is well observed in the water budgets for the Tay River Near Perth gauge and the Rideau River Above Smiths Falls gauge, with lower spring stream flows and higher stream flows throughout the rest of the year. The flow data for the Rideau River Above Smiths Falls gauge is possibly affected during navigation season (May – October) by a backwater effect caused by the dam above Abbott Street in Smiths Falls.

Similar to MVC, regulated subwatersheds in RVCA that are affected by dam operations and canal lockstations show less variation in average monthly flows, with higher flows in the summer and lower flows in the spring compared to a natural (unregulated) subwatershed.

4.0 Percent Water Demand Equation

This section introduces the general methods for the Tier 1 water quantity stress assessment. The following sections describe water supply, water demand, and the stress assessment calculations for surface water and groundwater for each of the Tier 1 subwatersheds. The calculations were completed as per the requirements given in the Technical Rules and the methodologies given in the Guidance.

4.1 Percent Water Demand Equation

The ratio of water demand to water supply (less water reserve) is used to determine if a water supply is stressed with respect to water quantity. Percent water demand is calculated as follows:

$$\%WaterDemand = \frac{QDemand}{QSupply - Q\mathrm{Re}serve} x100$$

where,

Q_{Demand} is the anthropogenic (consumptive) water demand,

Q_{Supply} is the water supply to the surface water or groundwater system, and

$Q_{Reserve}$ is the water reserve designed to account for other uses (e.g. ecological).

Percent water demand is a relative indicator of water quantity stress (hydrologic stress). Subwatersheds that are identified as stressed in Tier 1 will move on to Tier 2 for further analysis provided that they have a municipal drinking water system.

4.2 Demand Scenarios

Percent demand will be calculated for the following scenarios as per the Technical Rules:

i) current demand conditions; and

ii) 25-year future demand conditions.

The current demand scenario will identify areas that are stressed from existing water takings. Data related to land use should be reflective of future development. Although development may be substantial in isolated areas, it is not likely to have a significant impact on the overall land use across the SPR. Therefore, the current land use was used for the future demand scenario.

Water demand for the 25 year condition is adjusted by increasing (or decreasing) the municipal demand, taking into account population growth estimates. For Tier 1, future demand scenarios are based on current climate and streamflow conditions. Therefore, the water supplies are assumed to be the same for the current and future demand scenarios.

4.3 Time Scale of Stress Assessments

As per the Technical Rules, stress assessments were evaluated on a subwatershed scale, (independently for surface water and groundwater) and at the following temporal scales:

- Surface water stress assessments were completed on a monthly scale.
- Ground water stress assessments were completed on a monthly and annual scale.

5.0 Water Demand

The Guidance defines water demand as “water taken as a result of an anthropogenic activity”. Water demand in the Region consists of four sources: [1] permitted water takings or Permits To Take Water (PTTW), [2] municipal water takings (also permitted), [3] agricultural takings (e.g. livestock and irrigation), and [4] private wells (e.g. domestic wells). Sections 5.1 through 5.4 outline the data sources for each of these four categories.

5.1 Permits to Take Water

The MOE lists the PTTWs on Ontario’s Environmental Registry website (http://www.ebr.gov.on.ca). The MOE maintains a database of PTTWs. The PTTW database contains permits for water takings for large users (above 50,000 L/day). All permits registered for the SPR were obtained from the database in February 2008.

The PTTW database contains information on maximum daily takings and the days in the year the permit is valid. However, not all of the permits are operational and most of the permits only affect either surface water or groundwater, not both. The following criteria were used to remove a PTTW from consideration:

1) The permit was not considered for the surface water stress assessment if it was a groundwater taking. Surface water permits were not considered as a groundwater taking.

2) The permit was expired for greater than 5 years.

3) The permit was not a sustained water taking (e.g. a 72-hour pumping test).

4) The permit was for wildlife conservation (wetlands).

The Province has directed the SPR to exclude wetland permits from the stress assessment. This approach was also taken by the Grand River Conservation Authority

(GRCA, 2005). The permitted takings for the wetland permits permits are not a sustained water taking and do not represent true water takings. For example, in the Tay River At Perth subwatershed, the wildlife conservation permits represent 99% of the total permitted takings. Information on water usage for wildlife conservation is given in Appendix D.

Information was also obtained on several larger takings (>250,000 L/day) from willing permit operators. Specifically, information was available for the following permits:

- 03-P-4107 – Surface water takings data was collected from Omya Canada Inc., a calcite processing plant on the Tay River for 2004 to 2008.
- 6642-6V4T8Y – Groundwater pumping rates obtained for 2008
- 5214-6WNJGY – The PTTW database contained multiple listings for the same groundwater permit.
- 00-P-4006C – The wells were decommissioned.

Additional information was found by searching the permits on Ontario's Environmental Registry. For example, information was provided on the permit's seasonal conditions.

The PTTW database is subject to uncertainty and error. For example, applicants are required to submit GIS coordinates of their intended water takings; therefore, there may be mistakes associated with the permit locations. Additionally, the permit can be categorized as surface water, groundwater or both, but surface water and groundwater takings may be lumped together on a single permit. For example, a clubhouse well at a golf course may fall under a surface water permit because the permit for the golf course was also issued for irrigation ponds. Where possible, these types of permits were separated out for Tier 1. Finally, the database provides values for maximum takings, although some permit holders may not reach the maximum taking allowed by the permit. The maximum permitted takings were multiplied by the appropriate consumptive factors (see Section 5.5) and used in the consumptive demand calculations unless other information was available.

A list of the PTTWs used for surface water and groundwater stress assessments, including the monthly consumptive demand for each permit, is included in Appendix F.

5.2 Municipal Drinking Water Systems

Records of municipal drinking water takings were obtained from the municipalities in the SPR. Water use records from 2001 to 2005 (from the Conceptual Water Budget) were used to calculate average monthly takings for the surface water systems. Water use records from 2001 to 2005 (from the Conceptual Water Budget) were also used for

Kemptville and Merrickville groundwater systems, but the actual use data for 2008 were used for the remaining groundwater systems.

For Tier 1 a survey was issued to the municipal operators in 2009 to see if there had been any significant changes in water takings since 2005 (and thus the need for newer data). This approach was recommended by the Province. The responses to the municipal survey are given in Appendix E.

The results of the survey showed that no new data would be required for the surface water systems for Tier 1.

For the groundwater systems, new water taking data was obtained for Almonte, Carp, Munster, Kings Park and Westport wells for 2008 and used for the Tier 1 demand calculations. The well operators reported no significant change in use for 2008 compared to 2001 to 2005 for Kemptville and Merrickville. The future Lanark system was not operating in 2008 therefore; the predicted monthly pumping rates were used for the current and future demand scenarios (Stantec, 2008).

5.2.1 Future Demand

Future demands in 2033, 25 years into the future from 2008, were calculated for each subwatershed. Future demands for each municipal taking are based on population projections and are discussed in the following sections. To calculate the monthly and annual future water demands, the current actual takings were multiplied by the anticipated increase in percent demands reported below. Future demands for other PTTWs, private wells, and agricultural uses are assumed to remain equal to their current demand values.

The Town of Carleton Place currently has no future water demand study. However, based on communications with Ms. Lisa Young (Director of Planning, Town of Carleton Place), the population is expected to grow on average by 1 to 2% each year, based on trends observed in the last 7 to 10 years. The population in Carleton Place is 9,453 (2006 Census) and is expected to grow to 14,130 in the next 25 years. Carleton Place future demand estimates are based on an annual growth rate of 1.5%, which is equal to a 49% population difference over 25 years. The monthly municipal water use has been multiplied by 1.49.

The Town of Perth currently has no future water demand study. However, as part of an Official Plan review, the Town has recently developed growth scenarios in order to project possible population to the year 2031. Current average population is estimated at 5,940. Three ranges of population projection varying between 7,300 and 11,030 were estimated for the year 2031 depending on growth (Tunnock Consulting Ltd., 2007). According to Mr. Eric Cosens (Director of Planning, Town of Perth), the projection will depend on a boundary restructuring process. The maximum population projection (population of 11,030) is assumed for the year 2033. A factor of 1.86 is applied to each monthly municipal water use.

The Town of Smiths Falls currently has no future water demand study. The Town is in the process of planning for a new back-up surface water intake, after which it plans to begin a new study for future water use. In the interim, future water use is estimated from a population projection of 13,000, representing population for complete development within current town boundaries (Delcan, November 2007). Current average population is estimated at 9,512. Thus, a growth factor of 1.37 is applied to each monthly municipal water use.

The Carp municipal groundwater system future demand estimates are based on a projected population growth of 120% and a pumping rate increase of 50% in accordance with an Environmental Assessment in support of a water and wastewater infrastructure expansion (Stantec, 2007). The difference between the projected population increase and pumping rate for the Carp system and the other systems listed below may be related to future planning factors such as commercial planning decisions as well as potential population growth in developments that rely on private or small communal wells.

The Almonte system future demand estimates are based on a projected population growth of 60% with a pumping rate increase of 30% in accordance with the 2007 Official Plan.

The Kemptville system future demand water demand is based on a projected population growth of 240% and pumping rate increase of 270% in accordance with a water and wastewater servicing Master Plan (Stantec, 2005).

According to a WHPA study completed in 2002 (Golder, 2003), both Kings Park and Munster systems have nearly reached their designed maximum populations, therefore future water demand is based on a population and pumping rate increase of 5% for Munster and Kings Park.

The Merrickville system future demand water demand is based on a projected population and pumping rate growth of 60% for Merrickville in accordance with the Village of Merrickville-Wolford Official Plan (Delcan, 2004).

Westport future demand estimates are based on a projected population growth of 5% (Village of Westport, personal communication, 2007).

Finally, the Lanark system used the projected pumping rates for both the current and future demand scenarios (Stantec, 2008). Future rates were not available since the system was only recently activated and is anticipated to meet the projected needs for the community.

5.3 Agricultural Takings

Agricultural water takings data was obtained from the Agricultural Census Database (deLoe, 2002). Agricultural water takings were divided into two primary categories – livestock and irrigation. The agriculture water takings data was tabulated according to census areas, not the Tier 1 subwatershed areas shown in Figure 2.2-2.

The agricultural water takings were converted from the census delineation to the Tier 1 subwatershed delineation according to the following method. First, the takings were assumed to be equally distributed across the census area. To estimate the agricultural takings for a census area within a subwatershed the percentage of each census area within a subwatershed was determined and multiplied by the livestock and irrigation water takings. Finally, the total livestock use for the subwatershed was divided by 12 to calculate monthly demand. The irrigation water use was divided in 2, and equally distributed in July and August. Therefore, agricultural water demands are highest in July and August.

This method was repeated for each census area within a subwatershed and the livestock and irrigation water takings were summed together to estimate the total agricultural water takings in a subwatershed.

The collection of agricultural takings data by census area produces uncertainty in the data when it is applied to the subwatershed scale used in this report. By assuming the agricultural takings are averaged evenly throughout the census area, some uncertainty is added to the data since agricultural takings are likely from point sources. Therefore, large point source takings are averaged over an area, and possibly between subwatersheds, depending on the distribution of a census area between subwatersheds. Considering the large size of the subwatersheds, the misallocation of takings between subwatersheds is assumed to be minimal.

Livestock water use is not constant and varies from month to month. The source of the water taking will vary too. If livestock are put to pasture they will likely drink water from nearby streams. If they are indoors, they will be watered from an on-site source that is likely a well.

Irrigation will occur outside of July and August however will likely peak during the summer. Water used for irrigation will vary depending on the type of crop, the climate, and the soil.

5.4 Private Wells

Information on the location of private wells was obtained in November 2006 from the MOE Water Wells Information System (WWIS), referred to as the Wells Database. The number of wells in each subwatershed was determined in a GIS program. The MOE Wells Database does not contain information regarding pumping rates for the private wells.

Each private well was assumed to be used for a single household. Water use from private wells was estimated to be equal to the number of wells multiplied by an average per capita consumptive use. Data from five townships in the SPR collected in the Conceptual Water Budget based on records of population data for 4 years (1986, 1991, 1996, 2001) showed private wells supplied an average of 2.85 persons per well and had a consumption rate of 200 L per person per day. The same assumptions were used for private well pumping rates in this report. Monthly water taking from private wells was determined by the product of the number of wells in a subwatershed, 2.85 persons per well and 200 L per person per day. The number of private wells in each subwatershed in included brackets in the row header for private wells in Table 5.6-1.

5.5 Consumptive Demand

Water takings from PTTW, private wells and agricultural takings represent the volume extracted from surface water or groundwater. However, the Guidance indicates some of the water taken from the surface water and groundwater systems may be returned. For example, storm water that is temporarily stored is slowly released to a surface water system. Also, some groundwater for irrigation will infiltrate back into the groundwater. For both of these examples, water is returned to the original source (surface water or groundwater) but some water is lost or consumed by evapotranspiration.

Tier 1 calculations were completed based on consumptive demand. The consumptive demand is calculated as the water taken from surface water or groundwater and not returned locally in a reasonable time period. The consumption factor (F) is defined as:

$$F = (Q\ pumped - Qreturned) / Q\ pumped$$

Table 16 (p. 162) in Appendix D of the Guidance provides consumptive use factors (F). F ranges from 0 (no consumption) to 1 (100% consumption). Water consumption is influenced by the source of the supply and the intended use for the water. For example, water taken from a deep aquifer and returned at the surface by wastewater plants is 100% consumptive (F = 1), because it represents a loss from the groundwater system. However, surface water used for drinking water and returned to a surface water body is considered 20% consumptive (F = 0.2).

Section 3.1.4 (p. 157) in Appendix D of the Guidance provides rules for months that PTTW are active. For example, permits for camp grounds and dust control are active in the summer, and municipal takings and takings associated with groundwater remediation occur year-round.

The consumptive factor (0.2) was used for the municipal surface water demand as water for these systems is primarily returned to wastewater treatment plants. Municipal groundwater demand was considered to be completely consumed, since water for these systems is primarily discharged through sewer systems, and is not available for recharge. A consumptive factor (0.2) was used for the domestic water use (private wells) and is included in the domestic groundwater use values presented in the tables in Section 5.6.

Consumptive factors outlined in the Guidance for agricultural activities were between 0.8 and 0.9, meaning the large majority of water was consumed. A consumptive factor of 1 was used for agriculture because specific agricultural extractions and returns are not known. Using a factor of 1.0 provides a 10 to 20% overestimate of agricultural water use. However, water takings from agriculture represents the smallest or second smallest (behind private takings) in the subwatersheds. Therefore, this conservative estimate of agricultural water takings does not have a significant effect on the total consumptive demand presented in Table 5.7-1.

A consumption factor for stormwater management facilities was given in the Guidance. Therefore, an F value of 0.1 (dams and reservoirs) was assigned to stormwater management facilities (to account for losses to evapotranspiration).

5.6 Surface Water Demand

Surface water demand for each subwatershed includes water used by municipal drinking water systems (actual takings × 0.2), all other PTTW (maximum permitted takings × consumption use factor), and agriculture water demand. Agricultural water demand was split in half between the surface water and groundwater assessments because the source of the water taking was unknown. Municipal, other PTTW, and agriculture demands are described in Sections 5.1 through 5.3 (excluded private wells) and listed in Table 5.6-1 in “1000s of m^3/s” (equivalent to litres per second) for each of the subwatersheds. The demands in Table 5.6-1 are given in m^3/s to be consistent with the water supply data. They were multiplied by 1,000 to protect the accuracy of the data. Demands can be divided by 1,000 to get back to m^3/s. Additionally, future surface water demand described in Section 5.2.1 is included in Table 5.6-1. The consumptive demands are also summed together for total current and total future demands in each subwatershed. The monthly consumptive demands represent the numerator in the percent demand equation.

5.7 Groundwater Demand

Groundwater demand for each subwatershed includes water used by PTTW, agricultural practices, municipal drinking water supplies (actual takings), and private wells. Agricultural, municipal and private well demands are described in Section 5.1 through 5.3 and are shown for each subwatershed in Table 5.6-1. The annual demand was calculated by a weighted average of the monthly demands to account for the different number of days in each month. Additionally, the future groundwater demand described in Section 5.2.1 is included in Table 5.7-1. Table 5.7-1 lists the subwatersheds along with their consumptive demands in "1000s of m^3/s" (equivalent to litres per second). The demands in Table 5.7-1 are given in m^3/s to be consistent with the water supply data. They were multiplied by 1,000 to protect the accuracy of the data. Demands may be divided by 1,000 to obtain values in m^3/s. The demands for each subwatershed are also summed together for total current and total future demands. The monthly and annual consumptive demands represent the numerator in the percent water demand equation.

6.0 Water Supply and Reserve

6.1 Surface Water Supply and Reserve

Surface water supply rates were calculated for each of the subwatersheds in the SPR as the median monthly stream flow (i.e. monthly Q_{P50}). No significant land use changes are expected in the SPR that would modify the water supply hence water supply is not adjusted for the future - 25 year scenario. The current supply values are assumed the same for the future supply values.

A portion of the supply is reserved for in-stream ecosystem uses, dilution of wastewater treatment plant discharge, hydroelectric power, and navigation. For Tier 1, the surface water reserve is estimated as the tenth percentile of stream flow, or the rate of discharge that is exceeded in the long-term 90% of the time. The lower decile (Q_{P90}) monthly stream flow is used as a water reserve for current and future (25-year) conditions on a monthly basis.

Monthly supply (Q_{P50}) and reserve (Q_{P90}) values were estimated for each subwatershed using average monthly streamflow data over two periods of record: 1) a more recent 20 year period (1986 – 2005) and 2) an older but longer 30 year period (1971-2000). Supply (Q_{P50}) minus reserve (Q_{P90}) was calculated for each month and each period of record. The smallest value of supply minus reserve over the two periods (1986-2005 and 1971-2000) was selected for the denominator in the percent water demand equation. Both periods are representative of current flow regimes. The selection of a minimum value for supply minus reserve between two periods is more conservative.

The monthly surface water supply and reserve estimates for the MVC and RVCA subwatersheds are given in Table 6.1-1. They are shown in m^3/s. Annual values are not required for surface water.

6.2 Groundwater Supply and Reserve

Conceptually, the groundwater available in each of the subwatersheds is supplied through lateral groundwater flow and groundwater recharge. The Nepean Aquifer is a significant regional aquifer that is commonly used due to its high-quality and large quantity of water. The high transmissivity of the Nepean Aquifer makes it ideal for water supply.

The groundwater supply in the Technical Rules is interpreted as the sum of lateral groundwater flow and groundwater recharge. Additionally, all groundwater in a subwatershed is available throughout the subwatershed, i.e. deep groundwater is available to shallow wells and shallow groundwater is available to deep wells.

The calculations and discussion presented above in Section 3.2 showed lateral groundwater flow was negligible. Therefore, lateral groundwater flow was assumed to be zero. Groundwater supply was estimated solely from groundwater recharge. This is a conservative approach that likely leads to an underestimation of groundwater supply.

Annual groundwater recharge was calculated in a GIS program at a 25 m × 25 m scale using the MOEE (1995) method as described in Section 3.1. Groundwater supply in each subwatershed was calculated by integrating the recharge from each 25 m × 25 m cell in a subwatershed to obtain an annual volumetric groundwater recharge estimate in m^3.

Table 6.2-1 shows the annual and monthly volumetric groundwater recharge for each subwatershed. The groundwater supply was calculated as the annual volumetric recharge rate divided by the number of seconds in a year to produce values in m^3/s. The annual and monthly groundwater supplies are assumed to be equal, since groundwater recharge is assumed to be constant and the supply was calculated as recharge volume divided by time. Because the rate of groundwater supply (recharge) is constant, only one column for groundwater supply is shown in Table 6.2-1.

The Guidance requires the groundwater reserve to be calculated as 10% of the average annual baseflow to surface water or 10% of the groundwater supply. Estimates of baseflow were difficult due to stream regulation (Section 3.1.3); therefore, the groundwater reserve was calculated using the groundwater supply.

Since the annual and monthly supplies are equal (see above) the reserve values are also the same. The final column in Table 6.2-1 presents the difference between the supply and the reserve. This value represents the denominator in the percent water demand calculation.

7.0 Stress Assessment Calculations

The stress assessment evaluates the ratio of the consumptive demand to the water available in a subwatershed (supply – reserve) according to the following percent water demand calculation:

$$\%WaterDemand = \frac{QDemand}{QSupply - Q\mathrm{Re}serve} x100$$

where,

Q_{Demand} is the water demand as calculated in Section 5.6 (SW) and Section 5.7 (GW);

Q_{Supply} is the water supply as calculated in Section 6.1 (SW) and Section 6.2 (GW); and

$Q_{Reserve}$ is the water reserve as calculated as Q_{P90} for surface water and 10% of the groundwater supply ($Q_{Reserve} = 0.1Q_{Supply}$).

Note that as per direction from the Province, all consumptive demand for surface water within a subwatershed is added back into the surface water supply term in the percent water demand equation (otherwise the water takings may be double counted). This adding of the demand back into the supply term in the denominator of the above equation assumes that the demand has occurred constantly over the period of the supply. This is generally not the case and does introduce uncertainty into the equation.

The percent water demand calculation is a relative indicator (screening measure) of water quantity stress. It is designed to highlight subwatersheds where the degree of stress warrants further water budget analysis (Tier 2).

The percent water demand calculations were completed for surface water (monthly) and groundwater (monthly and annually) for the following scenarios:

i) current demand conditions; and
ii) 25-year future demand conditions.

The percent water demand is evaluated for surface water and groundwater independently.

7.1 Surface Water Stress Assessment

Percent water demand calculations for surface water are conducted on a monthly scale. The surface water demand data is described in Section 5.6. The supply and reserve data is described in Section 6.1.

The percent water demand calculations for surface water are to be compared to stress levels presented in Table 7.1-1 as per the Technical Rules. The stress levels apply to the current and future demand scenarios.

A stress category was assigned to each subwatershed by comparing its maximum monthly percent water demand, for the current and future demand conditions, to the stress criteria (Table 7.1-1).

The percent demand calculations and the resulting stress categories for the subwatersheds are presented in Table 7.1-2.

Percent water demand calculations that resulted in MODERATE and SIGNIFICANT stress levels for surface water do not contain municipal systems for surface water therefore they do not require a Tier 2 analysis.

Galetta Subwatershed and Power Generating Stations on the Mississippi River

The percent water demand calculations show that the Mississippi River At Galetta subwatershed has the highest monthly percent water demand in the SPR (80.8%). This is categorized as the only SIGNIFICANT stress level in the SPR. Over 99% of the permitted demand in this subwatershed is from three permits for power production from three generating stations on the Mississippi River. The permitted takings and the consumptive demands from each of the generating stations are an order of magnitude higher than any other permitted taking in the SPR. Consumptive demand was estimated based on the maximum permitted taking multiplied by a consumption factor of 0.1 (10%) as per the Guidance. There is no actual water takings data available for these generating stations. The permitted takings are believed to represent the daily volume of water allowed to be diverted through the generating stations and are therefore not actually lost to downstream purposes.

Aside from minor losses due to evaporation from the headponds, the only ability that these stations have to consume water such that it is not available for downstream purposes is through impounded storage. As a result of either physical or legal limitations the total storage volume of water that these stations can collectively remove amounts to 518 ha-m (hectare metres). This volume also accounts for a fourth station on the river that does not have a PTTW (and was therefore not included in the original 80.8%). The 518 ha-m is equivalent to an average monthly withdrawal of 1.9 m^3/s resulting in a percent water demand of 48% (also accounting for other demands within the subwatershed). These stations however operate within tighter "best practice" limits, which can result in a total storage volume of 155 ha.m. This volume is equivalent to an average monthly withdrawal of 0.6 m^3/s, a percent water demand of 21.6%, and a MODERATE stress level. Once the available storage has been used up, no further withdrawal can occur until additional water is released downstream.

In comparison, the percent water demand for losses to evaporation only was equivalent to a monthly flow of 0.21 m^3/s, which resulted in a percent water demand of 5.1% and a LOW stress (while still accounting for other demands in the subwatershed). The losses to evaporation represent a true consumptive demand. In comparison, water held in storage is potentially available while evaporative water is lost. The storage approach is the worst-case scenario as it assumes all four generating stations hold back water at the same time. The storage approach is conservative and results in a percent demand that is close to the LOW stress level (criteria is 20%). It can be concluded that the stress level for the Mississippi River At Galetta subwatershed can be reduced to LOW given that the evaporation of water from the head ponds represents the only true consumptive use. This approach was also taken by the Halton Region and Grand River Region.

A fifth generating station is located in the Mississippi River At High Falls subwatershed. The fifth station does not have a PTTW therefore its permitted demand was not included in the percent water demand calculations. The percent water demand for the affected subwatershed is low (1%). Therefore, the minimal demand from evaporation would not affect the stress level so no additional calculations were completed for this subwatershed.

Regarding the two non-permitted stations mentioned above, the Province stated that these stations may previously have been grandfathered however this would require that no modifications to the structure that increased the volume of water taken (held back by the dam or passed through the turbines) have been done since 1961. This provision will likely no longer exist once Section 34 of the Ontario Water Resources Act amendments that have passed the third reading is promulgated.

MODERATE Stress Levels (Surface Water)

The following three subwatersheds resulted in MODERATE stress levels (highest to lowest): Carp River At Kinburn (32.5%), Ottawa MVC (24.5%) and Fall River At Bennett Lake (22.5%). Consumptive demand for the PTTWs was calculated using the maximum daily takings multiplied by the consumptive factors (Table 16 in Appendix D of the Guidance). Permitted demands in these subwatersheds are described below.

The permitted demand in the Carp River At Kinburn subwatershed is from two permits for golf course irrigation and three permits for dewatering at pits and quarries. The consumptive factor for quarry operations was 0.25 and for irrigation was 0.7. Two of the quarry permits are valid every day all year long (i.e. no seasonal conditions).

The permitted demand in Ottawa MVC subwatershed is for a single golf course irrigation permit. The consumptive factor for irrigation was 0.7.

The permitted demand in Fall River At Bennett Lake subwatershed is for a single permit for commercial aquaculture. There are no seasonal conditions on this permit therefore it was applied each day all year. The consumptive factor for aquaculture was 0.1.

Without more information regarding any of the above takings, adjustments to the water demands (e.g. the actual water takings or the consumptive factor) were not possible.

Additional conservatism was built-in to the surface water stress calculations. Firstly, to estimate the amount of surface water supply for the percent demand calculations minimum streamflows were selected from two periods of record (1971-2000 and 1986-

2005) as described previously in Section 6.1. (Note that the average stream flow data from 1971-2000 was inadvertently used to define the water supply for Galetta instead of data from 1986-2005, which resulted in a higher flow. This means that the Galetta results are less conservative in comparison to the remaining subwatersheds). Secondly, where possible, the consumptive demand was applied to the month of the year that the minimum surface water supply occurred. This was only done if it did not break any rules for months that the PTTW is active (Section 3.1.4 of Appendix D of the Guidance) or any seasonal conditions on the permit itself. For example, a quarry in the Carp River Near Kinburn subwatershed has a permit for dewatering on 14 days of the year. In Section 3.1.4 of Appendix D of the Guidance, Table 15 says that dewatering permits can be active 12 months of the year. Instead of dividing the 14 days of water takings over 12 months of the year (1.2 water takings per month), a conservative assumption was made that all the dewatering occurs in a single month (12 water takings per month). Additionally, where possible, this month was selected as the same month that the minimum supply minus reserve occurred. For example, if the minimum supply minus reserve occurred in July, then the demand (takings) was applied in July thus maximum percent water demand. This was only done if seasonal conditions on the permit were met and the selected month was active according to Table 15 in Appendix D of the Guidance. In the above stressed subwatersheds, this second layer of conservatism only occurred for the example case noted here.

None of the surface water subwatersheds that resulted in a SIGNIFICANT or MODERATE stress contain a municipal surface water system. Therefore, depending on the requirements for a sensitivity analysis, no subwatersheds will move on to Tier 2 for surface water. If the sensitivity analysis changes the stress level of a subwatershed with a municipal drinking water system from LOW to MODERATE then Tier 2 is required. The requirements for a sensitivity analysis for surface water are discussed below.

As per Technical Rule (32 (c)), a subwatershed shall be assigned a surface water stress level of MODERATE, if the result of one or more maximum monthly percent water demand calculations is between 18% and 20% inclusive, and a sensitivity analysis of the data suggests that the stress level for the subwatershed could be MODERATE. In other words, a sensitivity analysis is required if percent water demand is within the 2% identified in the Technical Rules (e.g. 18 to 20% for surface water). If percent water demand is below this (e.g. 17.3%) a sensitivity analysis is not required (direction from the Province). The rationale for the sensitivity analysis is to ensure that those subwatersheds are captured that require further study.

Given the results of the percent water demand calculations, a sensitivity analysis is not required for the surface water stress assessment.

7.2 Groundwater Stress Assessment

Groundwater stress assessments were conducted on monthly and annual scales. The groundwater demand data was obtained from Section 5.7 and the supply and reserve data was obtained from Section 6.2.

The results of the percent water demand calculations were compared to the stress levels presented in Table 7.2-1, which were obtained from the Technical Rules. The stress levels apply to the current and future scenarios.

The results of the monthly demand calculations for all subwatersheds for the current demand scenario were all below 16% (Table 7.2-2), which is categorized as LOW stress by the Technical Rules. Similarly, the future demand results (adjusted municipal demands) were all below 16%, which is categorized as LOW by the Technical Rules. The percent demand results were all slightly higher for the subwatersheds with municipal systems. The results did not change for the remaining subwatersheds without municipal groundwater systems since the increase in demand was considered to be negligible.

The results for the annual percent water demand calculations showed all of the systems were below 10%, or LOW, except for the Rideau River At Ottawa subwatershed. The Rideau River At Ottawa subwatershed had an annual percent water demand value of 11.7%, which is assigned a MODERATE stress level. The Rideau River At Ottawa subwatershed does not contain a municipal groundwater system therefore it does not require a Tier 2 analysis.

The water demand in the Rideau River At Ottawa subwatershed is primarily from commercial PTTWs, including three for quarry operations and three permits for golf course irrigation. Consumptive demand for the PTTWs was calculated using the maximum daily takings multiplied by the consumptive factors (Table 15 in Appendix D of the Guidance). The consumptive factor for quarry operations was 0.25 and was 0.7 for irrigation. One quarry permit operator provided information regarding the actual takings, which was used in the analysis. Repeated enquiries were made into the actual takings at the golf courses but responses were not obtained. Without additional information regarding the takings, adjustments to the water demands (e.g. the actual takings or the consumptive factor) were not possible.

The calculation results for the future demand scenario produced the same results as the current demand scenario. Only the Rideau River At Ottawa subwatershed had an annual percent water demand value of 11.7%, which was assigned a MODERATE stress level. The remaining annual and all monthly future percent demand calculations were assigned LOW stresses.

The LOW stress category for the municipal groundwater systems for both the monthly and annual percent demand calculations indicates no subwatershed will be considered for a Tier 2 study based on the Tier 1 results.

7.3 Historical Performance of Municipal Water Systems

According to the Technical Rules, a subwatershed where a surface water intake or well has had historical problems meeting municipal water quantity will be assigned, as a minimum, a MODERATE stress level, regardless of the percent water demand calculations. This automatically triggers a Tier 2 assessment.

7.3.1 Surface Water

Technical Rule 32 (2) (b) reads as follows:

"A subwatershed shall be assigned a surface water stress level of MODERATE, if at any time after January 1, 1990, in relation to a type I, II or III system within the subwatershed:

(i) any part of a surface water intake was not below the water's surface during normal operation of the intake; or
(ii) the operation of a surface water intake pump was terminated because of an insufficient quantity of water being supplied to the intake."

There are unfortunately no long-term records of intake performance at the drinking water plants. Based on a review of available information, however, there are no indications of past surface water supply shortages at the municipal drinking water plants. All three municipal surface water intakes are located either downstream of major surface water reservoirs or along a river reach that benefits from low flow augmentation practices.

In the Town of Perth, a weir located approximately 2 metres downstream of the intake creates a pond that helps build enough head above the intake even in low flow conditions. Also, flow contributions from Bobs Lake upstream are seen as a safety against low flow conditions - whenever drier periods are encountered. The Town of Perth benefits from water released from that large reservoir to augment flows and water levels downstream along the Rideau Canal (personal communication: Mr. Grant Machan, Senior Superintendent of Environmental Services, Town of Perth). Furthermore, low flow conditions occurred during the fall of 2007 along the Tay River, when daily stream flow rates fell under 1.0 m^3/s. When such conditions occur, water supply for Omya Canada Inc. is switched from the river to the supply wells in order to allow a stream flow reserve in the river. The water supply in the Town of Perth was not impacted during that recent low flow period.

In the early 1930's, some years were very dry. Annual precipitation was 100 mm lower than the average (Mr. Bill Hogg, of Environment Canada). There's even an old account that the South Nation River, a river in the neighbouring South Nation Source Protection Region, ran dry in the early 1930's (personal communication, Dr. Ed Watt). This is confirmed by HYDAT stream flow data; mean monthly stream flow rates for the South Nation River near Plantagenet Springs (near the river outlet) were indeed recorded as 0 m^3/s from September 1930-February 1931. How were flow conditions in the Mississippi-Rideau Source Protection Region during that dry period? From the Mississippi River gauge at Appleton WSC gauge (02KF006), which has been in operation since October 1918, it is seen that for the period of October 1930 to February 1931, the river was flowing with average monthly stream flows varying between 5.6 and 10.0 m^3/s. While these flow rates are well below the average monthly stream flow rates for these months; it is interesting to note that the river was still flowing even in an abnormally dry year. Low flow augmentation in the Mississippi River (using water stored in the upper lake reservoirs) is certainly one reason for maintaining flow rates even in stressed conditions. Indeed, the current Mississippi River Water Management Plan requires a minimum flow rate objective of 5 m^3/s be maintained in the main reach of the Mississippi River (from Crotch Lake to the outlet) throughout the year. It should be noted that although this operational policy has been in place for approximately 20 to 25 years stream flow rates nevertheless fell below the 5 m^3/s limit in some months on the following dates: August 1999 (3.5 m^3/s), August 2001 (3.8 m^3/s), and October 2002 (4.8 m^3/s).

There is no HYDAT data available within the Rideau watershed for 1930 and 1931 unfortunately, but given the similarity between the Mississippi and Rideau river systems, the same resilience to drought conditions would also apply to the Rideau River main stem. The principal flow control point along the Rideau River is at the Poonamalie locks, which are located upstream of the Town of Smiths Falls. During hot, dry summer periods, discharges at Poonamalie are regulated to essentially satisfy navigation depths along the canal route and to meet evaporation losses in the downstream part of the system. The minimum desirable discharge at Poonamalie was 8.5 m^3/s during the summer and 5.7 m^3/s during the fall (Acres, 1994).

Municipal Survey Results

In 2009, a survey issued to operators of all of the municipal systems (Appendix E) confirmed that NONE of the surface water systems (Carleton Place, Perth or Smiths Falls) have reported either of the following criteria since January 1, 1990:

(i) any part of a surface water intake was not below the water's surface during normal operation of the intake; or

(ii) the operation of a surface water intake pump was terminated because of an insufficient quantity of water being supplied to the intake

Therefore, historical performance issues have NOT been identified with the municipal surface water systems in the SPR.

7.3.2 Groundwater

The survey to each of the municipal drinking water system operators indicated that NONE of the groundwater systems (Almonte, Carp, Kemptville, Kings Park, Merrickville, Munster, or Westport) have reported either of the following criteria since January 1, 1990 (Technical Rule 33 (2) (c)):

(a) the groundwater level in the vicinity of the well was not at a level sufficient for the normal operation of the well; or

(b) the operation of a well pump was terminated because of an insufficient quantity of water being supplied to the well.

Therefore, historical performance issues have NOT been identified with the municipal groundwater systems in the SPR.

7.4 Subwatershed Stress Levels and Tier 2 Requirements

Subwatershed stress levels were assessed based on the stress level results from the percent demand calculations and the reported historical issues (municipal surveys).

No historical issues at the municipal systems were reported (Municipal Survey 2009).

Percent water demand calculations that resulted in MODERATE and SIGNIFICANT stress levels for surface water or groundwater do not contain municipal systems for surface water or groundwater respectively therefore they do not require a Tier 2 analysis.

Although the percent water demand calculations for groundwater did not indicate that the groundwater supplies were stressed in the Carp River Near Kinburn subwatershed and Mississippi River At Galetta subwatershed, the percent water demand calculations for the surface water supplies showed that surface water supplies were stressed in these two subwatersheds (The stress level for Galetta has been reduced to LOW as described in Section 7.1).

Previous hydrologic studies showed the water entering the wells at these two municipal supplies (Carp system for the Carp River Near Kinburn subwatershed and the Almonte system in Mississippi River At Galetta subwatershed) is not directly connected to surface water (Oliver, Mangione, McCalla & Associates, 2001; R.V. Anderson Associates Ltd., 2001). Additionally, well head protection studies did not identify surface water recharging groundwater in the vicinity of these wells (Carp - Dillon Consulting Ltd., 2004; Almonte - Intera Engineering, 2003). These studies do not preclude some surface water supply to the groundwater systems, but they do suggest the amount of surface water that recharges the groundwater flow system is small. Therefore, the potential surface water stress identified by the percent water demand in the Kinburn and Galetta subwatersheds does not likely have a significant effect on the groundwater supply in these two subwatersheds.

The percent water demand for the Mississippi River At Galetta subwatershed initially had a SIGNIFICANT stress level, which was reduced to a LOW stress given reasons described in Section 7.1.

This leaves four of the subwatersheds with MODERATE stress levels (three are for surface water and one is for groundwater).

A summary of the surface water and groundwater stress assessments for Tier 1 and requirements for Tier 2 are given in Table 7.4-1 for each subwatershed. Final subwatershed stress levels are given on Figure 7.4-1 for surface water and Figure 7.4-2 for groundwater.

None of the subwatersheds will require Tier 2 analysis.

8.0 Uncertainty

8.1 Surface Water

For the surface water stress assessment, the surface water supply data (where available) is more accurate compared to the consumptive demand estimates.

For the surface water supplies, the largest uncertainty pertains to the ungauged subwatersheds and where large data gaps had to be filled for gauged subwatersheds as described in Section 3.1.1.

Surface water supply for the Mississippi River At Galetta subwatershed was estimated by pro-rating to gauges on the Indian River and Carp River and adding them to the flows measured at the gauges on the Mississippi River At Appleton and the Indian River Near Blakeney. This is reasonable considering the topography, land cover and lack of regulation downstream of Appleton. The measured flows provide reasonable approximations. The estimated flows have a higher error than the measured flows.

Surface water supply for the Tay River At Perth subwatershed was more estimated than measured (Appendix A). A validation of the method using measured flow rates at Omya Canada Inc. for the year 2004 and 2005 showed that estimated long-term summer stream flows would tend to be either equal or slightly underestimated when compared to actual conditions.

Surface water supply for the ungauged Ottawa RVCA West and East subwatersheds were estimated with a higher degree of uncertainty as they were pro-rated to a Toronto gauge (Black Creek). This was done to account for the impervious cover. The gauge data was also a very strong record compared to gauges in neighbouring regions. Flow estimates were adjusted for precipitation differences between Ottawa and Toronto. There is still a greater degree of uncertainty in these estimates compared to measured values. However using the Toronto gauges may be more accurate than pro-rating to a local gauge with no impervious cover (or limited data) as impervious cover is a major factor in determining runoff. The stream flow estimating technqiue is described in Appendix A.

Actual amounts for water reserves are unknown. Water reserve was estimated using the 10^{th} percentile for the surface water stress assessment. This estimate appears adequate when compared with known flow rate restrictions used in the SPR. For example, the lowest reserve amount in Mississippi River At Appleton subwatershed is 5.0 m^3/s for the month of August. This flow rate corresponds to the minimum flow rate objective along the Mississippi River (Mississippi River Water Management Plan). For the Tay River at Perth subwatershed, the lowest monthly reserve is 1.2 m^3/s for November. This value is higher than the 1.0 m^3/s cut-off rate that Omya Canada Inc. is respecting.

The minimum value of supply minus reserve ($Q_{P50} - Q_{P90}$) was selected from two time periods (1986-2005 and 1971-2000) for conservatism (although the conservatism may be somewhat negated by adding in the consumptive demand to the supply term in the denominator of the percent demand equation). Both time periods are reasonable for approximating current flow regimes.
Municipal water takings (and Omya Canada Inc.) represent accurate data. For all other PTTW, the maximum daily takings were used to estimate consumptive demand. This is likely an overestimation of consumptive demand.

There is also uncertainty with the agricultural water use however the values were so small that it's likely negligible or within the range of error.

Future water demand is uncertain. However, high population projections were used in determining the future municipal demand for Perth and Smiths Falls.

The potential overestimation of consumptive demand likely resulted in conservatively large results for the percent water demand calculations. This increases the confidence that the subwatersheds with the municipal systems that were identified as LOW stress are not experiencing water quantity issues.

8.2 Groundwater

The municipal groundwater takings are considered to be accurate. The uncertainty associated with estimating a daily consumption rate for private wells (200 L/person/d, Section 5.4) is likely small, assuming variation in household use is distributed normally across each subwatershed.

Similarly, some uncertainty is expected in the distribution of agricultural takings. Agricultural takings were assumed to be evenly distributed across each census area (Section 5.3), but takings occur at point sources. It is possible that the even distribution of agricultural takings leads to underestimation of takings in isolated areas, which could impact stress assessments in individual subwatersheds. But this uncertainty is considered small, due to the relatively small consumptive demands for agricultural takings (Table 5.6-1) compared to municipal and PTTW demand.

The primary sources of uncertainty for the groundwater stress assessment were in the estimation of PTTW demand and the estimation of groundwater recharge. The PTTW database lists the maximum permitted takings for PTTWs, although some permit holders may not take the maximum permitted water volume. Also, in the case of permits that take water from both the surface water and groundwater, no division is made for the surface water or groundwater taking. For example, an irrigation pond that collects the majority of water from snowmelt runoff may use little groundwater. But without specific information regarding the quantity of water actually taken, the maximum taking is distributed in the irrigation season (June to September), despite the potential for very little groundwater to be consumed.

Data on actual PTTW takings was obtained for a small number of permits. A comparison of the actual takings versus the maximum takings showed the actual takings were substantially less, in some cases the actual takings were less than 10% of the maximum takings listed in the PTTW database. Using the maximum taking data likely over-estimates groundwater demand in some cases.

Groundwater recharge is difficult to determine due to geological heterogeneity, plant life cycles and timing of precipitation/melt events. This report used a simplified estimate of groundwater recharge based on surficial geology, slope and land cover (MOEE, 1995). This approach was the best method available considering the regional scale of the water balance and the limited data available at the time of this study. The comparison of this approach to a baseflow approach showed the MOEE (1995) method produced a conservatively low estimate of groundwater recharge (Section 3.1.3).

Additionally, lateral groundwater flow into the subwatersheds was considered to be negligible. The combination of small values for groundwater recharge and no lateral groundwater flow resulted in a relatively small estimate of groundwater supply.

The percent water demand calculations used conservatively large estimates of groundwater demand, primarily due to overestimated takings from PTTWs, and conservatively low estimates groundwater supply. These estimates produced conservatively high percent water demand calculation results. The percent water demand calculations resulted in only one subwatershed, Rideau at Ottawa with a MODERATE stress. Considering the significant groundwater takings for irrigation and commercial PTTWs in this subwatershed, it is not surprising that groundwater in this subwatershed is identified as moderately stressed. The conservatively high percent water demand results increase the confidence of the low stress assignments results for the remaining subwatersheds. Therefore, all other subwatersheds (except for Rideau At Ottawa) should be considered low stress.

The percent water demand calculations were performed at a subwatershed scale that was based on surface topography, which may not be an appropriate spatial scale for groundwater. Delineating groundwater "subwatersheds" in the SPR would be a difficult task given the complex geology and fairly extensive bedrock faulting in the SPR (Conceptual Water Budget).

Groundwater stress may exist at a smaller scale in the areas of large takings and groundwater conditions in the areas around large takings should be monitored closely. Should further information become available the stress calculations will need to be performed again. Also, significant changes in any of the data used to calculate groundwater demand and supply may result in changes to the percent water demand calculation results.

9.0 Conclusions and Recommendations

Based on methodologies and results presented in this report, a Tier 2 study is NOT required for the Mississippi-Rideau SPR.

Tier 1 results can only be applied on a monthly, subwatershed scale. The subwatershed scale will mask local impacts on surface water and groundwater supplies. The monthly scale will hide any impacts that may occur on a weekly or daily scale.

Regulation of river and lakes by water management structures helps to maintain surface water supply and thus control drinking water stresses. Current stress levels assume that regulation regimes will remain unchanged. Changes in the regulatory regime are not recommended without consideration for the effects on subwatershed stress levels.

In order to reduce the uncertainty of subsequent related studies, it is recommended that the following be considered:

- Actual water takings data is recommended for all percent demand calculations. The Province is currently collecting this information for all permitted users. When this information becomes available, it is recommended that the stress calculations be updated.

- Flow monitoring on the Mississippi River downstream of Appleton is recommended. Should further information in this area become available, it is recommended that the stress calculations be performed again.

Groundwater recharge estimates were calculated and compared to a second calculation method (baseflow). Groundwater recharge was not compared to field measured values, therefore, it is difficult to determine the uncertainty in the calculations. Future field work designed to specifically examine groundwater recharge in the SPR would improve the understanding of how water flows through the SPR.

Studies designed to examine how the Nepean Aquifer is recharged would improve the understanding of recharge to this regionally significant aquifer.

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Table 2.1-1 Municipal Drinking Water Systems in the Mississippi-Rideau Source Protection Region

Type of System		Watershed	Name	Source of Water
Surface Water	Inter-Provincial	Rideau	Britannia	Ottawa River[1]
			Lemieux	
	Inland River	Mississippi	Carleton Place	Mississippi River
		Rideau	Smiths Falls	Rideau River
			Perth	Tay River
Ground Water		Mississippi	Carp	Sand & gravel esker
			Almonte	Nepean aquifer
		Rideau	Kings Park[2]	
			Munster Hamlet	
			Kemptville	
			Merrickville	
			Westport	

[1]As outlined in Technical Rule #4 (*Clean Water Act, 2006*), water budgets completed will not include any part of a surface water body that is a Great Lake, a connecting channel, Lake Simcoe, Lake Nipissing, Lake St. Clair or the Ottawa River. Water budgets and stress levels must be completed for subwatersheds within the SPR that discharge to the Ottawa River (Inland Rivers). However, the water taken from the Ottawa River (Britannia & Lemieux) should be omitted from the demand portion (Direction from MNR to MRSPR, February 17, 2009).

[2]Kings Park is a subdivision in the Village of Richmond that is serviced by a municipal well.

Table 2.2-1 Drainage areas for MVC and RCVA Subwatersheds (Individual, Cumulative)

Subwatershed	Individual	Cumulative[1]	
	Area (km²)	Area (km²)	Upstream Subwatersheds
Mississippi River Below Marble Lake	359	359	-[2]
Mississippi River At High Falls	874	1,234	Mississippi River Below Marble Lake
Clyde River Near Lanark	617	617	-
Fall River At Bennett Lake	281	281	-
Mississippi River At Fergusons Falls	532	2,664	Mississippi River At High Falls (Cumulative) + Fall River At Bennett Lake + Clyde River Near Lanark
Mississippi River At Appleton	272	2,936	Mississippi River At Fergusons Falls (Cumulative)
Indian River Near Blakeney	212	212	-
Mississippi River At Galetta	588	3,736	Mississippi River At Appleton (Cumulative) + Indian River Near Blakeney
Mississippi River (Outlet)	29	3,765	Mississippi River At Galetta (Cumulative)
Carp River At Kinburn	255	255	-
Carp River (Outlet)	48	303	Carp River At Kinburn
Ottawa MVC	283	283	-
Tay River at Perth	676	676	-
Rideau River Above Smiths Falls	572	1,248	Tay River at Perth
Rideau River Below Merrickville	715	1,963	Rideau River Above Smiths Falls (Cumulative)
Kemptville Creek at Kemptville	413	413	-
Rideau River Below Manotick	764	3,140	Rideau R. Below Merrickville (Cumulative) + Kemptville Creek Near Kemptville
Jock River Near Richmond	524	524	-
Rideau River At Ottawa	143	3,808	Rideau River Below Manotick (Cumulative) + Jock River Near Richmond
Rideau River (Outlet)	43	3,851	Rideau River At Ottawa (Cumulative)
Ottawa RVCA (West)	120	120	-
Ottawa RVCA (East)	263	263	-

[1]Cumulative Area (Total Drainage Area) = Individual Area + Upstream Subwatersheds

[2]Headwater subwatershed has no subwatershed upstream (individual area = cumulative area)

Table 3.3-1 Long-term, Annual Water Budgets for MVC and RVCA Subwatersheds

Subwatershed (from upstream to downstream)	Water Budget Component				
	Gauge ID	P[1]	AET[2]	SW_{OUT}[3]	ΔS + Residual[4]
MISSISSIPPI VALLEY CONSERVATION					
Mississippi River Below Marble Lake	02KF016	919	540	420	-41
Mississippi River At High Falls	High Falls G.S.	925	543	359	23
Clyde River Near Lanark	02KF010	889	549	357	-17
Fall River At Bennett Lake	02KF014/18	900	561	383	-44
Mississippi River At Fergusons Falls	02KF001	905	550	375	-20
Mississippi River At Appleton	02KF006	904	552	358	-6
Indian River At Blakeney	02KF012	876	560	330	-15
Mississippi River At Galetta	ungauged	898	555	331	12
Mississippi River (Outlet)	ungauged	898	555	331	12
Carp River At Kinburn	02KF011	902	571	326	5
Carp River (Outlet)	ungauged	896	571	344	-19
Ottawa MVC	ungauged	884	573	344	-33
RIDEAU VALLEY CONSERVATION AUTHORITY					
Tay River at Perth	02LA024	906	567	355	-16
Rideau River Above Smiths Falls	02LA005	909	570	383	-44
Rideau River Below Merrickville	02LA011	914	574	375	-35
Kemptville Creek At Kemptville	02LA006	949	586	383	-20
Rideau River Below Manotick	02LA012	925	576	368	-19
Jock River Near Richmond	02LA007	917	575	386	-44
Rideau River At Ottawa	02LA004	924	576	367	-19
Rideau River (Outlet)	ungauged	924	575	367	-18
Ottawa RVCA (West)	ungauged	916	544	477	-105
Ottawa RVCA (East)	ungauged	941	560	409	-28

[1] Precipitation
[2] Actual Evapotranspiration
[3] Surface water out (streamflow)
[4] Delta storage plus residual

Table 3.4-1 Long-term Monthly Water Budgets for MVC Subwatersheds

Water Budget Component [1]	Equivalent Water Depth (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mississippi Rive Below Marble Lake (Station 02KF016)													
Precipitation	79	53	73	69	75	86	77	82	90	77	83	75	919
Evapotranspiration (Actual)	0	0	0	25	75	109	123	106	70	31	1	0	540
Surface Water (out)	37	31	39	86	58	22	14	8	9	18	42	57	420
Delta Storage + Residual	42	22	34	-42	-58	-46	-60	-31	12	27	40	18	-41
Missisippi River At High Falls (OPG Generating Station)													
Precipitation	85	53	75	68	74	85	78	79	90	74	86	76	925
Evapotranspiration (Actual)	0	0	0	25	75	110	123	106	70	32	1	0	544
Surface Water (out)[2]	39	35	42	55	45	18	17	17	17	16	25	35	359
Delta Storage + Residual	46	19	34	-11	-45	-43	-63	-44	3	26	60	41	22
Clyde River Near Lanark (Station 02KF010)													
Precipitation	74	53	70	68	75	81	78	79	86	73	77	75	889
Evapotranspiration (Actual)	0	0	0	26	76	111	125	107	70	32	1	0	549
Surface Water (out)	23	19	46	126	59	19	8	5	3	8	16	24	357
Delta Storage + Residual	51	34	24	-84	-60	-49	-55	-34	12	33	60	51	-16
Fall River At Bennett Lake (Station 02KF014)													
Precipitation	76	55	71	70	75	78	74	77	89	74	81	79	900
Evapotranspiration (Actual)	0	0	0	27	76	112	126	109	72	34	4	0	561
Surface Water (out)	33	32	58	109	61	23	10	6	5	5	13	29	383
Delta Storage + Residual	43	23	13	-66	-62	-57	-63	-37	12	35	64	50	-44
Mississippi River At Fergusons Falls (Station 02KF001)													
Precipitation	78	54	72	69	75	82	77	79	88	74	81	77	905
Evapotranspiration (Actual)	0	0	0	26	76	111	125	107	71	33	2	0	550
Surface Water (out)	33	30	49	90	56	21	12	11	11	12	20	31	375
Delta Storage + Residual	45	24	23	-47	-57	-50	-59	-40	7	30	59	46	-20
Mississippi River At Appleton (Station 02KF006)													
Precipitation	77	54	72	69	75	81	77	79	88	74	81	77	904
Evapotranspiration (Actual)	0	0	0	26	76	111	125	107	71	33	2	0	552
Streamflow (out)	31	28	47	89	56	20	10	10	9	11	18	29	358
Delta Storage + Residual	46	26	24	-46	-57	-50	-58	-38	8	30	60	48	-6
Indian River Near Blakeney (Station 02KF012)													
Precipitation	67	54	67	68	75	78	78	80	84	75	73	76	876
Evapotranspiration (Actual)	0	0	0	28	77	113	128	108	71	33	2	0	560
Surface Water (out)	20	17	46	115	49	15	9	6	6	11	15	21	330
Delta Storage + Residual	47	37	22	-75	-51	-50	-58	-34	6	32	56	55	-15
Mississippi River At Galetta (ungauged)													
Precipitation	75	54	71	68	75	80	78	79	87	75	79	77	898
Evapotranspiration (Actual)	0	0	0	27	76	112	126	108	71	33	2	0	555

Water Budget Component [1]	Equivalent Water Depth (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Surface Water (out)[3]	26	24	46	89	50	17	9	9	8	10	17	25	331
Delta Storage + Residual	48	30	25	-47	-52	-49	-58	-37	8	32	60	51	12
Mississippi River Outlet (ungauged)													
Precipitation	75	54	71	68	75	80	78	79	87	75	79	77	898
Evapotranspiration (Actual)	0	0	0	27	76	112	126	108	71	33	2	0	555
Surface Water (out)[3]	26	24	46	89	50	17	9	8	8	10	17	25	331
Delta Storage + Residual	48	30	25	-47	-52	-49	-58	-37	8	32	60	51	11
Carp River Near Kinburn (Station 02KF011)													
Precipitation	68	56	70	68	77	80	82	84	84	78	75	79	902
Evapotranspiration (Actual)	0	0	0	29	78	114	130	111	72	33	3	0	571
Surface Water (out)	12	11	69	126	34	11	6	6	4	10	18	19	326
Delta Storage + Residual	56	45	1	-87	-36	-45	-53	-33	8	35	54	60	4
Carp River Outlet (ungauged)													
Precipitation	68	56	70	68	76	78	82	84	83	78	75	78	896
Evapotranspiration (Actual)	0	0	0	29	79	114	130	111	72	33	3	0	571
Surface Water (out)[4]	13	11	72	133	36	12	6	7	4	11	19	20	344
Delta Storage + Residual	55	44	-3	-95	-38	-48	-54	-34	7	34	52	59	-19
Ottawa MVC (ungauged)													
Precipitation	68	55	69	68	76	68	82	85	82	79	75	78	884
Evapotranspiration (Actual)	0	0	0	30	79	115	130	111	72	33	3	0	573
Surace Water (out)[4]	13	11	72	133	36	12	6	7	4	11	19	20	344
Delta Storage + Residual	55	44	-3	-95	-38	-59	-54	-34	6	35	52	58	-33

1. Refer to Section 3.4 for a description of estimation methods.
2. Surface water flows for Mississippi River At High Falls were obtained from the OPG generation station.
3. Flows for Missisippi River At Galetta was estimated by taking flows from the Appleton and Blakeney gauges and adding average pro-rated flows to Carp River Near Kinburn and Indian River Near Blakeney gauges
4. Flows at Carp River (Outlet) and Ottawa MVC were estimated by pro-rating to Carp River At Kinburn (02KF011).

Table 3.4-2 Long-term Monthly Water Budgets for RVCA Subwatersheds

Water Budget Component [1]	Equivalent Water Depth (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Tay River At Perth (Station 02LA024)													
Precipitation	74	57	71	72	76	77	73	78	90	76	82	81	906
Evapotranspiration (Actual)	0	0	0	28	76	112	128	110	73	34	5	0	567
Surface water (out)	33	24	31	80	49	25	16	17	18	17	18	28	355
Δ Storage + Residual	42	33	40	-36	-50	-60	-71	-48	-2	24	59	53	-17
Rideau River Above Smiths Falls (Station 02LA005)													
Precipitation	73	57	70	72	76	76	74	79	90	77	82	82	909
Evapotranspiration (Actual)	0	0	0	29	77	113	129	110	73	35	5	0	570
Surface water (out)	32	28	36	67	43	25	23	22	26	28	23	29	383
Δ Storage + Residual	41	29	34	-24	-44	-62	-78	-53	-9	15	53	52	-45
Rideau River Below Merrickville (Station 02LA011)													
Precipitation	73	58	71	72	76	76	76	81	91	77	81	82	914
Evapotranspiration (Actual)	0	0	0	29	77	113	129	111	73	35	6	0	574
Surface water (out)	34	28	54	84	37	17	13	12	16	23	26	32	375
Δ Storage + Residual	39	30	17	-42	-38	-54	-66	-42	2	20	49	50	-35
Kemptville Creek Near Kemptville (02LA006)													
Precipitation	73	59	73	74	78	78	85	85	96	79	83	85	949
Evapotranspiration (Actual)	0	0	0	31	78	114	131	112	74	35	11	0	586
Surface water (out)	25	24	81	127	34	10	5	5	5	11	25	32	383
Δ Storage + Residual	49	35	-8	-84	-34	-46	-51	-32	18	33	47	53	-21
Rideau River Below Manotick (Station 02LA012)													
Precipitation	72	58	72	72	77	77	80	82	92	78	81	83	925
Evapotranspiration (Actual)	0	0	0	30	78	113	130	111	73	35	7	0	576
Surface water (out)	29	25	63	97	34	14	8	8	11	18	27	33	368
Δ Storage + Residual	43	33	9	-54	-34	-50	-58	-37	8	25	47	49	-20
Jock River Near Richmond (Station 02LA007)													
Precipitation	70	57	72	70	77	79	84	83	88	78	77	81	917
Evapotranspiration (Actual)	0	0	0	30	78	114	130	112	73	34	4	0	575
Surface water (out)	20	18	75	144	36	12	7	6	6	13	23	26	387
Δ Storage + Residual	50	39	-4	-103	-37	-46	-54	-34	9	31	49	55	-44

Water Budget Component [1]	Equivalent Water Depth (mm)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Rideau River At Ottawa (Station 02LA004)													
Precipitation	72	58	72	72	77	78	81	82	91	78	80	83	924
Evapotranspiration (Actual)	0	0	0	30	78	113	130	111	73	34	6	0	576
Surface water (out)	27	25	64	102	34	14	9	8	10	18	25	31	367
Δ Storage + Residual	45	33	8	-60	-34	-49	-58	-37	8	25	49	52	-18
Rideau River Outlet (ungauged)													
Precipitation	72	58	72	72	77	78	81	82	91	78	80	83	924
Evapotranspiration (Actual)	0	0	0	30	78	113	130	111	73	34	6	0	575
Surface water (out)	27	25	64	102	34	14	9	8	10	18	25	31	367
Δ Storage + Residual	45	33	8	-60	-34	-50	-58	-37	8	25	49	52	-17
Ottawa RVCA West (ungauged)													
Precipitation	70	57	72	70	78	70	86	86	87	80	77	82	916
Evapotranspiration (Actual)	0	0	0	29	79	114	115	97	72	33	4	0	544
Surface water (out)	22	21	67	103	48	37	32	32	30	32	26	26	477
Δ Storage + Residual	48	36	5	-62	-49	-81	-61	-43	-15	15	47	56	-105
Ottawa RVCA East (ungauged)													
Precipitation	71	59	72	72	80	72	88	91	90	82	80	83	941
Evapotranspiration (Actual)	0	0	0	29	79	113	125	106	71	33	4	0	560
Surface water (out)	17	16	70	119	42	24	19	19	17	21	23	23	409
Δ Storage + Residual	54	43	2	-75	-41	-65	-56	-35	2	29	54	61	-27

1. Refer to Section 3.4 for a description of estimation methods.
2. Flows for Rideau River (Outlet) were estimated by pro-rating to the gauge at Ottawa (02LA004).
3. Flows for Ottawa RVCA West/East were estimated by pro-rating to Black Creek gauge in Toronto.
Black Creek has a higher degree of imperviousness than other M-R subwatersheds and a contiuous record.
Flows were multiplied by the ratio of average annual precipitation between Ottawa and Toronto (1971-2000) to account for precipitation differences between the gauges. See Appendix A for further details.

Table 5.6-1 Consumptive Demand for Surface Water within MVC and RVCA Subwatersheds

Subwatershed	Surface Water - Consumptive Demand ($m^3/s \times 1,000$)[1]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MISSISSIPPI VALLEY CONSERVATION												
Mississippi River Below Marble Lake												
PTTW	0.625	0.625	0.625	0.625	0.909	0.909	0.909	0.909	0.909	0.909	0.625	0.625
Agriculture	0.801	0.801	0.801	0.801	0.801	0.801	3.967	3.967	0.801	0.801	0.801	0.801
Total - Current	1.426	1.426	1.426	1.426	1.711	1.711	4.877	4.877	1.711	1.711	1.426	1.426
Total - Future	1.426	1.426	1.426	1.426	1.711	1.711	4.877	4.877	1.711	1.711	1.426	1.426
Mississippi River At High Falls												
PTTW	5.440	5.440	5.440	5.440	5.440	5.440	5.440	5.440	5.440	5.440	5.440	5.440
Agriculture	0.996	0.996	0.996	0.996	0.996	0.996	4.905	4.905	0.996	0.996	0.996	0.996
Total - Current	6.435	6.435	6.435	6.435	6.435	6.435	10.345	10.345	6.435	6.435	6.435	6.435
Total - Future	6.435	6.435	6.435	6.435	6.435	6.435	10.345	10.345	6.435	6.435	6.435	6.435
Clyde River At Lanark												
PTTW	15.046	15.046	15.046	15.046	15.046	15.046	15.046	19.803	15.046	15.046	15.046	15.046
Agriculture	0.462	0.462	0.462	0.462	0.462	0.462	4.451	4.451	0.462	0.462	0.462	0.462
Total - Current	15.509	15.509	15.509	15.509	15.509	15.509	19.498	24.254	15.509	15.509	15.509	15.509
Total - Future	15.509	15.509	15.509	15.509	15.509	15.509	19.498	24.254	15.509	15.509	15.509	15.509
Fall River At Bennett Lake												
PTTW	17.500	17.500	17.500	17.500	17.500	17.500	17.500	17.500	17.500	17.500	17.500	17.500
Agriculture	0.308	0.308	0.308	0.308	0.308	0.308	0.447	0.447	0.308	0.308	0.308	0.308
Total - Current	17.808	17.808	17.808	17.808	17.808	17.808	17.947	17.947	17.808	17.808	17.808	17.808
Total - Future	17.808	17.808	17.808	17.808	17.808	17.808	17.947	17.947	17.808	17.808	17.808	17.808
Mississippi River At Fergusons Falls												

[1] Equivalent to Litres per Second (L/s)

Subwatershed	Surface Water - Consumptive Demand (m^3/s x 1,000)[1]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PTTW	25.240	25.240	25.240	25.882	26.487	27.234	30.161	32.704	33.752	25.882	25.240	25.240
Agriculture	0.889	0.889	0.889	0.889	0.889	0.889	3.779	3.779	0.889	0.889	0.889	0.889
Total - Current	26.129	26.129	26.129	26.771	27.376	28.123	33.940	36.483	34.641	26.771	26.129	26.129
Total - Future	26.129	26.129	26.129	26.771	27.376	28.123	33.940	36.483	34.641	26.771	26.129	26.129
Mississippi River At Appleton												
Municipal - Current	15.020	14.777	14.164	14.617	14.186	15.134	16.826	15.653	14.417	14.121	14.390	14.835
Municipal - Future	22.453	22.088	21.172	21.849	21.206	22.622	25.151	23.398	21.550	21.108	21.510	22.175
PTTW	-	-	-	-	13.078	17.575	17.575	17.575	13.078	-	-	-
Agriculture	0.654	0.654	0.654	0.654	0.654	0.654	3.371	3.371	0.654	0.654	0.654	0.654
Total - Current	15.675	15.431	14.818	15.271	27.918	33.363	37.772	36.599	28.148	14.775	15.044	15.489
Total - Future	23.107	22.743	21.826	22.503	34.937	40.851	46.097	44.344	35.282	21.762	22.164	22.830
Indian River Near Blakeney												
PTTW	-	-	10.198	10.198	10.198	10.198	10.198	10.198	10.198	10.198	10.198	-
Agriculture	0.471	0.471	0.471	0.471	0.471	0.471	2.740	2.740	0.471	0.471	0.471	0.471
Total - Current	0.471	0.471	10.669	10.669	10.669	10.669	12.938	12.938	10.669	10.669	10.669	0.471
Total - Future	0.471	0.471	10.669	10.669	10.669	10.669	12.938	12.938	10.669	10.669	10.669	0.471
Mississippi River At Galetta												
PTTW	8,884.56	8,867.19	8,849.82	8,849.82	8,849.82	8,849.82	8,851.46	8,851.46	8,849.82	8,849.82	8,849.82	8,867.19
Agriculture	1.320	1.320	1.320	1.320	1.320	1.320	6.545	6.545	1.320	1.320	1.320	1.320
Total - Current	8,885.88	8,868.51	8,851.14	8,851.14	8,851.14	8,851.14	8,858.00	8,858.00	8,851.14	8,851.14	8,851.14	8,868.51
Total - Future	8,885.88	8,868.51	8,851.14	8,851.14	8,851.14	8,851.14	8,858.00	8,858.00	8,851.14	8,851.14	8,851.14	8,868.51
Mississippi River (Outlet)												
Agriculture	0.151	0.151	0.151	0.151	0.151	0.151	1.244	1.244	0.151	0.151	0.151	0.151
Total - Current	0.151	0.151	0.151	0.151	0.151	0.151	1.244	1.244	0.151	0.151	0.151	0.151
Total - Future	0.151	0.151	0.151	0.151	0.151	0.151	1.244	1.244	0.151	0.151	0.151	0.151

Subwatershed	Surface Water - Consumptive Demand (m^3/s x 1,000)[1]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Carp River Near Kinburn												
PTTW	20.031	20.031	20.031	21.596	32.316	32.316	34.425	32.316	32.316	21.596	20.031	20.031
Agriculture	1.498	1.498	1.498	1.498	1.498	1.498	12.791	12.791	1.498	1.498	1.498	1.498
Total - Current	21.528	21.528	21.528	23.094	33.813	33.813	47.216	45.106	33.813	23.094	21.528	21.528
Total - Future	21.528	21.528	21.528	23.094	33.813	33.813	47.216	45.106	33.813	23.094	21.528	21.528
Carp River (Outlet)												
Agriculture	0.283	0.283	0.283	0.283	0.283	0.283	2.418	2.418	0.283	0.283	0.283	0.283
Total - Current	0.283	0.283	0.283	0.283	0.283	0.283	2.418	2.418	0.283	0.283	0.283	0.283
Total - Future	0.283	0.283	0.283	0.283	0.283	0.283	2.418	2.418	0.283	0.283	0.283	0.283
Ottawa MVC												
PTTW	-	-	-	-	-	23.325	23.325	23.325	23.325	-	-	-
Agriculture	1.647	1.647	1.647	1.647	1.647	1.647	14.061	14.061	1.647	1.647	1.647	1.647
Total - Current	1.647	1.647	1.647	1.647	1.647	24.972	37.387	37.387	24.972	1.647	1.647	1.647
RIDEAU VALLEY CONSERVATION AUTHORITY												
Tay River At Perth												
Municipal - Current	10.589	11.017	10.909	10.453	11.132	11.446	12.745	13.388	12.754	11.68	10.66	10.288
Municipal - Future	19.663	20.458	20.256	19.411	20.672	21.253	23.667	24.859	23.683	21.689	19.794	19.104
PTTW	3.7649	4.4578	3.7588	4.3451	5.0095	8.9904	9.8259	8.7532	9.0587	4.9563	3.2014	2.8816
Agriculture	1.419	1.419	1.419	1.419	1.419	1.419	1.6855	1.6855	1.419	1.419	1.419	1.419
Total - Current	15.773	16.894	16.087	16.217	17.561	21.855	24.257	23.826	23.232	18.055	15.28	14.589
Total - Future	24.847	26.334	25.434	25.175	27.1	31.663	35.178	35.298	34.161	28.064	24.415	23.404
Rideau River Above Smiths Falls												
PTTW	-	-	-	-	-	1.199	1.199	1.199	1.199	-	-	-
Agriculture	1.860	1.860	1.860	1.860	1.860	1.860	2.197	2.197	1.860	1.860	1.860	1.860
Total - Current	1.860	1.860	1.860	1.860	1.860	3.058	3.396	3.396	3.058	1.860	1.860	1.860

Subwatershed	Surface Water - Consumptive Demand (m^3/s x 1,000)[1]											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Total - Future	1.860	1.860	1.860	1.860	1.860	3.058	3.396	3.396	3.058	1.860	1.860	1.860
Rideau River Below Merrickville												
Municipal - Current	21.678	22.778	23.185	21.108	21.415	21.704	22.407	22.905	22.067	20.534	20.296	20.416
Municipal - Future	29.629	31.132	31.689	28.850	29.269	29.665	30.626	31.306	30.161	28.065	27.739	27.904
PTTW	0.530	0.530	0.530	6.149	11.767	11.767	11.767	11.767	11.767	11.767	0.530	0.530
Agriculture	3.075	3.075	3.075	3.075	3.075	3.075	14.064	14.064	3.075	3.075	3.075	3.075
Total - Current	25.284	26.384	26.791	30.333	36.258	36.547	48.239	48.736	36.910	35.377	23.902	24.022
Total - Future	33.234	34.738	35.294	38.075	44.112	44.508	56.457	57.137	45.004	42.908	31.345	31.510
Kemptville Creek Near Kemptville												
Agriculture	1.638	1.638	1.638	1.638	1.638	1.638	9.2006	9.2006	1.638	1.638	1.638	1.638
Total - Current	1.638	1.638	1.638	1.638	1.638	1.638	9.2006	9.2006	1.638	1.638	1.638	1.638
Total - Future	1.638	1.638	1.638	1.638	1.638	1.638	9.2006	9.2006	1.638	1.638	1.638	1.638
Rideau River Below Manotick												
PTTW	-	-	-	47.864	288.846	290.476	298.370	306.154	298.370	112.643	-	-
Agriculture	3.500	3.500	3.500	3.500	3.500	3.500	25.457	25.457	3.500	3.500	3.500	3.500
Total - Current	3.500	3.500	3.500	51.364	292.346	293.976	323.827	331.611	301.870	116.144	3.500	3.500
Total - Future	3.500	3.500	3.500	51.364	292.346	293.976	323.827	331.611	301.870	116.144	3.500	3.500
Jock River Near Richmond												
PTTW	3.788	3.788	3.788	3.788	10.160	41.119	25.640	29.718	33.435	24.113	3.788	3.788
Agriculture	2.584	2.584	2.584	2.584	2.584	2.584	18.477	18.477	2.584	2.584	2.584	2.584
Total - Current	6.373	6.373	6.373	6.373	12.745	43.704	44.117	48.195	36.020	26.697	6.373	6.373
Total - Future	6.373	6.373	6.373	6.373	12.745	43.704	44.117	48.195	36.020	26.697	6.373	6.373
Rideau River At Ottawa												
PTTW	509.685	509.685	509.685	535.548	538.650	566.600	567.982	567.982	591.861	538.650	509.685	509.685
Agriculture	0.628	0.628	0.628	0.628	0.628	0.628	4.387	4.387	0.628	0.628	0.628	0.628

Subwatershed	Surface Water - Consumptive Demand (m^3/s x 1,000)[1]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total - Current	510.313	510.313	510.313	536.176	539.278	567.228	572.370	572.370	592.489	539.278	510.313	510.313
Total - Future	510.313	510.313	510.313	536.176	539.278	567.228	572.370	572.370	592.489	539.278	510.313	510.313
Rideau River (Outlet)												
Agriculture	0.177	0.177	0.177	0.177	0.177	0.177	1.226	1.226	0.177	0.177	0.177	0.177
Total - Current	0.177	0.177	0.177	0.177	0.177	0.177	1.226	1.226	0.177	0.177	0.177	0.177
Total - Future	0.177	0.177	0.177	0.177	0.177	0.177	1.226	1.226	0.177	0.177	0.177	0.177
Ottawa RVCA (West)												
Agriculture	0.688	0.688	0.688	0.688	0.688	0.688	5.827	5.827	0.688	0.688	0.688	0.688
Total - Current	0.688	0.688	0.688	0.688	0.688	0.688	5.827	5.827	0.688	0.688	0.688	0.688
Total - Future	0.688	0.688	0.688	0.688	0.688	0.688	5.827	5.827	0.688	0.688	0.688	0.688
Ottawa RVCA (East)												
PTTW	-	-	-	-	7.858	7.858	7.858	14.501	7.858	7.858	-	-
Agriculture	0.100	0.100	0.100	0.100	0.100	0.100	0.837	0.837	0.100	0.100	0.100	0.100
Total - Current	0.100	0.100	0.100	0.100	7.959	7.959	8.696	15.338	7.959	7.959	0.100	0.100
Total - Future	0.100	0.100	0.100	0.100	7.959	7.959	8.696	15.338	7.959	7.959	0.100	0.100

Table 5.7-1 Consumptive Demand for Groundwater within MVC and RVCA Subwatersheds

Sub-watershed	Groundwater - Consumptive Demand ($m^3/s \times 1,000$)[1]												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual[2]
MISSISSIPPI VALLEY CONSERVATION													
Mississippi River Below Marble Lake													
PTTW	0.000	0.000	0.000	0.000	0.038	0.040	0.038	0.038	0.040	0.000	0.000	0.000	0.016
Agriculture	0.801	0.801	0.801	0.801	0.801	0.801	3.967	3.967	0.801	0.801	0.801	0.801	1.339
Private (150)[3]	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198
Total Current	0.999	0.999	0.999	0.999	1.037	1.039	4.203	4.203	1.039	0.999	0.999	0.999	1.553
Total Future	0.999	0.999	0.999	0.999	1.037	1.039	4.203	4.203	1.039	0.999	0.999	0.999	1.553
Mississippi River At High Falls													
PTTW	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083
Agriculture	0.996	0.996	0.996	0.996	0.996	0.996	4.905	4.905	0.996	0.996	0.996	0.996	1.660
Private (919)	1.213	1.213	1.213	1.213	1.213	1.213	1.213	1.213	1.213	1.213	1.213	1.213	1.213
Total Current	2.292	2.292	2.292	2.292	2.292	2.292	6.201	6.201	2.292	2.292	2.292	2.292	2.956
Total Future	2.292	2.292	2.292	2.292	2.292	2.292	6.201	6.201	2.292	2.292	2.292	2.292	2.956
Clyde River Near Lanark													
Municipal – Current	11.300	11.300	11.300	11.300	11.300	11.300	11.300	11.300	11.300	11.300	11.300	11.300	11.300
Municipal – Future	11.300	11.300	11.300	11.300	11.300	11.300	11.300	11.300	11.300	11.300	11.300	11.300	11.300
Agriculture	0.462	0.462	0.462	0.462	0.462	0.462	4.451	4.451	0.462	0.462	0.462	0.462	1.140
Private (735)	0.970	0.970	0.970	0.970	0.970	0.970	0.970	0.970	0.970	0.970	0.970	0.970	0.970

[1] Equivalent to Litres per Second (L/s)
[2] The annual demand was calculated by a weighted average of the monthly demands to account for the different number of days in each month.
[3] Number of private wells in subwatershed

Sub-watershed	Groundwater - Consumptive Demand (m^3/s x 1,000)[1]												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual[2]**
Total Current	12.732	12.732	12.732	12.732	12.732	12.732	16.721	16.721	12.732	12.732	12.732	12.732	13.410
Total Future	12.732	12.732	12.732	12.732	12.732	12.732	16.721	16.721	12.732	12.732	12.732	12.732	13.410
Fall River At Bennett Lake													
PTTW	0.000	0.000	0.000	0.201	0.201	0.201	0.201	0.201	0.000	0.000	0.000	0.000	0.084
Agriculture	0.308	0.308	0.308	0.308	0.308	0.308	0.447	0.447	0.308	0.308	0.308	0.308	0.332
Private (1061)	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400
Total Current	1.708	1.708	1.708	1.909	1.909	1.909	2.048	2.048	1.708	1.708	1.708	1.708	1.815
Total Future	1.708	1.708	1.708	1.909	1.909	1.909	2.048	2.048	1.708	1.708	1.708	1.708	1.815
Mississippi River At Fergusons Falls													
PTTW	23.119	23.161	23.119	23.132	23.119	23.132	23.119	23.119	23.132	23.119	23.132	23.119	23.127
Agriculture	0.889	0.889	0.889	0.889	0.889	0.889	3.779	3.779	0.889	0.889	0.889	0.889	1.380
Private (1535)	2.025	2.025	2.025	2.025	2.025	2.025	2.025	2.025	2.025	2.025	2.025	2.025	2.025
Total Current	26.034	26.075	26.034	26.046	26.034	26.046	28.924	28.924	26.046	26.034	26.046	26.034	26.532
Total Future	26.034	26.075	26.034	26.046	26.034	26.046	28.924	28.924	26.046	26.034	26.046	26.034	26.532
Mississippi River At Appleton													
PTTW	0.823	0.823	0.823	0.823	0.988	2.594	2.537	2.537	2.594	0.823	0.823	0.823	1.418
Agriculture	0.654	0.654	0.654	0.654	0.654	0.654	3.371	3.371	0.654	0.654	0.654	0.654	1.116
Private (2206)	2.911	2.911	2.911	2.911	2.911	2.911	2.911	2.911	2.911	2.911	2.911	2.911	2.911
Total Current	4.388	4.388	4.388	4.388	4.553	6.159	8.819	8.819	6.159	4.388	4.388	4.388	5.444
Total Future	4.388	4.388	4.388	4.388	4.553	6.159	8.819	8.819	6.159	4.388	4.388	4.388	5.444
Indian River Near Blakeney													
PTTW	7.504	8.309	7.504	7.755	7.504	7.755	7.504	7.504	7.755	7.504	7.755	7.504	7.655
Agriculture	0.471	0.471	0.471	0.471	0.471	0.471	2.740	2.740	0.471	0.471	0.471	0.471	0.857
Private (587)	0.775	0.775	0.775	0.775	0.775	0.775	0.775	0.775	0.775	0.775	0.775	0.775	0.775
Total Current	8.750	9.554	8.750	9.000	8.750	9.000	11.019	11.019	9.000	8.750	9.000	8.750	9.286

Sub-watershed	Groundwater - Consumptive Demand (m^3/s x 1,000)[1]												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**[2]
Total Future	8.750	9.554	8.750	9.000	8.750	9.000	11.019	11.019	9.000	8.750	9.000	8.750	9.286
Mississippi River At Galetta													
Municipal - Current	21.244	25.609	26.899	26.473	21.989	21.690	22.971	19.826	21.306	22.548	23.824	25.274	23.285
Municipal - Future	27.617	33.292	34.968	34.415	28.586	28.197	29.863	25.773	27.697	29.313	30.971	32.856	30.271
PTTW	24.284	26.885	1.556	1.608	1.556	1.608	1.556	1.556	1.608	1.556	1.608	24.284	7.472
Agriculture	1.320	1.320	1.320	1.320	1.320	1.320	6.545	6.545	1.320	1.320	1.320	1.320	2.207
Private (2075)	2.738	2.738	2.738	2.738	2.738	2.738	2.738	2.738	2.738	2.738	2.738	2.738	2.738
Total Current	49.585	56.552	32.512	32.138	27.603	27.355	33.811	30.665	26.971	28.162	29.489	53.615	35.702
Total Future	55.958	64.235	40.582	40.080	34.200	33.862	40.702	36.613	33.363	34.926	36.636	61.197	42.688
Mississippi River (Outlet)													
PTTW	1.167	1.292	1.167	1.206	1.167	1.206	1.167	1.167	1.206	1.167	1.206	1.167	1.190
Agriculture	0.151	0.151	0.151	0.151	0.151	0.151	1.244	1.244	0.151	0.151	0.151	0.151	0.337
Private (177)	0.234	0.234	0.234	0.234	0.234	0.234	0.234	0.234	0.234	0.234	0.234	0.234	0.234
Total Current	1.551	1.676	1.551	1.590	1.551	1.590	2.645	2.645	1.590	1.551	1.590	1.551	1.761
Total Future	1.551	1.676	1.551	1.590	1.551	1.590	2.645	2.645	1.590	1.551	1.590	1.551	1.761
Carp River Near Kinburn													
Municipal – Current	11.793	11.768	11.373	12.816	15.665	15.769	16.333	15.062	13.885	11.307	11.213	10.624	13.142
Municipal – Future	17.689	17.652	17.060	19.224	23.498	23.654	24.499	22.594	20.827	16.960	16.820	15.936	19.713
PTTW	28.428	28.713	27.929	28.612	30.175	30.377	30.136	29.873	30.028	30.156	29.065	28.836	29.361
Agriculture	1.498	1.498	1.498	1.498	1.498	1.498	12.791	12.791	1.498	1.498	1.498	1.498	3.416
Private (2130)	2.810	2.810	2.810	2.810	2.810	2.810	2.810	2.810	2.810	2.810	2.810	2.810	2.810

Sub-watershed	Groundwater - Consumptive Demand (m^3/s x 1,000)[1]												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual[2]
Total Current	44.528	44.789	43.610	45.736	50.148	50.455	62.070	60.537	48.221	45.771	44.586	43.768	48.729
Total Future	50.424	50.673	49.296	52.144	57.981	58.339	70.236	68.068	55.163	51.424	50.193	49.081	55.300
Carp River (Outlet)													
PTTW	0.000	0.000	0.000	0.251	0.251	0.251	0.251	0.251	0.251	0.000	0.000	0.000	0.126
Agriculture	0.283	0.283	0.283	0.283	0.283	0.283	2.418	2.418	0.283	0.283	0.283	0.283	0.646
Private (267)	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352
Total Current	0.635	0.635	0.635	0.887	0.887	0.887	3.022	3.022	0.887	0.635	0.635	0.635	1.124
Total Future	0.635	0.635	0.635	0.887	0.887	0.887	3.022	3.022	0.887	0.635	0.635	0.635	1.124
Ottawa MVC													
PTTW	14.525	14.811	14.525	14.614	14.525	81.545	80.587	80.587	81.545	14.525	14.614	14.525	36.744
Agriculture	1.647	1.647	1.647	1.647	1.647	1.647	14.061	14.061	1.647	1.647	1.647	1.647	3.755
Private (2641)	3.485	3.485	3.485	3.485	3.485	3.485	3.485	3.485	3.485	3.485	3.485	3.485	3.485
Total Current	19.657	19.942	19.657	19.745	19.657	86.676	98.133	98.133	86.676	19.657	19.745	19.657	43.984
Total Future	19.657	19.942	19.657	19.745	19.657	86.676	98.133	98.133	86.676	19.657	19.745	19.657	43.984
RIDEAU VALLEY CONSERVATION AUTHORITY													
Tay River At Perth													
PTTW	3.733	3.733	3.733	3.733	3.733	3.733	3.733	3.733	3.733	3.733	3.733	3.733	3.733
Agriculture	1.419	1.419	1.419	1.419	1.419	1.419	1.686	1.686	1.419	1.419	1.419	1.419	1.464
Private (2397)	3.163	3.163	3.163	3.163	3.163	3.163	3.163	3.163	3.163	3.163	3.163	3.163	3.163
Total - Current	8.315	8.315	8.315	8.315	8.315	8.315	8.582	8.582	8.315	8.315	8.315	8.315	8.360
Total - Future	8.315	8.315	8.315	8.315	8.315	8.315	8.582	8.582	8.315	8.315	8.315	8.315	8.360
Rideau River Above Smiths Falls													
Municipal – Current	4.136	4.273	3.943	4.066	4.419	4.735	4.729	4.802	4.586	2.939	2.410	2.207	3.934

Sub-watershed	Groundwater - Consumptive Demand (m^3/s x 1,000)[1]												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual[2]
Municipal – Future	4.343	4.487	4.140	4.270	4.640	4.972	4.965	5.042	4.815	3.086	2.531	2.317	4.131
PTTW	1.342	1.342	1.342	1.342	1.342	1.342	1.342	1.342	1.342	1.342	1.342	1.342	1.342
Agriculture	1.860	1.860	1.860	1.860	1.860	1.860	2.197	2.197	1.860	1.860	1.860	1.860	1.917
Private (3380)	4.460	4.460	4.460	4.460	4.460	4.460	4.460	4.460	4.460	4.460	4.460	4.460	4.460
Total Current	11.798	11.935	11.604	11.728	12.081	12.397	12.728	12.801	12.247	10.601	10.071	9.868	11.653
Total Future	12.004	12.148	11.801	11.931	12.302	12.633	12.964	13.041	12.477	10.748	10.192	9.978	11.850
Rideau River Below Merrickville													
Municipal – Current	6.756	6.923	6.781	6.715	6.795	7.050	7.007	6.870	6.733	6.057	5.623	5.760	6.589
Municipal – Future	10.809	11.077	10.850	10.745	10.872	11.279	11.212	10.992	10.774	9.691	8.997	9.217	10.543
PTTW	56.920	57.335	56.920	63.309	63.180	63.309	63.180	63.180	63.309	63.180	57.049	56.920	60.649
Agriculture	3.075	3.075	3.075	3.075	3.075	3.075	14.064	14.064	3.075	3.075	3.075	3.075	4.942
Private (3496)	4.613	4.613	4.613	4.613	4.613	4.613	4.613	4.613	4.613	4.613	4.613	4.613	4.613
Total Current	71.364	71.946	71.389	77.713	77.664	78.047	88.864	88.727	77.731	76.925	70.360	70.368	76.794
Total Future	75.417	76.100	75.458	81.742	81.741	82.277	93.069	92.849	81.771	80.559	73.735	73.825	80.747
Kemptville Creek Near Kemptville													
Agriculture	1.638	1.638	1.638	1.638	1.638	1.638	9.201	9.201	1.638	1.638	1.638	1.638	2.923
Private (1467)	1.936	1.936	1.936	1.936	1.936	1.936	1.936	1.936	1.936	1.936	1.936	1.936	1.936
Total Current	3.574	3.574	3.574	3.574	3.574	3.574	11.136	11.136	3.574	3.574	3.574	3.574	4.858
Total Future	3.574	3.574	3.574	3.574	3.574	3.574	11.136	11.136	3.574	3.574	3.574	3.574	4.858
Rideau River Below Manotick													
Municipal - Current	19.700	19.829	19.782	18.935	18.788	19.886	18.578	17.122	17.907	17.211	17.421	16.094	18.438

Sub-watershed	Groundwater - Consumptive Demand (m^3/s x 1,000)[1]												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual[2]
Municipal - Future	53.189	53.538	53.411	51.124	50.727	53.692	50.161	46.229	48.348	46.469	47.037	43.453	49.782
PTTW	150.838	154.274	163.096	164.574	181.427	190.966	189.692	189.692	190.966	181.427	164.574	150.838	172.697
Agriculture	3.500	3.500	3.500	3.500	3.500	3.500	25.457	25.457	3.500	3.500	3.500	3.500	7.230
Private (6861)	9.053	9.053	9.053	9.053	9.053	9.053	9.053	9.053	9.053	9.053	9.053	9.053	9.053
Total Current	183.090	186.656	195.431	196.061	212.767	223.405	242.780	241.324	221.425	211.190	194.548	179.484	207.417
Total Future	216.580	220.365	229.060	228.251	244.707	257.211	274.363	270.432	251.867	240.449	224.163	206.844	238.761
Jock River Near Richmond													
Municipal - Current	22.568	23.249	23.805	27.773	30.099	28.788	28.960	28.933	29.124	28.651	25.434	26.959	27.051
Municipal - Future	23.696	24.411	24.995	29.161	31.604	30.227	30.408	30.379	30.580	30.084	26.705	28.307	28.404
PTTW	99.669	96.146	110.065	134.760	131.782	129.901	130.237	128.709	129.515	109.588	110.560	95.988	117.243
Agriculture	2.584	2.584	2.584	2.584	2.584	2.584	18.477	18.477	2.584	2.584	2.584	2.584	5.284
Private (3415)	4.506	4.506	4.506	4.506	4.506	4.506	4.506	4.506	4.506	4.506	4.506	4.506	4.506
Total Current	129.327	126.485	140.960	169.623	168.971	165.779	182.181	180.624	165.730	145.330	143.084	130.037	154.085
Total Future	130.455	127.647	142.150	171.011	170.476	167.219	183.629	182.071	167.186	146.762	144.356	131.385	155.437
Rideau River At Ottawa													
PTTW	43.998	45.144	63.171	96.992	95.413	96.992	95.413	95.413	96.992	63.171	59.680	43.998	74.698
Agriculture	0.628	0.628	0.628	0.628	0.628	0.628	4.387	4.387	0.628	0.628	0.628	0.628	1.267
Private (2119)	2.796	2.796	2.796	2.796	2.796	2.796	2.796	2.796	2.796	2.796	2.796	2.796	2.796
Total Current	47.422	48.568	66.595	100.415	98.837	100.415	102.597	102.597	100.415	66.595	63.104	47.422	78.761
Total Future	47.422	48.568	66.595	100.415	98.837	100.415	102.597	102.597	100.415	66.595	63.104	47.422	78.761
Rideau River (Outlet)													

Sub-watershed	Groundwater - Consumptive Demand (m^3/s x 1,000)[1]												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual[2]**
PTTW	0.119	0.132	0.119	0.123	0.119	0.123	0.119	0.119	0.123	0.119	0.123	0.119	0.121
Agriculture	0.177	0.177	0.177	0.177	0.177	0.177	1.226	1.226	0.177	0.177	0.177	0.177	0.355
Private (544)	0.718	0.718	0.718	0.718	0.718	0.718	0.718	0.718	0.718	0.718	0.718	0.718	0.718
Total Current	1.013	1.026	1.013	1.017	1.013	1.017	2.063	2.063	1.017	1.013	1.017	1.013	1.194
Total Future	1.013	1.026	1.013	1.017	1.013	1.017	2.063	2.063	1.017	1.013	1.017	1.013	1.194
Ottawa RVCA (West)													
PTTW	24.313	24.480	24.313	24.365	24.313	24.365	24.313	24.313	24.365	24.313	24.365	24.313	24.344
Agriculture	0.688	0.688	0.688	0.688	0.688	0.688	5.827	5.827	0.688	0.688	0.688	0.688	1.561
Private (2288)	3.019	3.019	3.019	3.019	3.019	3.019	3.019	3.019	3.019	3.019	3.019	3.019	3.019
Total Current	28.020	28.188	28.020	28.072	28.020	28.072	33.158	33.158	28.072	28.020	28.072	28.020	28.924
Total Future	28.020	28.188	28.020	28.072	28.020	28.072	33.158	33.158	28.072	28.020	28.072	28.020	28.924
Ottawa RVCA (East)													
PTTW	28.668	29.056	28.668	34.630	37.089	37.968	39.988	39.988	37.968	34.320	28.789	28.668	33.817
Agriculture	0.100	0.100	0.100	0.100	0.100	0.100	0.837	0.837	0.100	0.100	0.100	0.100	0.226
Private (2539)	3.350	3.350	3.350	3.350	3.350	3.350	3.350	3.350	3.350	3.350	3.350	3.350	3.350
Total Current	32.118	32.507	32.118	38.080	40.540	41.419	44.176	44.176	41.419	37.771	32.239	32.118	37.392
Total Future	32.118	32.507	32.118	38.080	40.540	41.419	44.176	44.176	41.419	37.771	32.239	32.118	37.392

Table 6.1-1 Surface Water Supply and Reserve in MVC and RVCA Subwatersheds

Subwatershed	Surface Water - Supply and Reserve (m^3/s)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
MISSISSIPPI VALLEY CONSERVATION												
Mississippi River Below Marble Lake												
Supply	4.20	3.51	3.95	11.15	5.71	3.04	1.17	0.57	0.43	1.94	5.33	7.85
Reserve	2.92	2.27	2.00	4.95	2.66	1.17	0.50	0.23	0.19	0.96	3.13	5.62
Supply – Reserve	1.28	1.25	1.94	6.20	3.05	1.88	0.67	0.35	0.24	0.98	2.20	2.23
Mississippi River At High Falls												
Supply	18.54	17.44	16.22	23.43	13.91	8.02	5.82	6.78	5.88	6.59	9.87	16.03
Reserve	10.47	12.38	9.44	8.29	5.71	5.23	4.97	4.92	4.82	4.42	4.98	5.14
Supply – Reserve	8.07	5.06	6.79	15.14	8.19	2.79	0.85	1.87	1.06	2.17	4.90	10.89
Clyde River Near Lanark												
Supply	4.27	3.95	10.38	32.00	12.70	4.05	1.45	0.76	0.57	1.22	3.16	5.30
Reserve	2.35	1.68	3.63	15.82	5.56	2.05	0.62	0.21	0.14	0.26	1.21	2.06
Supply – Reserve	1.92	2.27	6.75	16.18	7.14	2.00	0.83	0.55	0.43	0.96	1.95	3.24
Fall River At Bennett Lake												
Supply	2.96	2.99	4.09	8.90	5.42	2.28	0.67	0.18	0.11	0.26	1.00	2.75
Reserve	1.41	1.38	2.32	6.69	2.73	1.02	0.20	0.07	0.04	0.03	0.20	0.92
Supply – Reserve	1.55	1.61	1.77	2.21	2.69	1.27	0.47	0.12	0.06	0.23	0.80	1.83
Mississippi River At Fergusons Falls												
Supply	30.60	29.85	36.30	80.25	42.30	21.90	10.15	8.78	7.99	11.39	19.00	30.39
Reserve	15.40	17.60	24.35	49.23	19.24	12.14	6.84	5.41	6.30	5.56	9.37	12.06
Supply – Reserve	15.20	12.25	11.95	31.02	23.06	9.76	3.31	3.37	1.69	5.83	9.63	18.33
Mississippi River At Appleton												
Supply	33.05	33.30	37.35	84.05	44.20	23.90	10.17	8.45	8.00	12.33	18.90	32.01
Reserve	15.68	17.78	24.33	55.16	19.69	11.55	6.03	5.03	5.90	5.97	8.82	12.30

Subwatershed	Surface Water - Supply and Reserve (m^3/s)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Supply – Reserve	17.37	15.52	13.02	28.89	24.51	12.35	4.13	3.42	2.10	6.36	10.08	19.71
Indian River Near Blakeney												
Supply	1.58	1.27	2.63	7.27	3.24	1.18	0.59	0.35	0.29	0.48	0.75	1.88
Reserve	0.67	0.25	1.45	4.45	1.34	0.37	0.29	0.20	0.19	0.21	0.28	0.25
Supply – Reserve	0.91	1.02	1.18	2.81	1.90	0.81	0.30	0.16	0.10	0.27	0.47	1.63
Mississippi River At Galetta												
Supply	37.76	37.11	49.73	114.07	55.15	27.67	11.97	9.57	9.02	14.23	23.02	38.58
Reserve	17.62	18.61	30.13	71.60	24.05	12.74	7.01	5.58	6.45	6.87	10.61	13.53
Supply – Reserve	17.37	15.52	13.02	28.89	24.51	12.35	4.13	3.42	2.10	6.36	10.08	19.71
Mississippi River (Outlet)												
Supply	37.91	37.23	50.22	115.20	55.53	27.79	12.03	9.61	9.05	14.30	23.19	38.81
Reserve	17.68	18.63	30.35	72.19	24.20	12.78	7.04	5.60	6.47	6.90	10.69	13.58
Supply – Reserve	17.37	15.52	13.02	28.89	24.51	12.35	4.13	3.42	2.10	6.36	10.08	19.71
Carp River Near Kinburn												
Supply	0.77	0.77	5.84	12.25	2.46	0.92	0.31	0.16	0.25	0.59	1.71	1.69
Reserve	0.30	0.19	2.07	5.04	1.06	0.26	0.14	0.07	0.06	0.23	0.63	0.55
Supply – Reserve	0.47	0.58	3.77	7.21	1.40	0.66	0.16	0.09	0.19	0.36	1.08	1.14
Carp River (Outlet)												
Supply	0.91	0.92	6.93	14.55	2.92	1.10	0.36	0.19	0.29	0.70	2.03	2.01
Reserve	0.35	0.23	2.45	5.99	1.26	0.31	0.17	0.08	0.07	0.27	0.75	0.65
Supply – Reserve	0.56	0.69	4.48	8.56	1.66	0.79	0.19	0.11	0.23	0.43	1.28	1.36
Ottawa MVC												
Supply	0.91	0.75	5.88	12.22	3.10	0.91	0.38	0.27	0.32	0.71	2.26	2.02
Reserve	0.34	0.21	2.25	5.60	1.11	0.29	0.26	0.08	0.10	0.37	1.10	0.61
Supply – Reserve	0.58	0.53	3.63	6.62	1.99	0.63	0.12	0.19	0.22	0.34	1.16	1.41

Subwatershed	Surface Water - Supply and Reserve (m^3/s)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
RIDEAU VALLEY CONSERVATION AUTHORITY												
Tay River At Perth												
Supply	7.82	6.23	6.43	18.93	11.19	5.40	3.26	3.70	4.90	4.32	2.51	6.41
Reserve	3.60	2.56	3.21	9.97	4.11	3.05	1.75	2.45	2.47	1.43	1.17	1.58
Supply – Reserve	4.22	3.66	3.22	8.96	7.07	2.35	1.51	1.25	2.43	2.89	1.34	4.83
Rideau River Above Smiths Falls												
Supply	12.81	12.35	14.60	33.35	19.46	11.60	10.24	9.36	10.27	11.78	8.76	10.55
Reserve	5.59	4.75	7.85	16.26	8.72	8.06	7.57	7.90	6.85	5.84	4.41	4.16
Supply – Reserve	7.22	7.61	6.75	17.09	10.73	3.55	2.67	1.46	3.42	5.94	4.35	6.39
Rideau River Below Merrickville												
Supply	19.25	19.32	35.32	66.09	23.45	11.30	8.15	7.79	9.00	14.40	17.85	22.25
Reserve	9.68	11.68	24.61	33.54	9.65	6.87	5.69	6.72	6.48	9.18	7.06	9.05
Supply - Reserve	9.57	7.64	10.70	32.55	13.80	4.42	2.46	1.07	2.52	5.22	10.79	13.20
Kemptville Creek Near Kemptville												
Supply	3.23	2.72	11.45	18.65	5.18	1.40	0.38	0.12	0.07	1.16	4.15	3.99
Reserve	1.02	0.69	6.19	11.15	1.70	0.40	0.08	0.04	0.03	0.04	0.38	1.22
Supply – Reserve	2.21	2.02	5.26	7.50	3.48	1.00	0.30	0.08	0.04	1.12	3.77	2.76
Rideau River Below Manotick												
Supply	26.30	25.86	65.09	111.37	39.11	14.40	7.70	6.91	7.83	17.12	29.80	35.55
Reserve	11.33	13.72	40.08	66.97	12.82	7.58	5.05	4.86	5.51	9.81	10.41	11.90
Supply – Reserve	14.97	12.14	25.01	44.40	26.29	6.82	2.65	2.05	2.31	7.31	19.39	23.65
Jock River Near Richmond												
Supply	2.63	2.23	11.90	24.45	6.07	1.62	0.48	0.31	0.27	0.99	4.25	4.50
Reserve	0.86	0.50	4.10	14.14	2.56	0.52	0.10	0.07	0.05	0.14	0.84	1.28
Supply – Reserve	1.77	1.73	7.80	10.31	3.51	1.10	0.37	0.24	0.22	0.85	3.41	3.22

Subwatershed	Surface Water - Supply and Reserve (m^3/s)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Rideau River At Ottawa												
Supply	29.55	28.20	71.35	130.00	46.50	22.30	11.40	9.13	9.30	20.90	36.35	35.20
Reserve	16.34	13.11	41.79	71.14	14.04	9.07	5.88	6.03	6.52	11.82	13.12	18.27
Supply – Reserve	13.21	15.09	29.56	58.86	32.46	13.23	5.52	3.10	2.78	9.08	23.23	16.93
Rideau River (Outlet)												
Supply	29.89	28.52	72.16	131.48	47.03	22.55	11.53	9.23	9.41	21.14	36.76	35.60
Reserve	16.53	13.26	42.27	71.95	14.20	9.17	5.95	6.10	6.59	11.95	13.27	18.48
Supply – Reserve	13.36	15.26	29.90	59.53	32.83	13.38	5.58	3.13	2.81	9.18	23.49	17.12
Ottawa RVCA (West)												
Supply	0.31	0.33	1.26	2.38	0.88	0.50	0.32	0.21	0.36	0.37	0.61	0.52
Reserve	0.17	0.11	0.52	1.13	0.32	0.16	0.22	0.06	0.11	0.20	0.33	0.20
Supply – Reserve	0.15	0.22	0.74	1.25	0.56	0.35	0.10	0.15	0.25	0.18	0.27	0.32
Ottawa RVCA (East)												
Supply	0.66	0.58	3.84	7.85	2.13	0.76	0.37	0.26	0.36	0.58	1.54	1.36
Reserve	0.27	0.17	1.49	3.62	0.77	0.24	0.26	0.08	0.11	0.30	0.77	0.44
Supply – Reserve	0.39	0.40	2.35	4.23	1.37	0.52	0.11	0.18	0.25	0.28	0.77	0.93

Table 6.2-1 Groundwater Supply and Reserve in MVC and RVCA Subwatersheds

Subwatershed Name	Area	Average Recharge Rate	Annual Recharge Volume	Monthly Recharge Volume	Groundwater Supply	Groundwater Reserve	Supply - Reserve
	km^2	mm/year	m^3	m^3	m^3/s	m^3/s	m^3/s
MISSISSIPPI VALLEY CONSERVATION							
Mississippi River Below Marble Lake	359	122	43,954,614	3,662,884	1.394	0.139	1.254
Mississippi River At High Falls	874	136	119,089,426	9,924,119	3.776	0.378	3.399
Clyde River Near Lanark	617	124	76,495,606	6,374,634	2.426	0.243	2.183
Fall River At Bennett Lake	281	129	36,168,384	3,014,032	1.147	0.115	1.032
Mississippi River At Fergusons Falls	532	126	67,086,418	5,590,535	2.127	0.213	1.915
Mississippi River At Appleton	272	130	35,227,099	2,935,592	1.117	0.112	1.005
Indian River Near Blakeney	212	115	24,316,102	2,026,342	0.771	0.077	0.694
Mississippi River At Galetta	588	116	68,383,076	5,698,590	2.168	0.217	1.952
Mississippi River (Outlet)	29	107	3,113,695	259,475	0.099	0.010	0.089
Carp River Near Kinburn	255	148	37,797,052	3,149,754	1.199	0.120	1.079
Carp River (Outlet)	48	113	5,417,610	451,467	0.172	0.017	0.155
Ottawa MVC	283	131	37,011,113	3,084,259	1.174	0.117	1.056
RIDEAU VALLEY CONSERVATION AUTHORITY							
Tay River at Perth	676	121	81,723,189	6,810,266	2.591	0.259	2.332
Rideau River Above Smiths Falls	572	121	69,179,391	5,764,949	2.194	0.219	1.974
Rideau River Below Merrickville	715	132	94,743,575	7,895,298	3.004	0.300	2.704
Kemptville Creek At Kemptville	413	156	64,306,399	5,358,867	2.039	0.204	1.835
Rideau River Below Manotick	764	168	128,476,725	10,706,394	4.074	0.407	3.667
Jock River Near Richmond	524	161	84,365,994	7,030,499	2.675	0.268	2.408
Rideau River At Ottawa	143	165	23,638,538	1,969,878	0.750	0.075	0.675
Rideau River (Outlet)	43	164	7,122,233	593,519	0.226	0.023	0.203
Ottawa RVCA (West)	120	139	16,654,331	1,387,861	0.528	0.053	0.475
Ottawa RVCA (East)	263	160	42,155,264	3,512,939	1.337	0.134	1.203

Table 7.1-1 Threshold Criteria for Stress Assessments – Surface Water

Surface Water Quantity Stress Level	Maximum Monthly % Demand
Significant	>50%
Moderate	20% - 50%
Low	<20%

Table 7.1-2 Surface Water Percent Demand and Assigned Stress Level in MVC and RVCA Subwatersheds

Subwatershed	Surface Water - Percent Demand (%)												Max. (%)	Stress Level
	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec		
MISSISSIPPI VALLEY CONSERVATION														
Mississippi River Below Marble Lake														
Current	0.1	0.1	0.1	0.0	0.1	0.1	0.7	1.4	0.7	0.2	0.1	0.1	1.4	Low
Future	0.1	0.1	0.1	0.0	0.1	0.1	0.7	1.4	0.7	0.2	0.1	0.1	1.4	Low
Mississippi River At High Falls														
Current	0.1	0.1	0.1	0.0	0.1	0.2	1.2	0.6	0.6	0.3	0.1	0.1	1.2	Low
Future	0.1	0.1	0.1	0.0	0.1	0.2	1.2	0.6	0.6	0.3	0.1	0.1	1.2	Low
Clyde River Near Lanark														
Current	0.8	0.7	0.2	0.1	0.2	0.8	2.3	4.2	3.5	1.6	0.8	0.5	4.2	Low
Future	0.8	0.7	0.2	0.1	0.2	0.8	2.3	4.2	3.5	1.6	0.8	0.5	4.2	Low
Fall River At Bennett Lake														
Current	1.1	1.1	1.0	0.8	0.7	1.4	3.7	13.5	22.5	7.1	2.2	1.0	22.5	Moderate
Future	1.1	1.1	1.0	0.8	0.7	1.4	3.7	13.5	22.5	7.1	2.2	1.0	22.5	Moderate
Mississippi River Fergusons Falls														
Current	0.2	0.2	0.2	0.1	0.1	0.3	1.0	1.1	2.0	0.5	0.3	0.1	2.0	Low
Future	0.2	0.2	0.2	0.1	0.1	0.3	1.0	1.1	2.0	0.5	0.3	0.1	2.0	Low
Mississippi River At Appleton														
Current	0.1	0.1	0.1	0.1	0.1	0.3	0.9	1.1	1.3	0.2	0.1	0.1	1.3	Low
Future	0.1	0.1	0.2	0.1	0.1	0.3	1.1	1.3	1.6	0.3	0.2	0.1	1.6	Low
Indian River Near Blakeney														
Current	0.1	0.0	0.9	0.4	0.6	1.3	4.1	7.6	10.0	3.8	2.2	0.0	10.0	Low
Future	0.1	0.0	0.9	0.4	0.6	1.3	4.1	7.6	10.0	3.8	2.2	0.0	10.0	Low
Mississippi River At Galetta														
Current	33.8	36.4	40.5	23.5	26.5	41.7	68.2	72.1	80.8	58.2	46.7	31.0	80.8	Significant

Subwatershed	Surface Water - Percent Demand (%)												Max. (%)	Stress Level
	Jan	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**		
Future	33.8	36.4	40.5	23.5	26.5	41.7	68.2	72.1	80.8	58.2	46.7	31.0	80.8	Significant
Mississippi River (Outlet)														
Current	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Low
Future	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Low
Carp River Near Kinburn														
Current	4.3	3.6	0.6	0.3	2.4	4.9	22.5	32.5	15.0	6.0	2.0	1.8	32.5	Moderate
Future	4.3	3.6	0.6	0.3	2.4	4.9	22.5	32.5	15.0	6.0	2.0	1.8	32.5	Moderate
Carp River (Outlet)														
Current	0.1	0.0	0.0	0.0	0.0	0.0	1.2	2.1	0.1	0.1	0.0	0.0	2.1	Low
Future	0.1	0.0	0.0	0.0	0.0	0.0	1.2	2.1	0.1	0.1	0.0	0.0	2.1	Low
Ottawa MVC														
Current	0.3	0.3	0.0	0.0	0.1	3.8	24.5	16.6	10.0	0.5	0.1	0.1	24.5	Moderate
Future	0.3	0.3	0.0	0.0	0.1	3.8	24.5	16.6	10.0	0.5	0.1	0.1	24.5	Moderate
RIDEAU VALLEY CONSERVATION AUTHORITY														
Tay River At Perth														
Current	0.4	0.5	0.5	0.2	0.2	0.9	1.6	1.9	0.9	0.6	1.1	0.3	1.9	Low
Future	0.6	0.7	0.8	0.3	0.4	1.3	2.3	2.7	1.4	1.0	1.8	0.5	2.7	Low
Rideau River At Smiths Falls														
Current	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.2	Low
Future	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.2	Low
Rideau River Below Merrickville														
Current	0.3	0.3	0.2	0.1	0.3	0.8	1.9	4.4	1.4	0.7	0.2	0.2	4.4	Low
Future	0.3	0.5	0.3	0.1	0.3	1.0	2.2	5.1	1.8	0.8	0.3	0.2	5.1	Low
Kemptville Creek Near Kemptville														
Current	0.1	0.1	0.0	0.0	0.0	0.2	3.0	10.6	3.8	0.1	0.0	0.1	10.6	Low

Subwatershed	Surface Water - Percent Demand (%)												Max. (%)	Stress Level
	Jan	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**		
Future	0.1	0.1	0.0	0.0	0.0	0.2	3.0	10.6	3.8	0.1	0.0	0.1	10.6	Low
Rideau River Below Manotick														
Current	0.0	0.0	0.0	0.1	1.1	4.1	10.9	13.9	11.5	1.6	0.0	0.0	13.9	Low
Future	0.0	0.0	0.0	0.1	1.1	4.1	10.9	13.9	11.5	1.6	0.0	0.0	13.9	Low
Jock River Near Richmond														
Current	0.4	0.4	0.1	0.1	0.4	3.8	10.6	16.6	14.3	3.0	0.2	0.2	16.6	Low
Future	0.4	0.4	0.1	0.1	0.4	3.8	10.6	16.6	14.3	3.0	0.2	0.2	16.6	Low
Rideau River At Ottawa														
Current	3.7	3.3	1.7	0.9	1.6	4.1	9.4	15.6	17.6	5.6	2.1	2.9	17.6	Low
Future	3.7	3.3	1.7	0.9	1.6	4.1	9.4	15.6	17.6	5.6	2.1	2.9	17.6	Low
Rideau River (Outlet)														
Current	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Low
Future	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Low
Ottawa West (RVCA)														
Current	0.5	0.3	0.1	0.1	0.1	0.2	5.6	3.8	0.3	0.4	0.3	0.2	5.6	Low
Future	0.5	0.3	0.1	0.1	0.1	0.2	5.6	3.8	0.3	0.4	0.3	0.2	5.6	Low
Ottawa East (RVCA)														
Current	0.0	0.0	0.0	0.0	0.6	1.5	7.1	7.9	3.0	2.8	0.0	0.0	7.9	Low
Future	0.0	0.0	0.0	0.0	0.6	1.5	7.1	7.9	3.0	2.8	0.0	0.0	7.9	Low

Table 7.2-1 Threshold Criteria for Stress Assessment – Groundwater Sources

Ground Water Quantity Stress Level Assignment	Maximum Monthly % Water Demand	Average Annual % Water Demand
Significant	>50%	>25%
Moderate	>25%	>10%
Low	0 – 25%	0 – 10%

Table 7.2-2 Monthly Groundwater Percent Demand and Assigned Stress Level in MVC and RVCA Subwatersheds

Subwatershed	Groundwater - Percent Demand (%)												Max. (%)	Stress Level
	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec		
MISSISSISSIPPI VALLEY CONSERVATION														
Mississippi River Below Marble Lake														
Current	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.3	0.1	0.1	0.1	0.1	0.3	LOW
Future	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.3	0.1	0.1	0.1	0.1	0.3	LOW
Mississippi River At High Falls														
Current	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.2	LOW
Future	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.2	LOW
Clyde River Near Lanark														
Current	0.6	0.6	0.6	0.6	0.6	0.6	0.8	0.8	0.6	0.6	0.6	0.6	0.8	LOW
Future	0.6	0.6	0.6	0.6	0.6	0.6	0.8	0.8	0.6	0.6	0.6	0.6	0.8	LOW
Fall River At Bennett Lake														
Current	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	LOW
Future	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	LOW
Mississippi River At Fergusons Falls														
Current	1.4	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.4	1.4	1.4	1.4	1.5	LOW
Future	1.4	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.4	1.4	1.4	1.4	1.5	LOW
Mississippi River At Appleton														
Current	0.4	0.4	0.4	0.4	0.5	0.6	0.9	0.9	0.6	0.4	0.4	0.4	0.9	LOW
Future	0.4	0.4	0.4	0.4	0.5	0.6	0.9	0.9	0.6	0.4	0.4	0.4	0.9	LOW
Indian River Near Blakeney														
Current	1.3	1.4	1.3	1.3	1.3	1.3	1.6	1.6	1.3	1.3	1.3	1.3	1.6	LOW
Future	1.3	1.4	1.3	1.3	1.3	1.3	1.6	1.6	1.3	1.3	1.3	1.3	1.6	LOW
Mississippi River At Galetta														
Current	2.5	2.9	1.7	1.6	1.4	1.4	1.7	1.6	1.4	1.4	1.5	2.7	2.9	LOW

Subwatershed	Groundwater - Percent Demand (%)												Max. (%)	Stress Level
	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec		
Future	2.9	3.3	2.1	2.1	1.8	1.7	2.1	1.9	1.7	1.8	1.9	3.1	3.3	LOW
Mississippi River (Outlet)														
Current	1.7	1.9	1.7	1.8	1.7	1.8	3.0	3.0	1.8	1.7	1.8	1.7	3.0	LOW
Future	1.7	1.9	1.7	1.8	1.7	1.8	3.0	3.0	1.8	1.7	1.8	1.7	3.0	LOW
Carp River Near Kinburn														
Current	4.1	4.2	4.0	4.2	4.6	4.7	5.8	5.6	4.5	4.2	4.1	4.1	5.8	LOW
Future	4.7	4.7	4.6	4.8	5.4	5.4	6.5	6.3	5.1	4.8	4.7	4.6	6.5	LOW
Carp River (Outlet)														
Current	0.4	0.4	0.4	0.6	0.6	0.6	2.0	2.0	0.6	0.4	0.4	0.4	2.0	LOW
Future	0.4	0.4	0.4	0.6	0.6	0.6	2.0	2.0	0.6	0.4	0.4	0.4	2.0	LOW
Ottawa MVC														
Current	1.9	1.9	1.9	1.9	1.9	8.2	9.3	9.3	8.2	1.9	1.9	1.9	9.3	LOW
Future	1.9	1.9	1.9	1.9	1.9	8.2	9.3	9.3	8.2	1.9	1.9	1.9	9.3	LOW
RIDEAU VALLEY CONSERVATION AUTHORITY														
Tay River At Perth														
Current	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	LOW
Future	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	LOW
Rideau River At Smiths Falls														
Current	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.6	LOW
Future	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.6	0.5	0.5	0.5	0.7	LOW
Rideau River Below Merrickville														
Current	2.6	2.7	2.6	2.9	2.9	2.9	3.3	3.3	2.9	2.8	2.6	2.6	3.3	LOW
Future	2.8	2.8	2.8	3.0	3.0	3.0	3.4	3.4	3.0	3.0	2.7	2.7	3.4	LOW
Kemptville Creek Near Kemptville														
Current	0.2	0.2	0.2	0.2	0.2	0.2	0.6	0.6	0.2	0.2	0.2	0.2	0.6	LOW

Subwatershed	Groundwater - Percent Demand (%)												Max. (%)	Stress Level
	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec		
Future	0.2	0.2	0.2	0.2	0.2	0.2	0.6	0.6	0.2	0.2	0.2	0.2	0.6	LOW
Rideau River Below Manotick														
Current	5.0	5.1	5.3	5.3	5.8	6.1	6.6	6.6	6.0	5.8	5.3	4.9	6.6	LOW
Future	5.9	6.0	6.2	6.2	6.7	7.0	7.5	7.4	6.9	6.6	6.1	5.6	7.5	LOW
Jock River Near Richmond														
Current	5.4	5.3	5.9	7.0	7.0	6.9	7.6	7.5	6.9	6.0	5.9	5.4	7.6	LOW
Future	5.4	5.3	5.9	7.1	7.1	6.9	7.6	7.6	6.9	6.1	6.0	5.5	7.6	LOW
Rideau River At Ottawa														
Current	7.0	7.2	9.9	14.9	14.7	14.9	15.2	15.2	14.9	9.9	9.4	7.0	15.2	LOW
Future	7.0	7.2	9.9	14.9	14.7	14.9	15.2	15.2	14.9	9.9	9.4	7.0	15.2	LOW
Rideau River (Outlet)														
Current	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0	0.5	0.5	0.5	0.5	1.0	LOW
Future	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0	0.5	0.5	0.5	0.5	1.0	LOW
Ottawa West (RVCA)														
Current	5.9	5.9	5.9	5.9	5.9	5.9	7.0	7.0	5.9	5.9	5.9	5.9	7.0	LOW
Future	5.9	5.9	5.9	5.9	5.9	5.9	7.0	7.0	5.9	5.9	5.9	5.9	7.0	LOW
Ottawa East (RVCA)														
Current	2.7	2.7	2.7	3.2	3.4	3.4	3.7	3.7	3.4	3.1	2.7	2.7	3.7	LOW
Future	2.7	2.7	2.7	3.2	3.4	3.4	3.7	3.7	3.4	3.1	2.7	2.7	3.7	LOW

Table 7.2-3 Annual Groundwater Percent Demand and Assigned Stress Level in MVC and RVCA Subwatersheds

MVC Subwatershed	Scenario	% Water Demand	Stress Level	RVCA Subwatershed	Scenario	% Water Demand	Stress Level
Mississippi Below Marble Lake	Current	0.1	LOW	**Tay River At Perth**	Current	0.4	LOW
	Future	0.1	LOW		Future	0.4	LOW
Mississippi River At High Falls	Current	0.1	LOW	**Rideau River Above Smiths Falls**	Current	0.6	LOW
	Future	0.1	LOW		Future	0.6	LOW
Clyde River Near Lanark	Current	0.6	LOW	**Rideau River Below Merrickville**	Current	2.8	LOW
	Future	0.6	LOW		Future	3.0	LOW
Fall River At Bennett Lake	Current	0.2	LOW	**Kemptville Creek Near Kemptville**	Current	0.3	LOW
	Future	0.2	LOW		Future	0.3	LOW
Mississippi River At Fergusons Falls	Current	1.4	LOW	**Rideau River Below Manotick**	Current	5.7	LOW
	Future	1.4	LOW		Future	6.5	LOW
Mississippi At Appleton	Current	0.5	LOW	**Jock River Near Richmond**	Current	6.4	LOW
	Future	0.5	LOW		Future	6.5	LOW
Indian River Near Blakeney	Current	1.3	LOW	**Rideau River At Ottawa**	Current	11.7	MODERATE
	Future	1.3	LOW		Future	11.7	MODERATE
Mississippi River At Galetta	Current	1.8	LOW	**Rideau River (Outlet)**	Current	0.6	LOW
	Future	2.2	LOW		Future	0.6	LOW
Mississippi River (Outlet)	Current	2.0	LOW	**Ottawa RVCA (West)**	Current	6.1	LOW
	Future	2.0	LOW		Future	6.1	LOW
Carp River At Kinburn	Current	4.5	LOW	**Ottawa RVCA (East)**	Current	3.1	LOW
	Future	5.1	LOW		Future	3.1	LOW
Carp River (Outlet)	Current	0.7	LOW				
	Future	0.7	LOW				
Ottawa MVC	Current	4.2	LOW				
	Future	4.2	LOW				

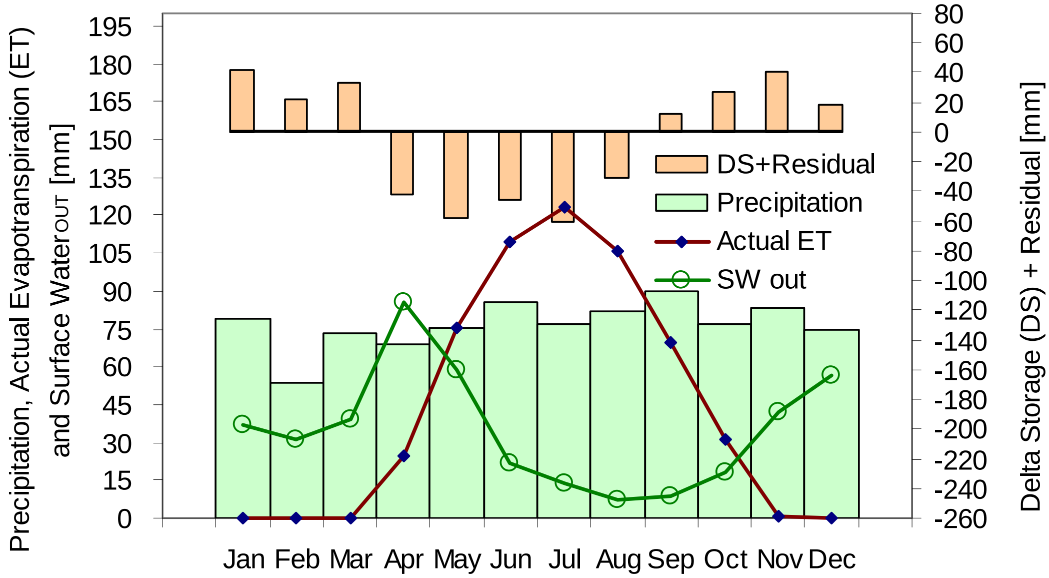
Table 7.4-1 Tier 1 Stress Assessment Summary for MVC and RVCA Subwatersheds

Subwatershed Name [Gauge ID in sq. brackets]	Municipal System		Final Stress Level		Historical Issues	Is Tier 2 required?
	SW	GW	SW	GW		
MISSISSIPPI VALLEY CONSERVATION						
Mississippi River Below Marble Lake [02KF016]	-	-	Low	Low	None	No
Mississippi River at High Falls [Generating Station]	-	-	Low	Low	None	No
Clyde River Near Lanark (02KF010)	-		Low	Low	None	No
Fall River At Bennett Lake [02KF014/18]	-	-	Moderate	Low	None	No
Mississippi River At Fergusons Falls [02KF001]	-	-	Low	Low	None	No
Mississippi River At Appleton [02KF006]	Carleton Place	-	Low	Low	None	No
Indian River Near Blakeney [02KF012]	-	-	Low	Low	None	No
Mississippi R. At Galetta	-	Almonte	Low	Low	None	No
Mississippi R. (Outlet)	-	-	Low	Low	None	No
Carp River Near Kinburn [02KF011]	-	Carp	Moderate	Low	None	No
Carp River (Outlet)	-	-	Low	Low	None	No
Ottawa MVC	-	-	Moderate	Low	None	No
RIDEAU VALLEY CONSERVATION AUTHORITY						
Tay R. At Perth [02LA024]	Perth	-	Low	Low	None	No
Rideau River Above Smiths Falls [02LA005]	-	Westport	Low	Low	None	No
Rideau River Below Merrickville [02LA011]	Smiths Falls	Merrickville	Low	Low	None	No
Kemptville Creek Near Kemptville [02LA006]	-	-	Low	Low	None	No
Rideau River Below Manotick [02LA012]	-	Kemptville	Low	Low	None	No
Jock River Near Richmond [02LA007]	-	Munster & Kings Park	Low	Low	None	No
Rideau River At Ottawa [02LA004]	-	-	Low	Moderate	None	No
Rideau River (Outlet)	-	-	Low	Low	None	No
Ottawa West	-	-	Low	Low	None	No
Ottawa East	-	-	Low	Low	None	No

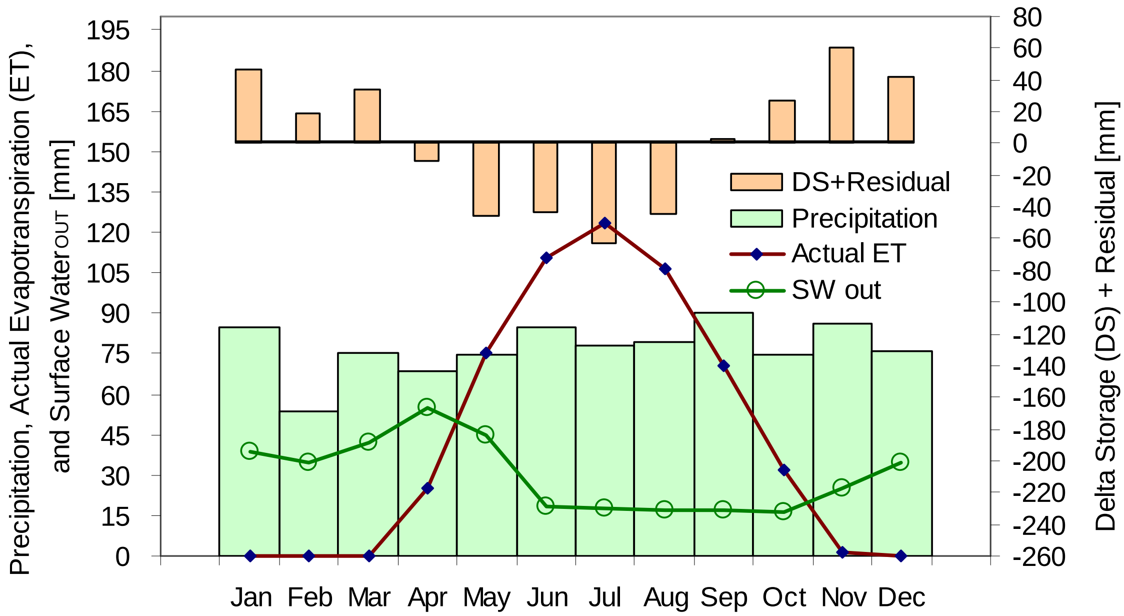
Long-Term Monthly Water Budgets (1971-2000)

MVC Subwatersheds

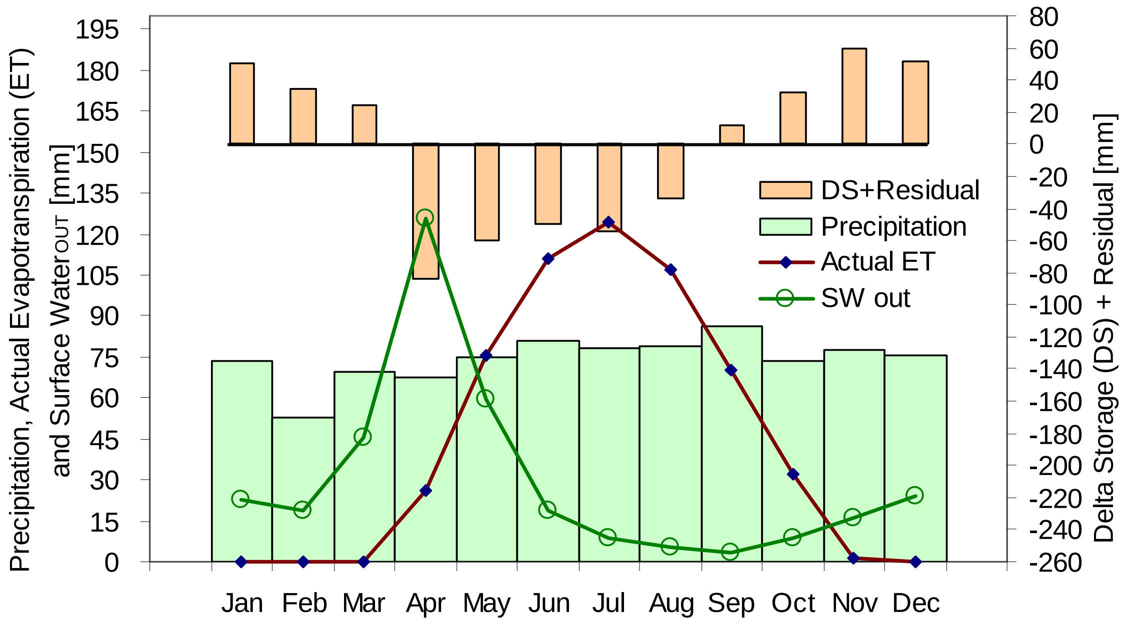
Graph 3.4-1 Monthly Water Budget – Mississippi River Below Marble Lake (02KF016)



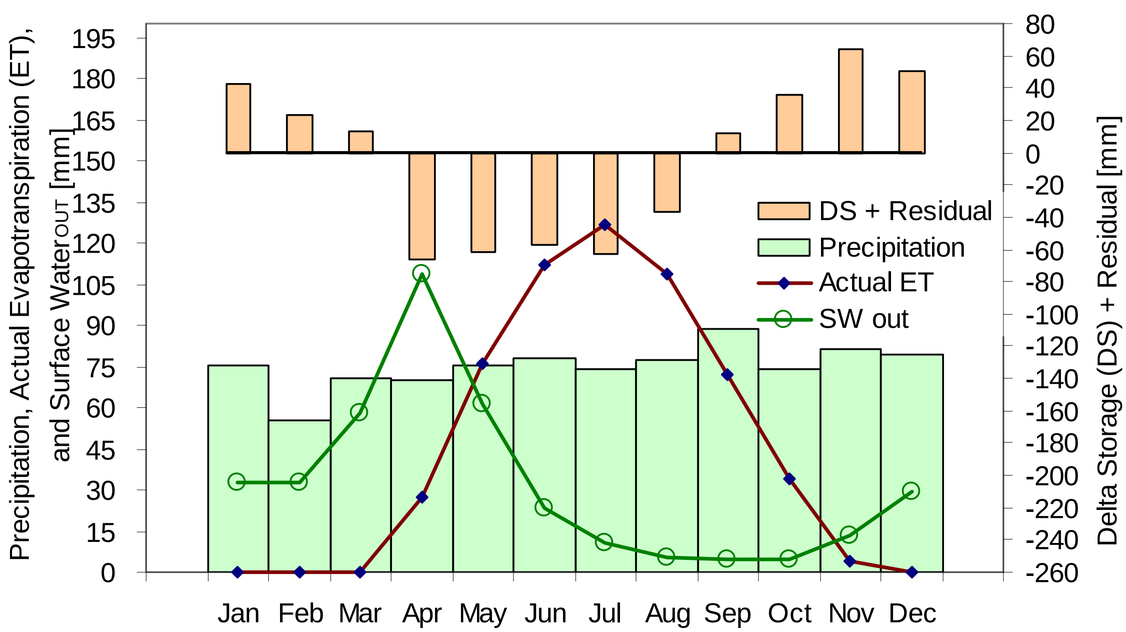
Graph 3.4-2 Monthly Water Budget – Mississippi River At High Falls (OPG Gauge)



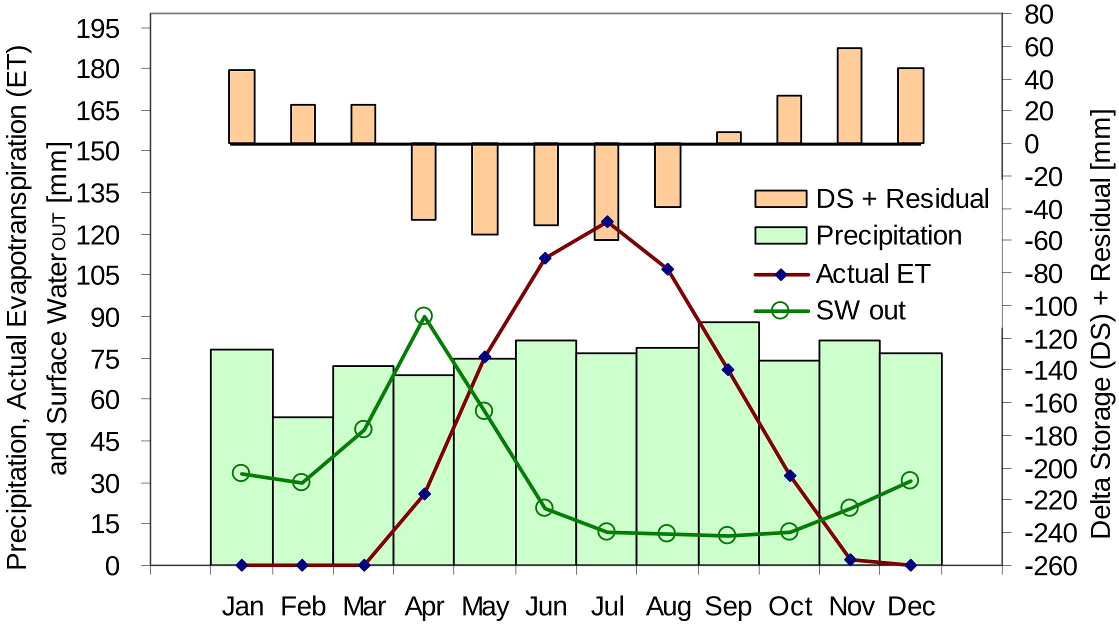
Graph 3.4-3 Monthly Water Budget – Clyde River Near Lanark (02KA010)



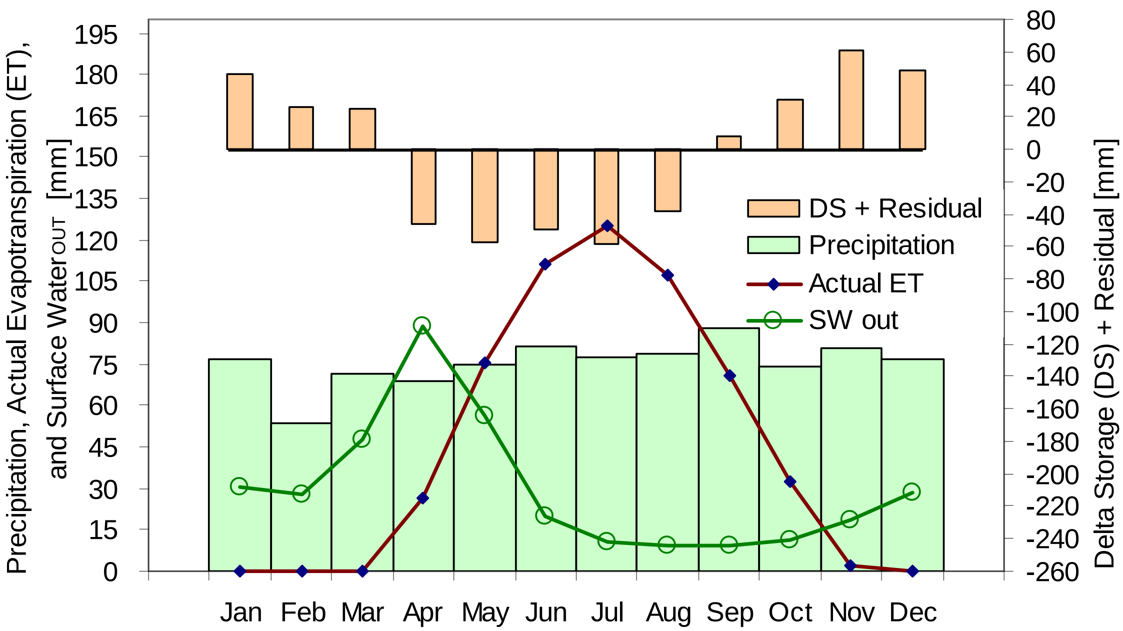
Graph 3.4-4 Monthly Water Budget – Fall River At Bennett Lake (02KF014)



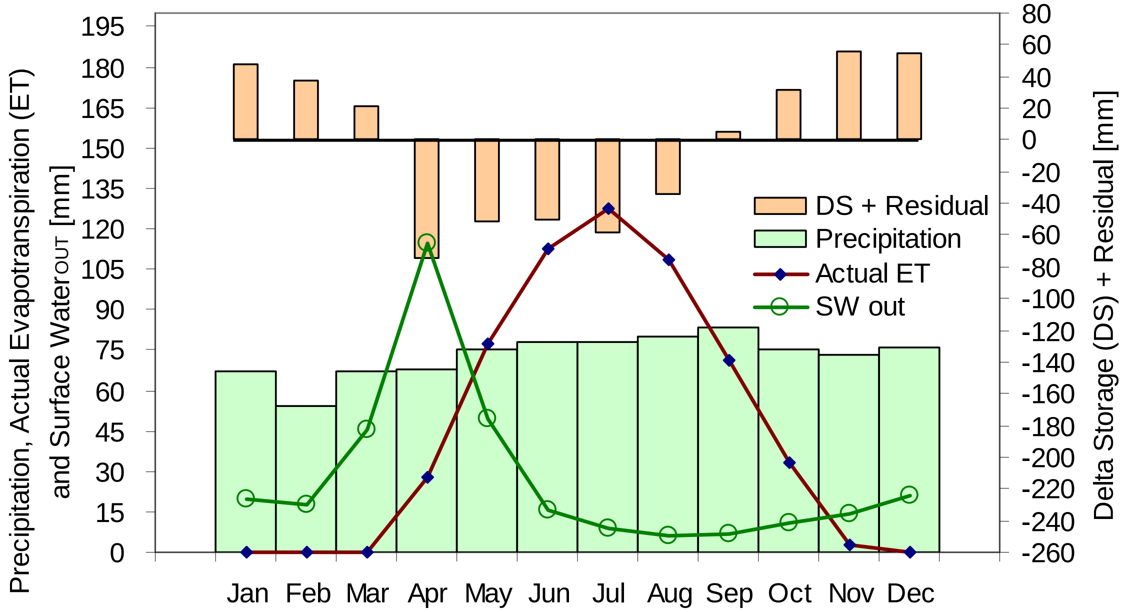
Graph 3.4-5 Monthly Water Budget – Mississippi River At Fergusons Falls (02KF001)



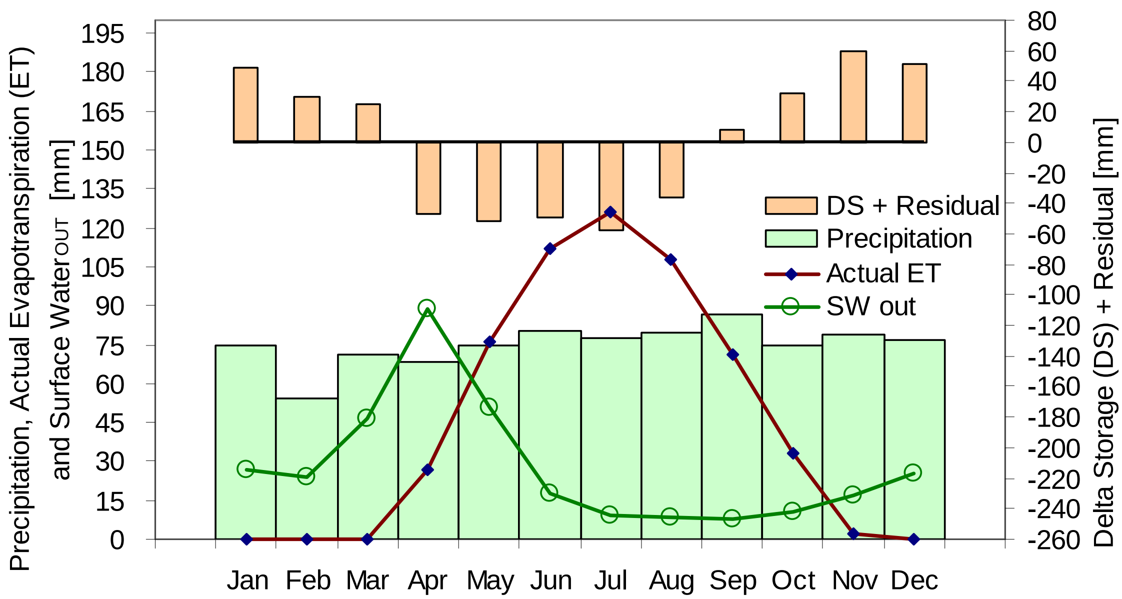
Graph 3.4-6 Monthly Water Budget – Mississippi River At Appleton (02KF006)



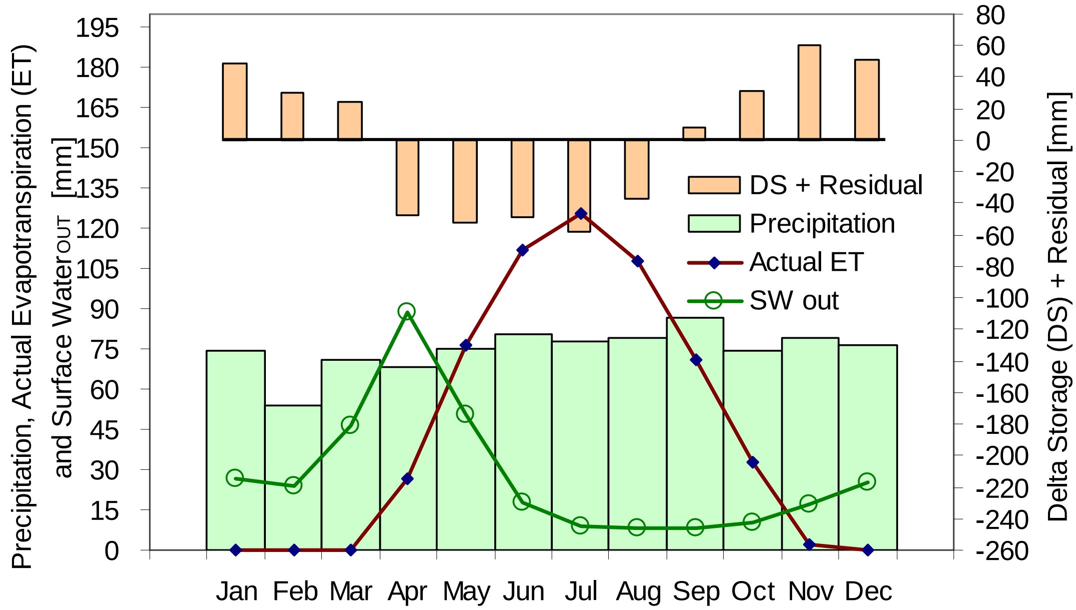
Graph 3.4-7 Monthly Water Budget – Indian River Near Blakeney (02KF012)



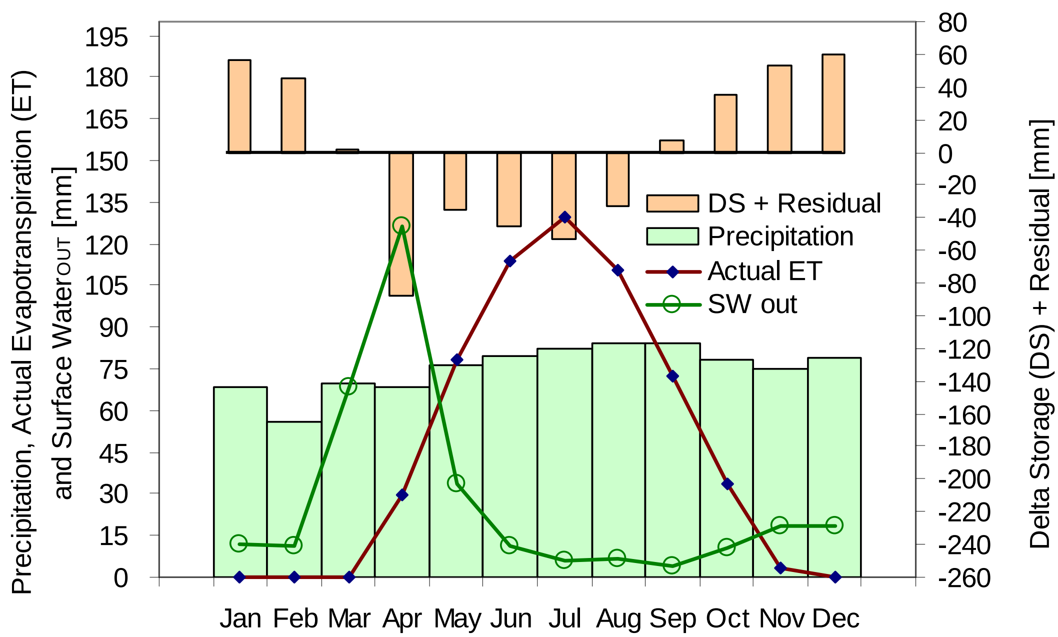
Graph 3.4-8 Monthly Water Budget – Mississippi River At Galetta (ungauged)



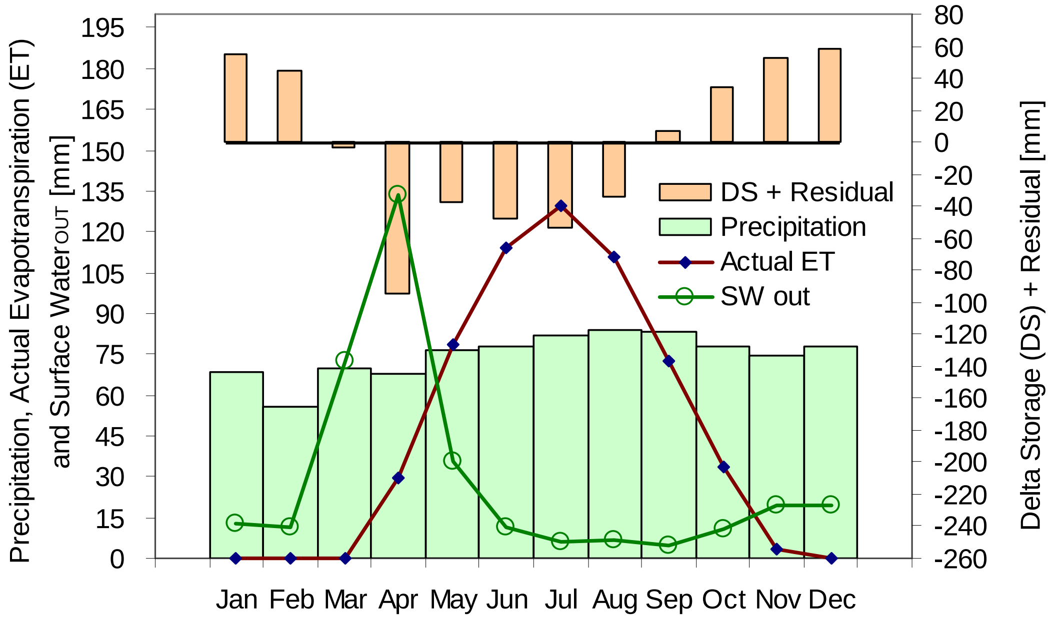
Graph 3.4-9 Monthly Water Budget – Mississippi River (Outlet) (ungauged)



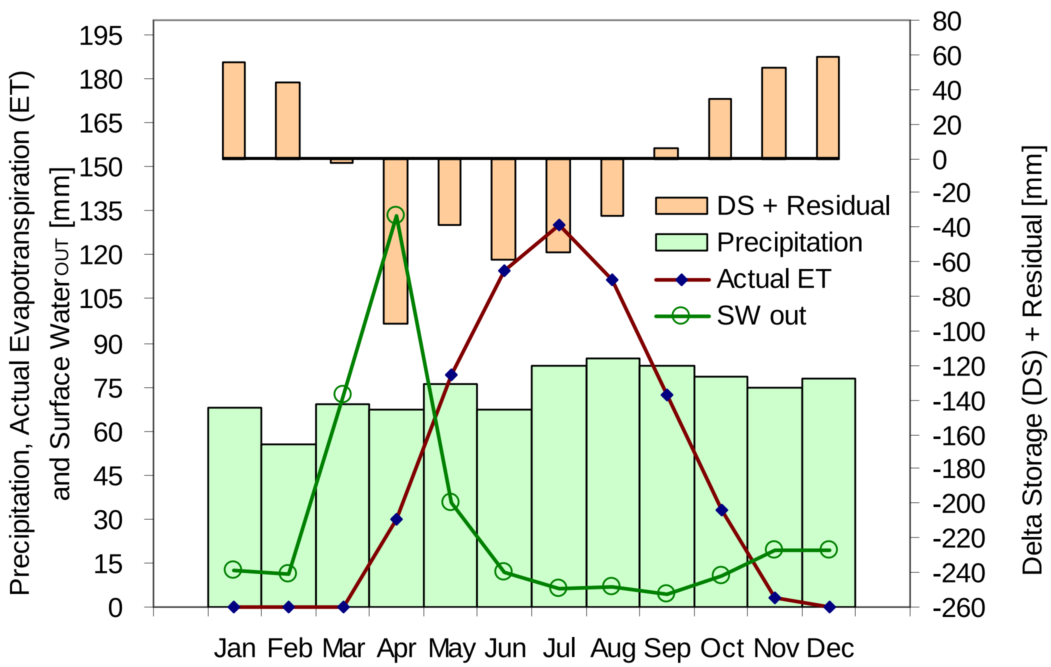
Graph 3.4-10 Monthly Water Budget – Carp River Near Kinburn (02KF011)



Graph 3.4-11 Monthly Water Budget – Carp River (Outlet) (ungauged)



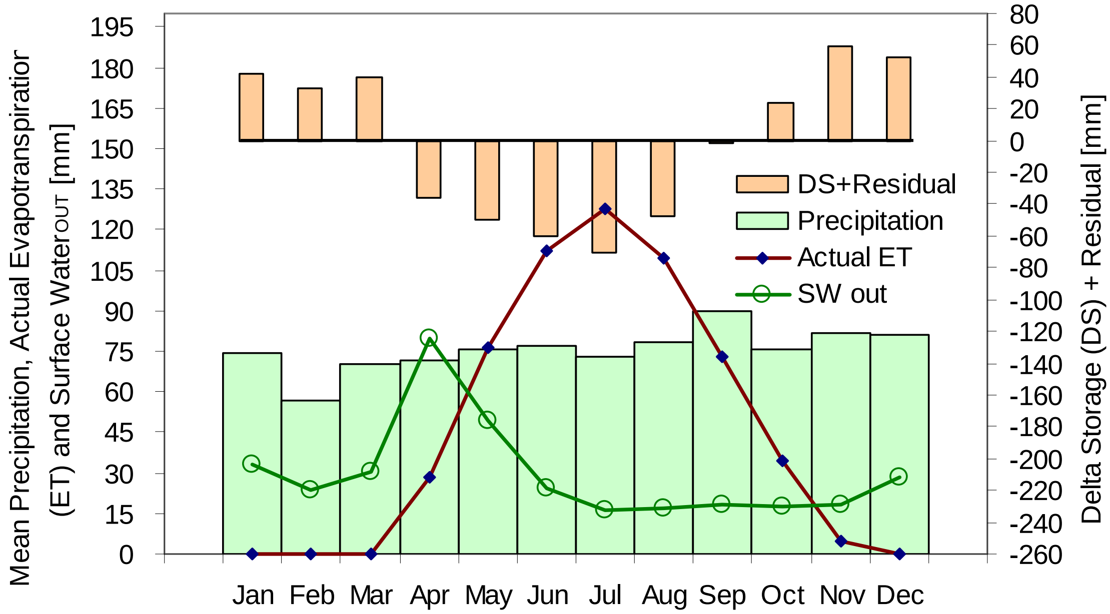
Graph 3.4-12 Monthly Water Budget – Ottawa MVC (ungauged)



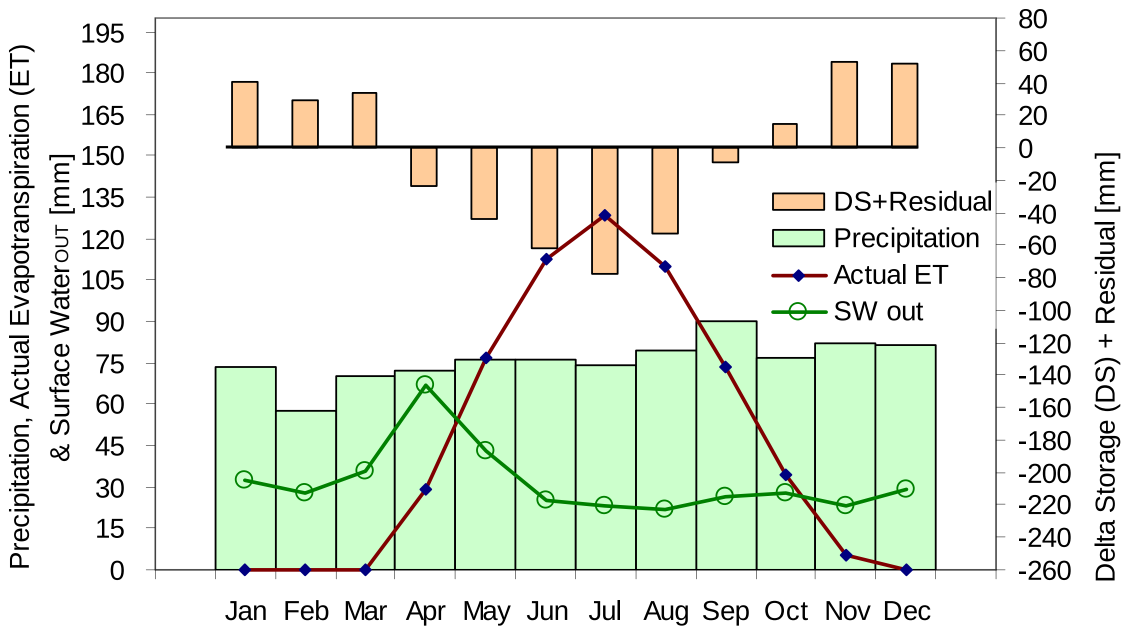
Long-Term Monthly Water Budgets (1971-2000)

RVCA Subwatersheds

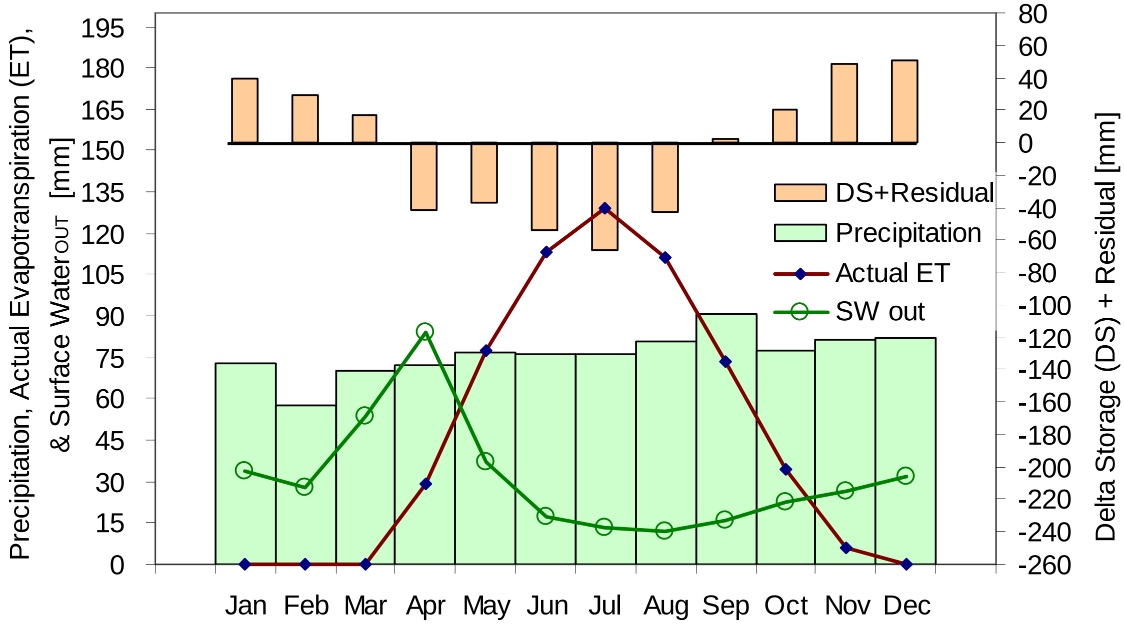
Graph 3.4-13 Monthly Water Budget – Tay River At Perth (02LA024)



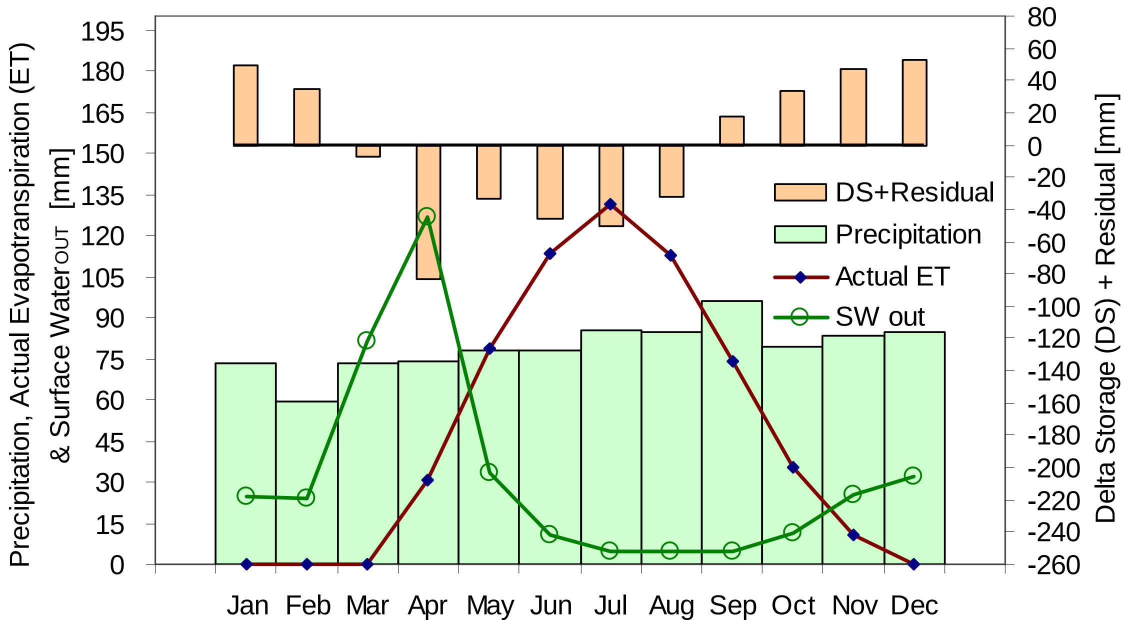
Graph 3.4-14 Monthly Water Budget – Rideau River Above Smiths Falls (02LA005)



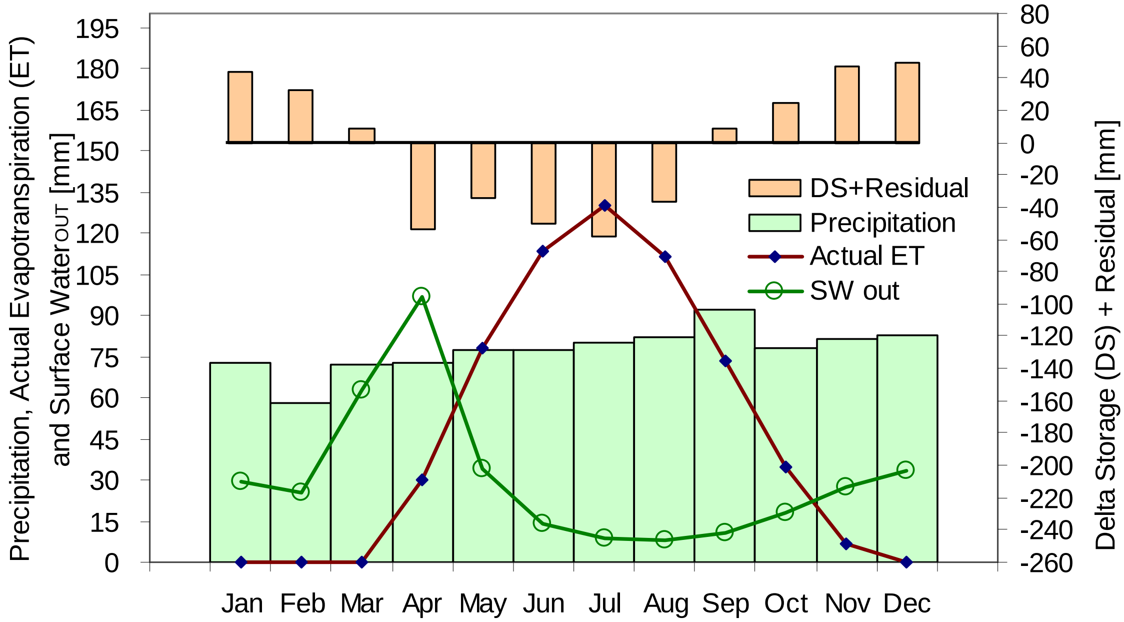
Graph 3.4-15 Monthly Water Budget – Rideau River Below Merrickville (02LA011)



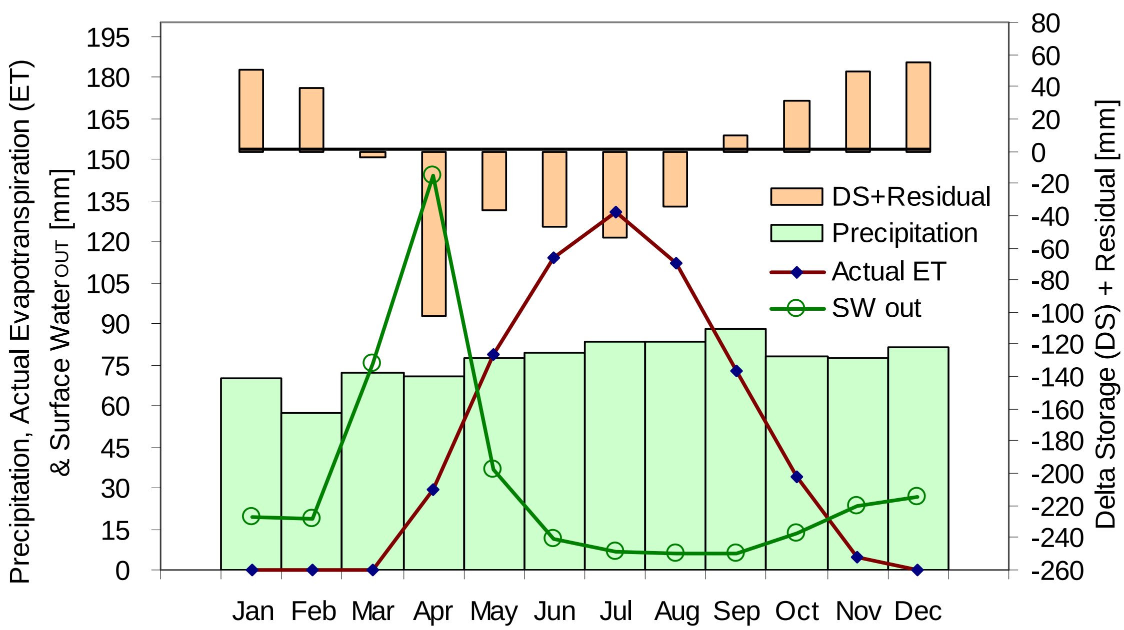
Graph 3.4-16 Monthly Water Budget – Kemptville Creek Near Kemptville (02LA006)



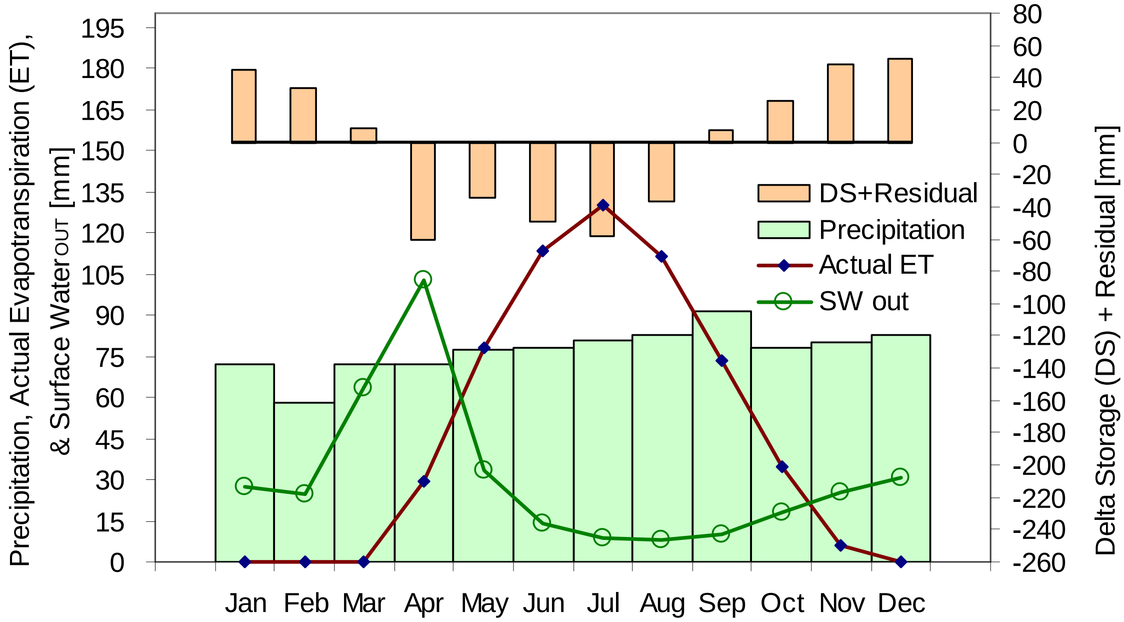
Graph 3.4-17 Monthly Water Budget – Rideau River Below Manotick (02LA012)



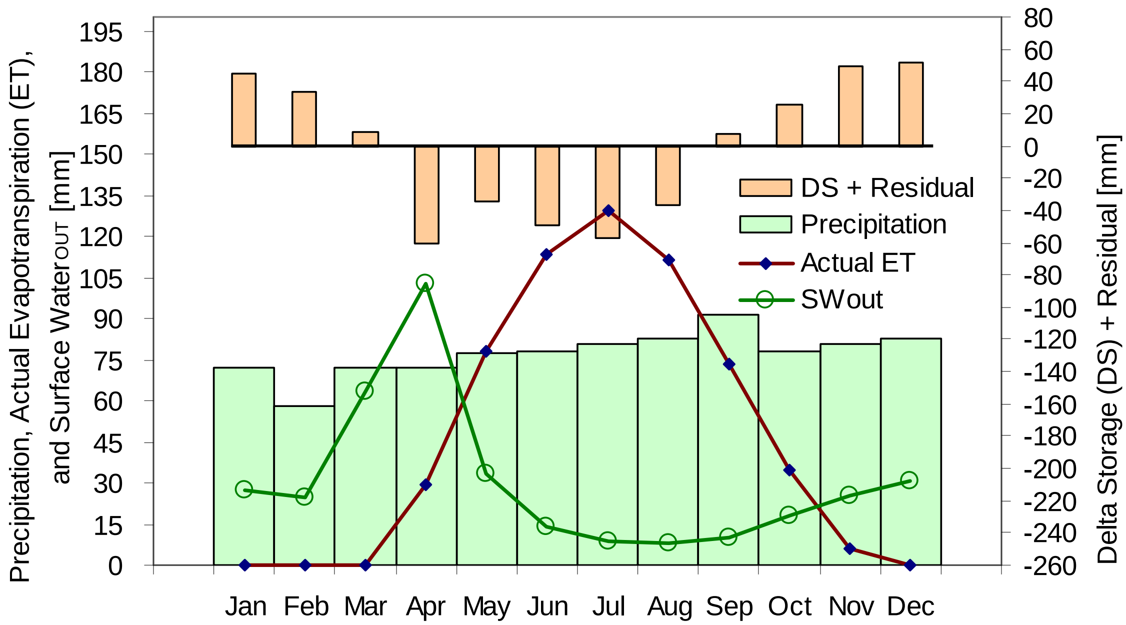
Graph 3.4-18 Monthly Water Budget – Jock River Near Richmond (02LA007)



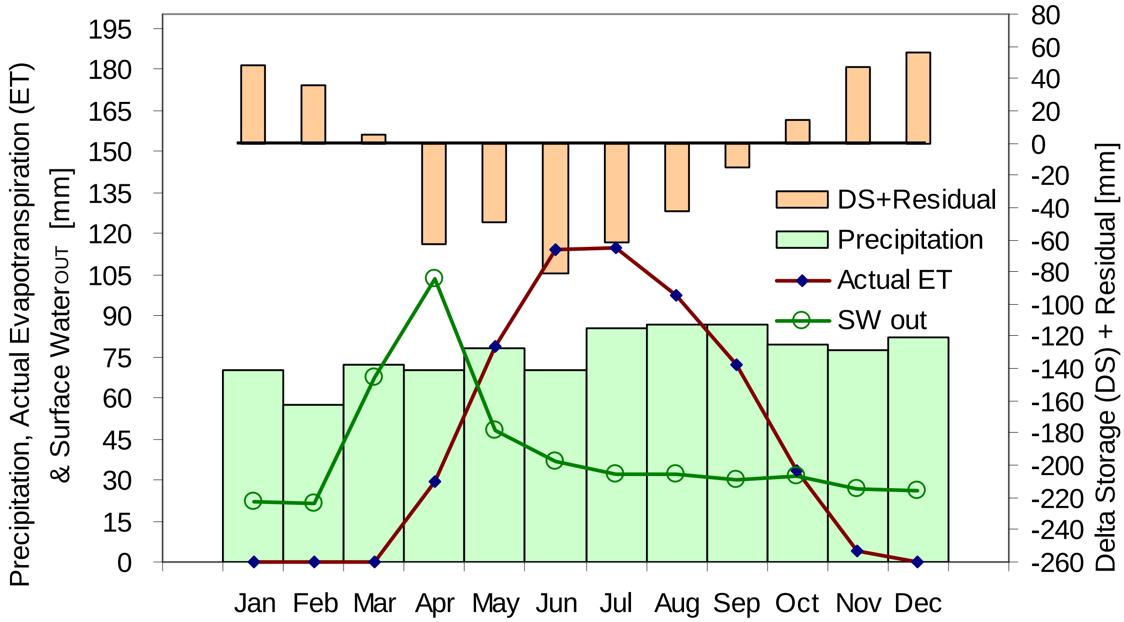
Graph 3.4-19 Monthly Water Budget – Rideau River At Ottawa (02LA004)



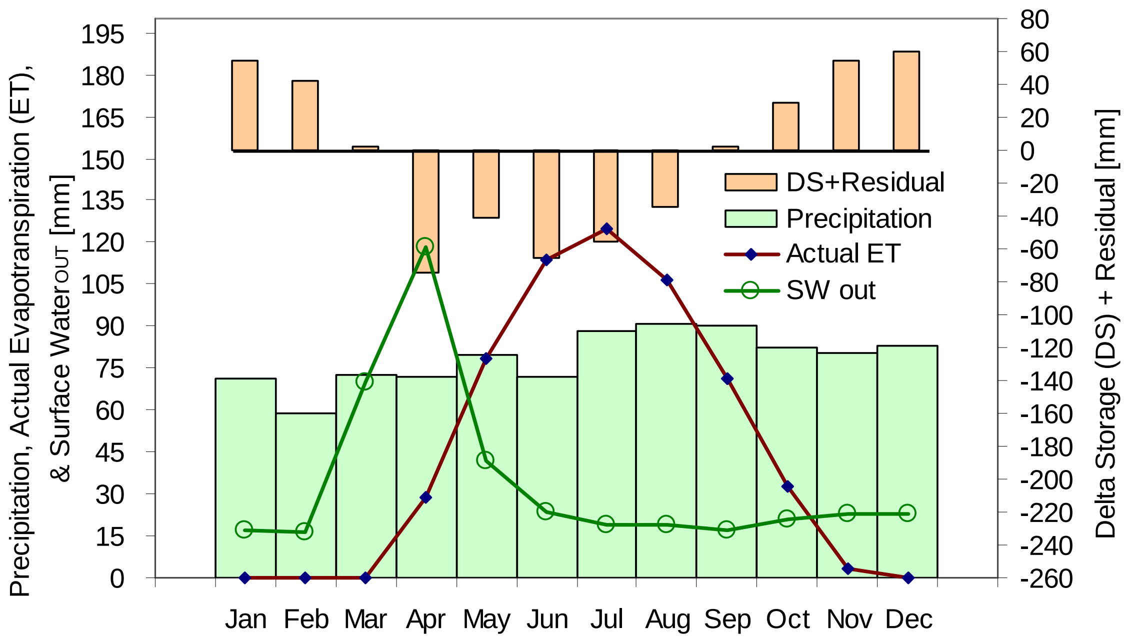
Graph 3.4-20 Monthly Water Budget – Rideau River (Outlet) (ungauged)



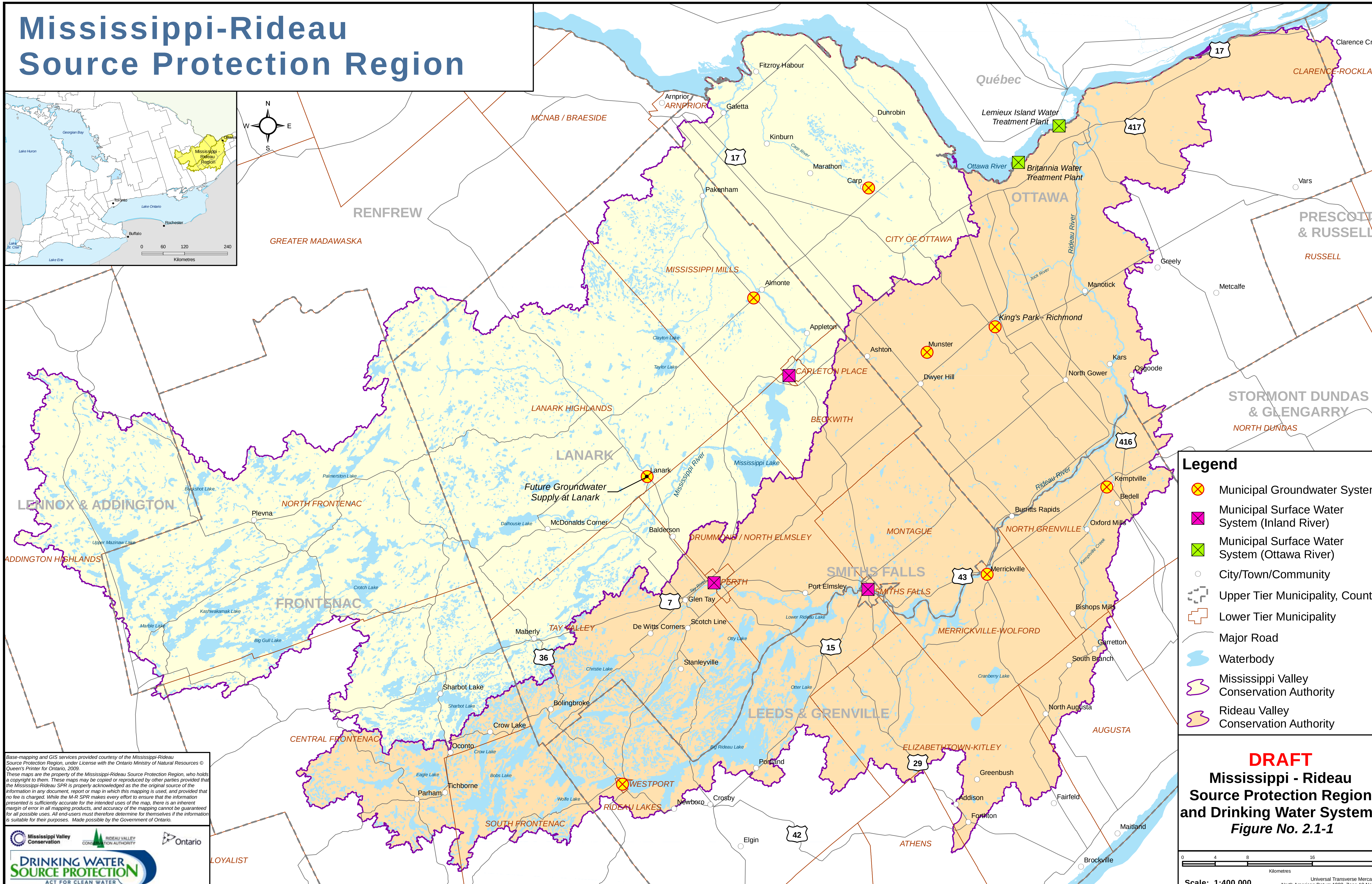
Graph 3.4-21 Monthly Water Budget – Ottawa RVCA West (ungauged)



Graph 3.4-22 Monthly Water Budget – Ottawa RVCA East (ungauged)



Mississippi-Rideau Source Protection Region



DRAFT

Mississippi - Rideau Source Protection Region and Drinking Water Systems

Figure No. 2.1-1

Scale: 1:400,000

Universal Transverse Mercator
North American Datum 1983, Zone 18 North

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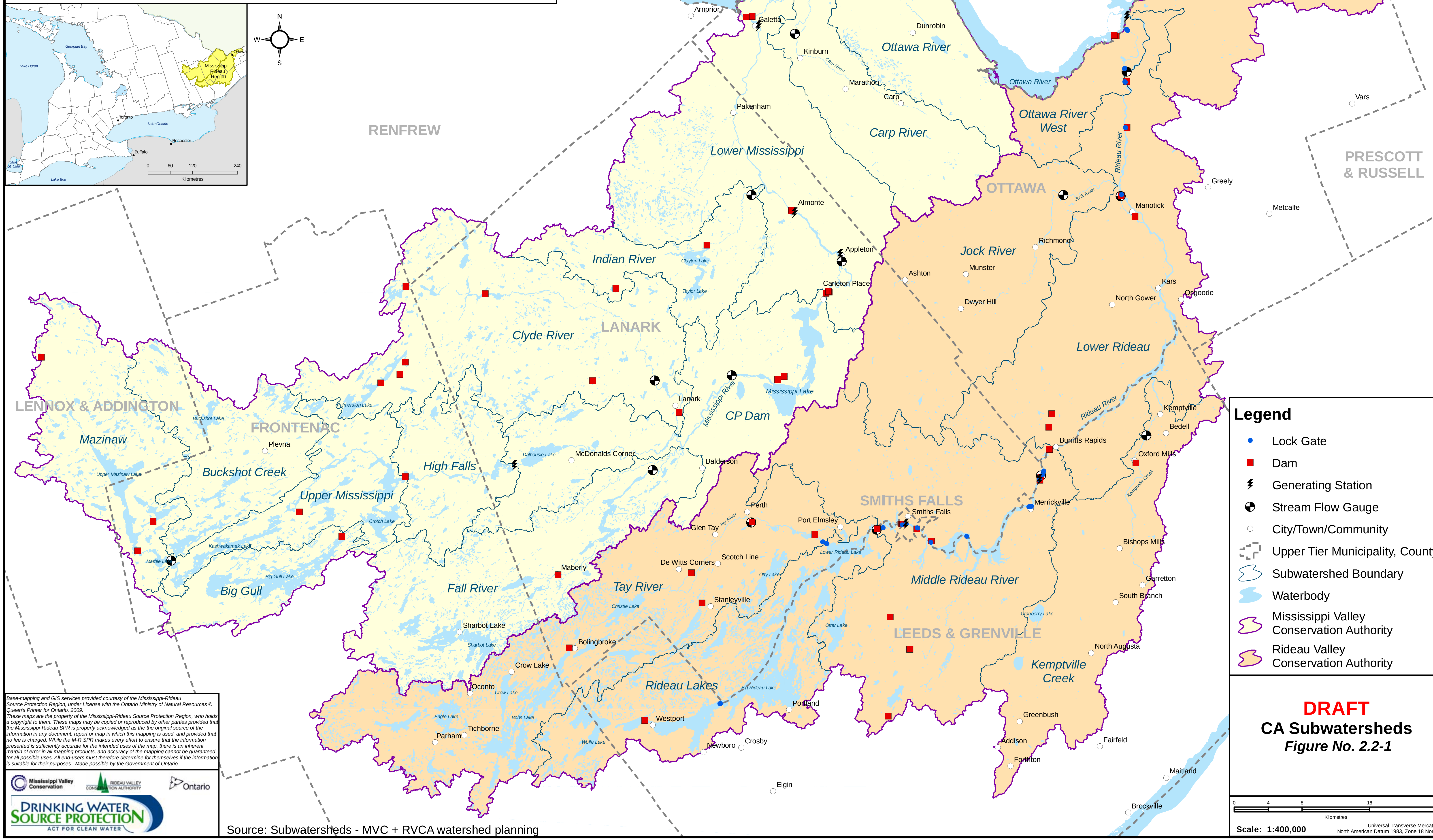
DRINKING WATER SOURCE PROTECTION — ACT FOR CLEAN WATER

FILE LOCATION: V:\Mapping\MXDs\SWP\03 Water Budget\Tier_1\Draft_June2009\Figure 2.1-1.mxd

Mississippi-Rideau Source Protection Region



DRAFT
CA Subwatersheds
Figure No. 2.2-1

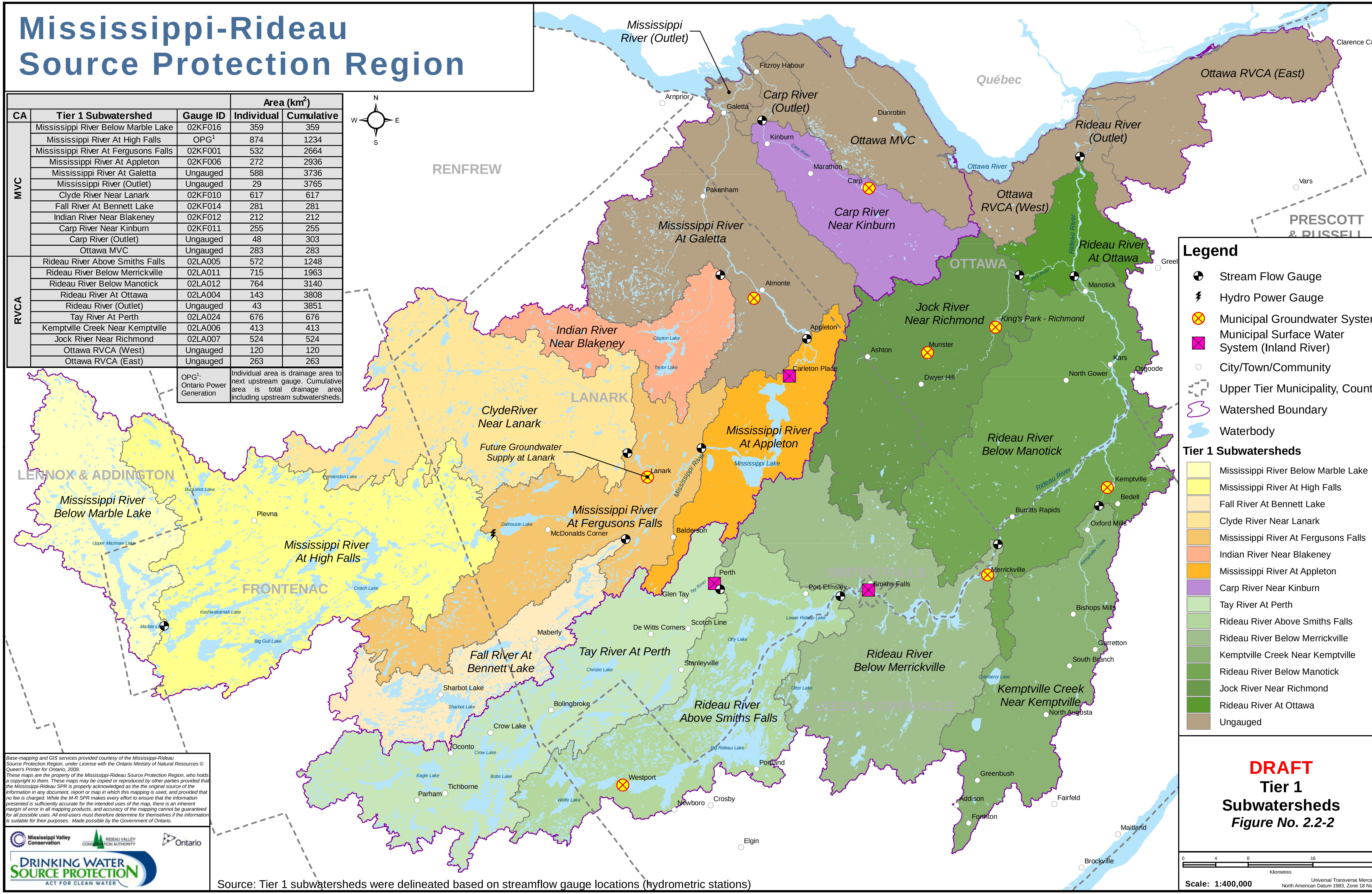
Source: Subwatersheds - MVC + RVCA watershed planning

Mississippi-Rideau Source Protection Region

			Area (km²)	
CA	Tier 1 Subwatershed	Gauge ID	Individual	Cumulative
MVC	Mississippi River Below Marble Lake	02KF016	359	359
MVC	Mississippi River At High Falls	OPG[1]	874	1234
MVC	Mississippi River At Fergusons Falls	02KF001	532	2664
MVC	Mississippi River At Appleton	02KF006	272	2936
MVC	Mississippi River At Galetta	Ungauged	588	3736
MVC	Mississippi River (Outlet)	Ungauged	29	3765
MVC	Clyde River Near Lanark	02KF010	617	617
MVC	Fall River At Bennett Lake	02KF014	281	281
MVC	Indian River Near Blakeney	02KF012	212	212
MVC	Carp River Near Kinburn	02KF011	255	255
MVC	Carp River (Outlet)	Ungauged	48	303
MVC	Ottawa MVC	Ungauged	283	283
RVCA	Rideau River Above Smiths Falls	02LA005	572	1248
RVCA	Rideau River Below Merrickville	02LA011	715	1963
RVCA	Rideau River Below Manotick	02LA012	764	3140
RVCA	Rideau River At Ottawa	02LA004	143	3808
RVCA	Rideau River (Outlet)	Ungauged	43	3851
RVCA	Tay River At Perth	02LA024	676	676
RVCA	Kemptville Creek Near Kemptville	02LA006	413	413
RVCA	Jock River Near Richmond	02LA007	524	524
RVCA	Ottawa RVCA (West)	Ungauged	120	120
RVCA	Ottawa RVCA (East)	Ungauged	263	263

OPG[1]: Ontario Power Generation

Individual area is drainage area to next upstream gauge. Cumulative area is total drainage area including upstream subwatersheds.



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Tier 1 Subwatersheds

Figure No. 2.2-2

Source: Tier 1 subwatersheds were delineated based on streamflow gauge locations (hydrometric stations)

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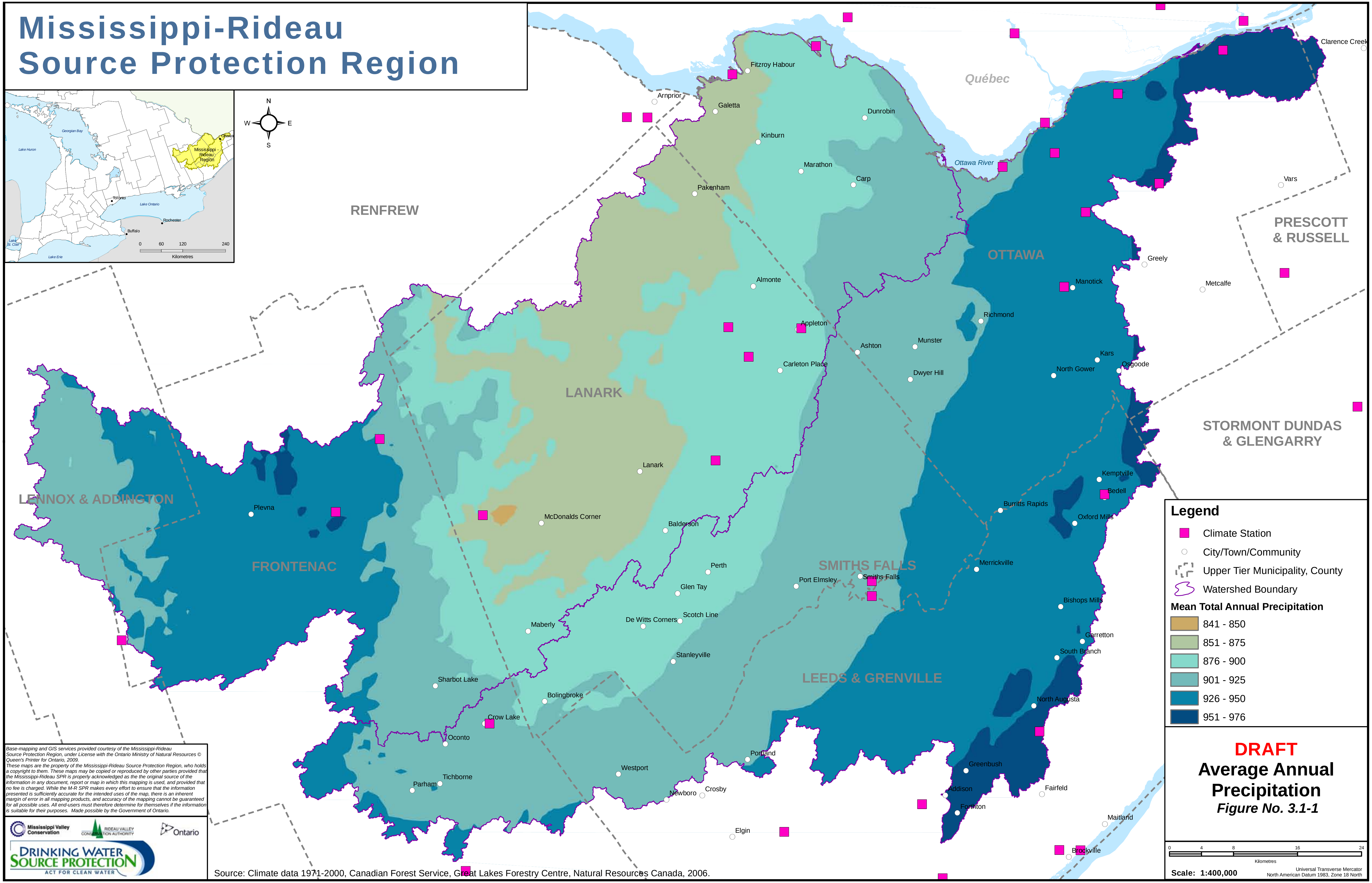
DRINKING WATER SOURCE PROTECTION — ACT FOR CLEAN WATER

FILE LOCATION: V:\Mapping\MXDs\SWP03 Water Budget\Tier_1\Draft_June2009\Figure 2.2-2.mxd



Mississippi-Rideau
Source Protection Region
N
W
E
S
Georgian Bay
Lake Huron
Mississippi-Rideau Region
Ottawa
Toronto
Lake Ontario
Rochester
Buffalo
Lake St. Clair
Lake Erie
0 60 120 240
Kilometres
RENFREW
LANARK
LENNOX & ADDINGTON
FRONTENAC
OTTAWA
PRESCOTT & RUSSELL
STORMONT DUNDAS & GLENGARRY
SMITHS FALLS
LEEDS & GRENVILLE
Québec
Ottawa River
Clarence Creek
Fitzroy Habour
Arnprior
Galetta
Dunrobin
Kinburn
Marathon
Carp
Pakenham
Vars
Greely
Metcalfe
Manotick
Almonte
Richmond
Appleton
Ashton
Munster
Carleton Place
Dwyer Hill
Kars
Osgoode
North Gower
Lanark
Kemptville
Bedell
Plevna
McDonalds Corner
Burritts Rapids
Oxford Mills
Balderson
Merrickville
Perth
Smiths Falls
Port Elmsley
Glen Tay
Bishops Mills
Maberly
De Witts Corners
Scotch Line
Garretton
South Branch
Stanleyville
Sharbot Lake
Bolingbroke
North Augusta
Crow Lake
Oconto
Portland
Greenbush
Westport
Tichborne
Parham
Crosby
Newboro
Addison
Fairfeld
Forthton
Maitland
Elgin
Brockville
Legend
Climate Station
City/Town/Community
Upper Tier Municipality, County
Watershed Boundary
Mean Total Annual Precipitation
841 - 850
851 - 875
876 - 900
901 - 925
926 - 950
951 - 976
DRAFT
Average Annual Precipitation
Figure No. 3.1-1
0 4 8 16 24
Kilometres
Scale: 1:400,000
Universal Transverse Mercator
North American Datum 1983, Zone 18 North
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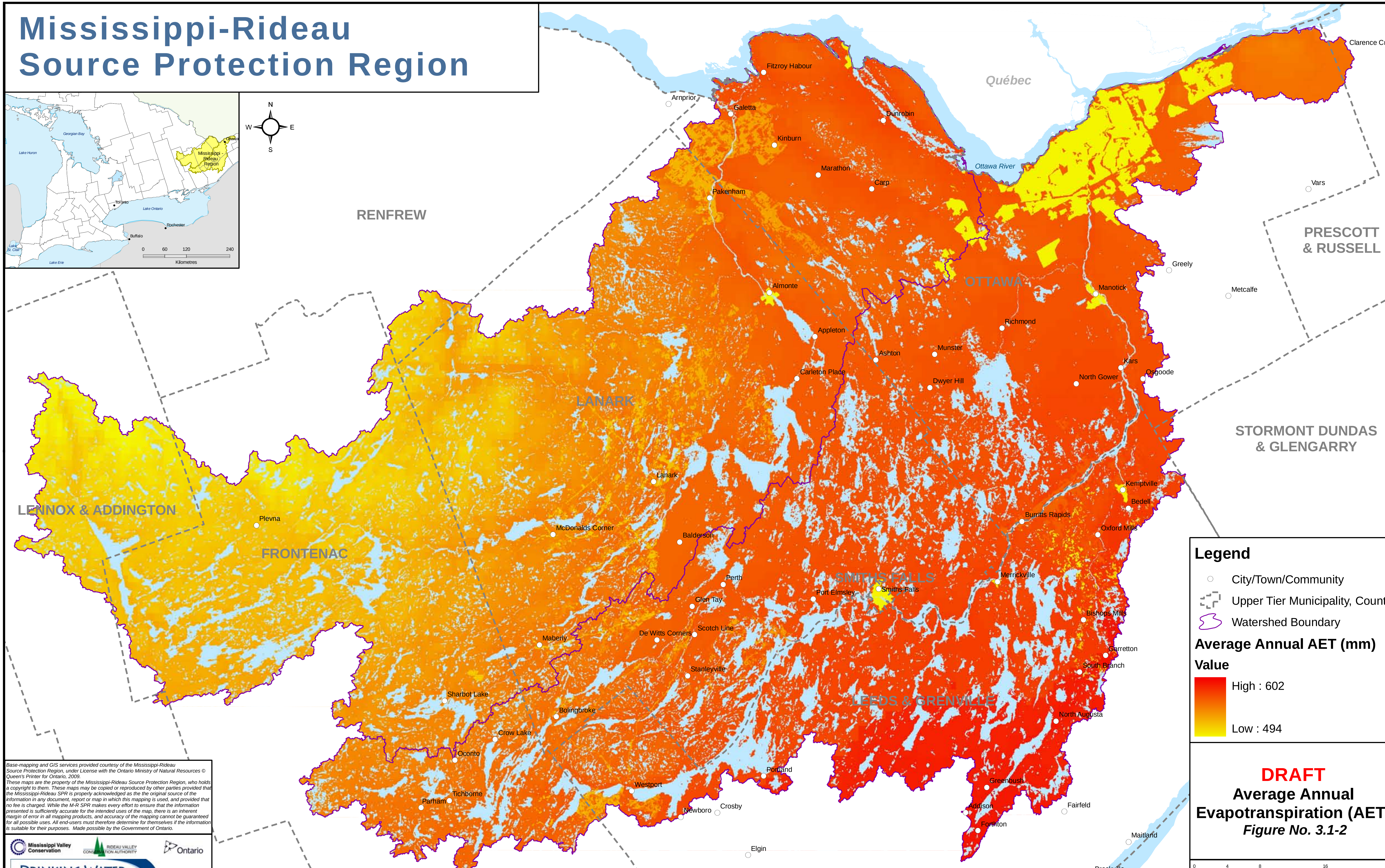
Mississippi Valley Conservation
Rideau Valley Conservation Authority
Ontario
Drinking Water Source Protection
Act for Clean Water
Source: Climate data 1971-2000, Canadian Forest Service, Great Lakes Forestry Centre, Natural Resources Canada, 2006.

Mississippi-Rideau Source Protection Region



Legend

- City/Town/Community
- Upper Tier Municipality, County
- Watershed Boundary

Average Annual AET (mm)

Value

High : 602

Low : 494

DRAFT

Average Annual Evapotranspiration (AET)

Figure No. 3.1-2

0 4 8 16 24

Kilometres

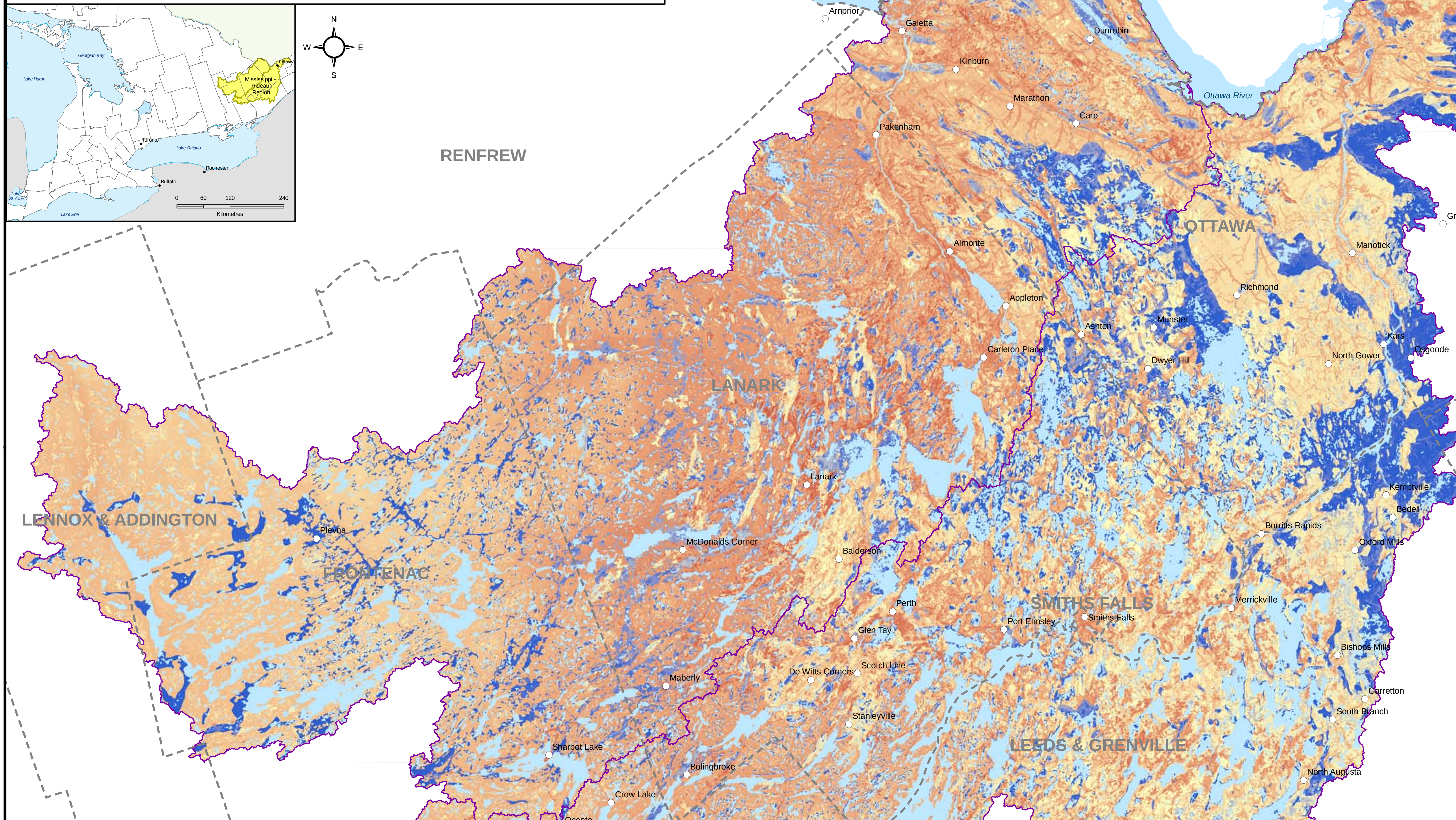
Scale: 1:400,000

Universal Transverse Mercator
North American Datum 1983, Zone 18 North

Source: Evapotranspiration values were calculated using Thornthwaite and Mather (1957) equations with climate data from the Canadian Forestry Service - Sault Ste. Marie (McKenney et al. 2006. Spatial Models of Canada and North America - 1971/2000 - Minimum and Maximum Temperature, Precipitation, and Derived Bioclimatic Variables, Technical Note No. 106.)

FILE LOCATION: V:\Mapping\MXDs\SWP\03 Water Budget\Tier_1\Draft_June2009\Figure 3.1-2.mxd

Mississippi-Rideau Source Protection Region



Legend

- City/Town/Community
- Upper Tier Municipality, County
- Watershed Boundary

Recharge Rate (mm/yr)

Value

High : 332

Low : 40

DRAFT

Calculated Groundwater Recharge (MOEE 1995)

Figure No. 3.1-3

0 4 8 16 24
Kilometres

Scale: 1:400,000

Universal Transverse Mercator
North American Datum 1983, Zone 18 North

Source: Groundwater recharge was calculated using the MOEE (1995) method, modified to suit the bedrock geology of the Mississippi-Rideau Source Protection Region.
Details of the approach are given in Appendix G of the Conceptual Water Budget Report (MRSPR, March 2007) and Section 3 of the Teir 1 Report herein

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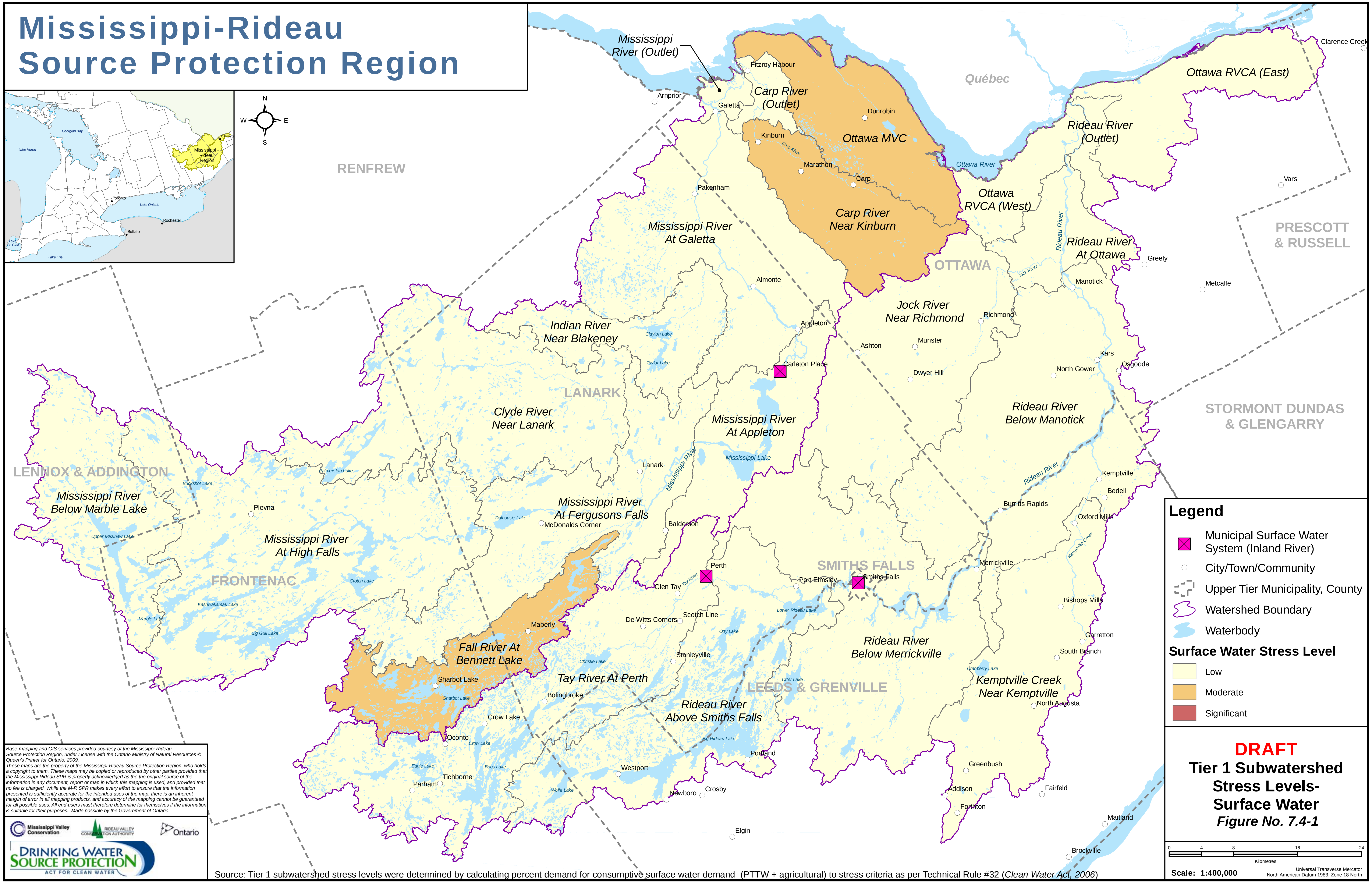
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

FILE LOCATION: V:\Mapping\MXDs\SWP\03 Water Budget\Tier_1\Draft_June2009\Figure 3.1-3.mxd



Mississippi-Rideau
Source Protection Region
N
W
E
S
RENFREW
LANARK
OTTAWA
Québec
PRESCOTT & RUSSELL
STORMONT DUNDAS & GLENGARRY
LENNOX & ADDINGTON
FRONTENAC
SMITHS FALLS
LEEDS & GRENVILLE
Mississippi River (Outlet)
Carp River (Outlet)
Ottawa MVC
Carp River Near Kinburn
Ottawa RVCA (East)
Rideau River (Outlet)
Ottawa RVCA (West)
Rideau River At Ottawa
Mississippi River At Galetta
Indian River Near Blakeney
Jock River Near Richmond
Clyde River Near Lanark
Mississippi River At Appleton
Rideau River Below Manotick
Mississippi River Below Marble Lake
Mississippi River At High Falls
Mississippi River At Fergusons Falls
Fall River At Bennett Lake
Tay River At Perth
Rideau River Below Merrickville
Rideau River Above Smiths Falls
Kemptville Creek Near Kemptville
Ottawa River
Carp River
Jock River
Rideau River
Mississippi River
Tay River
Kemptville Creek
Clarence Creek
Fitzroy Habour
Arnprior
Galetta
Dunrobin
Kinburn
Marathon
Carp
Pakenham
Almonte
Appleton
Carleton Place
Ashton
Munster
Dwyer Hill
Richmond
Manotick
Greely
Metcalfe
Vars
Kars
North Gower
Osgoode
Lanark
Plevna
McDonalds Corner
Balderson
Perth
Glen Tay
Port Elmsley
Smiths Falls
Scotch Line
De Witts Corners
Maberly
Stanleyville
Sharbot Lake
Bolingbroke
Crow Lake
Oconto
Tichborne
Parham
Westport
Newboro
Crosby
Portland
Elgin
Kemptville
Bedell
Burritts Rapids
Oxford Mills
Merrickville
Bishops Mills
Garretton
South Branch
North Augusta
Greenbush
Addison
Fairfield
Forthton
Maitland
Brockville
Clayton Lake
Taylor Lake
Mississippi Lake
Palmerston Lake
Buckshot Lake
Dalhousie Lake
Upper Mazinaw Lake
Crotch Lake
Kashwakamak Lake
Marble Lake
Big Gull Lake
Christie Lake
Otty Lake
Lower Rideau Lake
Otter Lake
Cranberry Lake
Big Rideau Lake
Sharbot Lake
Crow Lake
Bobs Lake
Eagle Lake
Wolfe Lake
Georgian Bay
Lake Huron
Mississippi-Rideau Region
Ottawa
Toronto
Lake Ontario
Rochester
Buffalo
Lake St. Clair
Lake Erie
Legend
Municipal Surface Water System (Inland River)
City/Town/Community
Upper Tier Municipality, County
Watershed Boundary
Waterbody
Surface Water Stress Level
Low
Moderate
Significant
DRAFT
Tier 1 Subwatershed Stress Levels- Surface Water
Figure No. 7.4-1
0 4 8 16 24
Kilometres
Scale: 1:400,000
Universal Transverse Mercator
North American Datum 1983, Zone 18 North
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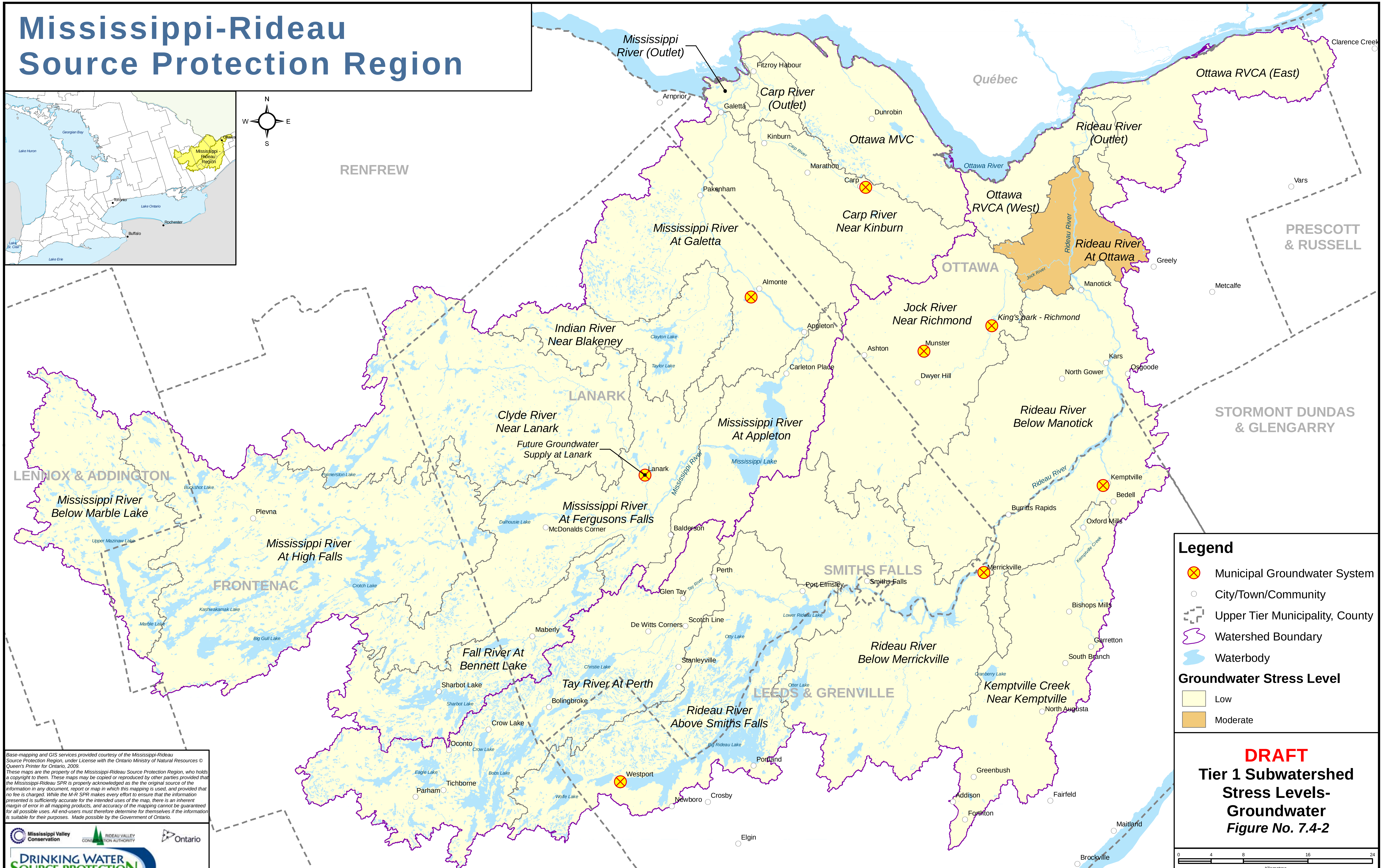
Source: Tier 1 subwatershed stress levels were determined by calculating percent demand for consumptive surface water demand (PTTW + agricultural) to stress criteria as per Technical Rule #32 (Clean Water Act, 2006)



Source: Tier 1 subwatershed stress levels were determined by calculating percent demand for consumptive groundwater demand and groundwater supplies to stress criteria as per Technical Rule #33 (*Clean Water Act, 2006*)

APPENDIX A

STREAMFLOW INFORMATION

APPENDIX A-1
STREAMFLOW DATA INVENTORY
AND
DATA INFILLING APPROACH

Streamflow Data Inventory and Data Infilling Approach

Station Name (Gauge ID)	Streamflow Data (to 2005) HYDAT	Parks Canada	MVC	OPG	# Years (1971-2005)	Data Gaps (1971-2005)	Data In-Filling Approach
Mississippi Valley Conservation (MVC)							
Mississippi River Below Marble Lake (02KF016)	1988-2005				17	Jan-Feb 1988, 1971-1987	Correlated with Gordon Rapids
Mississippi River At High Falls (OPG)[5]				1974-2005	35	1971-1973	Correlated with Clyde R. Lanark
Clyde River Near Lanark (02KF010)	1970-2005				35	June-Dec 1984, Jan 1985	Correlated with Skootamatta[1]
Fall River near Fallbrook (Bennett Lake) (02KF014)[2]	Oct-Dec 1974, 1975-Mar 1992		Apr 1992-2005[2,3]		35	1971-1973, Jan-Sep 1974	Correlated with Appleton
Mississippi River At Fergusons Falls (02KF001)	1915-1919, 1983-2005				23	1971-1982	Correlated with Appleton
Mississippi River At Appleton (02KF006)	1918-2005				30		
Indian River Near Blakeney (02KF012)	1971-1998, 2002-2005				27	Apr-Dec 1998, 1999-2001	Filled with Indian River Mill data
Carp River Near Kinburn (02KF011)	1971-2005				30		
Rideau Valley Conservation Authority (RVCA)							
Tay River At Perth (02LA024)	Oct-Dec 1994, 1995, Mar, Apr, Oct-Nov 1996-2003	1996-2005			6	1974-1993, Jan-Sept 1994, Sept 1998, Oct 2000	Estimated from Bobs Lake & Clyde R. at Lanark (Appendix A)
Rideau River Above Smiths Falls (02LA005)	Nov-Dec 1970, Jun-Dec 1971, 1972-1977, Jan-Apr, Nov-Dec 1978-1996	May-Oct 1978-1995[3], 1996-2005			26	Jan-Oct. 1971, Jan-May 1972, Aug 1980, May, Jun 1984, May 1985, Jul 1988, Jul 1990, Sep 1994, Jul & Sep 1995, Dec	Correlated with Rideau at Merrickville

						1997, Aug 1998	
Rideau River Below Merrickville (02LA011)	Dec 1979, 1980-1990, Jan-Apr, Nov-Dec 1991-1995, Jan-Apr 1996	May-Oct 1991-1995, 1996-2005			25	1971-1979[4]	Correlated with Rideau at Ottawa
Kemptville Creek Near Kemptville (02LA006)	1970-1999, Jan-Mar, Jun-Sep & Dec 2000, 2001-2005				35	Apr. & Nov 2000	Correlated with Jock River
Rideau River Below Manotick (02LA012)	Sept-Dec 1980, 1981-1990, Jan-Apr, Nov-Dec 1991-1995, Jan-Apr 1996	Jan-Aug 1980, May-Oct 1991-1995, 1996-2005			25	1971-1979[4], Oct 1992, Oct 1993, Oct 1995	Correlated with Rideau at Ottawa
Jock River Near Richmond (02LA007)	1970-2005				35		
Rideau River At Ottawa (02LA004)	May-Nov 1933-1945, Apr-Dec 1946, Jan-Nov 1947, Apr-Dec 1948, 1949-2005				35		

1. Skootamatta (gauge 02HL004) is in Moira R. watershed.
2. Fall River WSC gauge at Fallbrook was removed in Mar 1992. MVC installed a staff gauge 0.5 km downstream at Bennett L. outlet in Apr 1992 and an automatic gauge in 2004. WSC developed the rating curve.
3. Flows were estimated from a rating curve.
4. Data is not readily available. It is located on microfiche and on loose hard copy sheets at Parks Canada.
5. OPG Ontario Power Generation

APPENDIX A-2

ESTIMATION OF LONG-TERM STREAMFLOWS FOR THE TAY RIVER AT PERTH SUBWATERSHED

Estimation of Long-term Streamflows for the Tay River at Perth Subwatershed

Background

Streamflows have been measured over the years at a few sites throughout the Tay River subwatershed by Water Survey of Canada (WCS), Parks Canada and the Rideau Valley Conservation Authority (RVCA). The hydrometric station located at the subwatershed outlet, at Port Elmsley (WSC Gauge 02LA016), was in operation from 1983 to 1987. The operation was discontinued due to a property dispute and was relocated in the Town of Perth. The Tay River at Perth station (WSC Gauge 02LA024) was operated by WSC from October 1994 to December 1995. Operations were transferred to Parks Canada thereafter. The reliability of the flow measurements at this gauge are reported to be questionable, especially during low flow conditions (personal communication: Mr. Joe Slater, Crow Lake Community Association and previously employed by WSC). This is an important gauge with respect to water budgeting and stress assessments because it is located near the Town of Perth municipal drinking water intake. Streamflow measurements are also done upstream of Perth at the OMYA plant. While these measurements are reported to be accurate (personal communication: Dr. Ed Watt), measurements started only in October 2003.

Hydrometric data is collected at various hydraulic structures throughout the subwatershed. One such structure is located at Bobs Lake, which is one of the four major reservoirs that are controlled by Parks Canada for the operation of the Rideau Canal within the Rideau Watershed. Bobs Lake is operated solely as a reservoir lake, providing water to augment natural flows and to compensate for evaporation losses during seasonal dry periods. The live storage capacity of Bobs Lake is large and similar to that of the Big Rideau Lake, even though the surface area of Big Rideau is substantially greater. This difference is due to the greater operating range (fluctuation in water level) at Bobs Lake (Acres, June 1994). The Bobs Lake Control Structure is the most hydrologically significant in the Tay River subwatershed, controlling runoff from the upper 44% of the subwatershed (RVCA et al., June 2000). Operation of Bobs Lake reservoir has a major influence in downstream flows through the Town of Perth. In summer time, streamflow discharge at Bobs Lake dam make up a large part of the river flow, when evapotranspiration is high and rainfall runoff is small.

Estimation of Long-term Tay River Streamflow at Perth

Due to the unreliability of Perth's gauge data and the limited amount of data at other stations near Perth, an alternate method for estimating long-term streamflows was selected. Considering the importance of Bobs Lake in the subwatershed hydrologic regime, the Tay River streamflows at Perth are estimated as the sum of two components as expressed below.

Q Perth = Q gauged Bobs + Q ungauged LB

The first component, a gauged contribution, consists of the streamflows from Bobs Lake. The second, an ungauged contribution, consists of streamflows from a "Lower Basin" (LB) that accounts for streamflows generated within the drainage area (304 km^2) located between Bobs Lake and the Town of Perth.

Bobs Lake Streamflows – Q gauged Bobs

Streamflows are measured daily at Bobs Lake in two locations: above the dam (WSC Gauge 02LA023) and downstream of the dam (WSC Gauge 02LA017). Up to now, only sporadic discharge records were available for these sites from the HYDAT database and RVCA. However, Mr. Joe Slater of the Crow Lake Association, has transposed daily records kept by the Parks Canada and has made these available for this study. Because Bobs Lake reservoir operation has changed following the 1994 Rideau Canal Water Management Study (Acres), only streamflows for the 1994-2007 period are used in the calculation of a representative long-term monthly streamflow at Perth.

Lower Basin Streamflows – Q ungauged LB

The method to obtain "Q ungauged LB" is by direct transfer of hydrologic information, using streamflow records for a hydrologically similar basin.

Hydrological similarity includes:

- Similar physical and biological characteristics (including man-made regulation)
- Similar meteorological regime
- Drainage areas of about the same size (within an order of magnitude)

The LB is unregulated and therefore, a similar catchment should be unregulated as well. There are only four subwatersheds within the Region that are unregulated, namely: Clyde River, Jock River, Kemptville Creek and Carp River. Among these four, only the Clyde River subwatershed is located within the same physiographic region (i.e. the Algonquin Highlands). The meteorological regime in Clyde is also similar to that of the

Tay subwatershed. The Clyde subwatershed has slightly lower annual long-term average temperature (0.8 degrees Celsius less), and annual long-term average precipitation (16 mm less) than the Tay subwatershed.

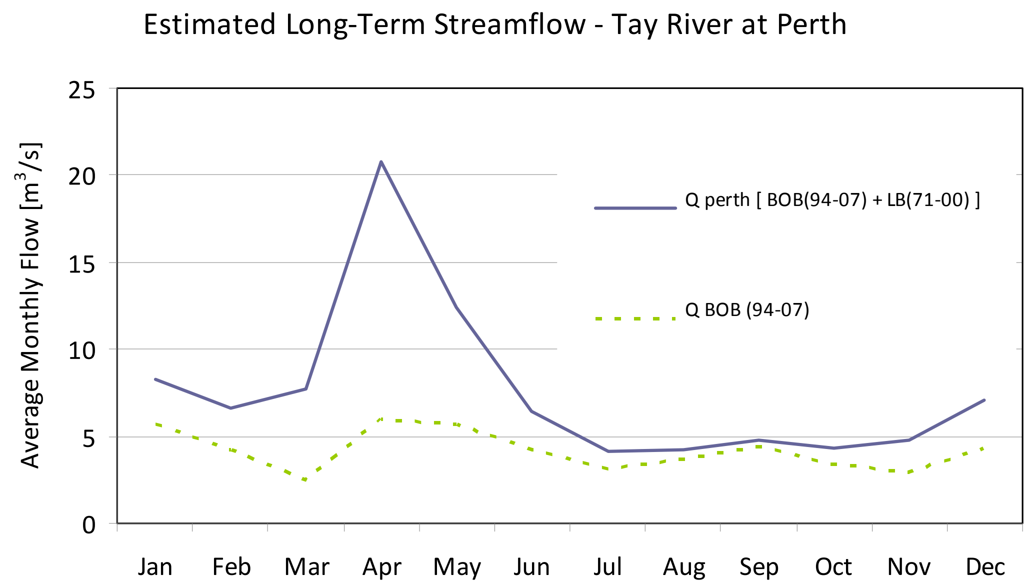
There are two gauges within the Clyde River:

- Gauge 02KF013 at Gordon Rapids with a drainage area of 280 km^2.
- Gauge 02KF010 at Lanark with a drainage area of 614 km^2.

Although the drainage area at Gordon Rapids is closer to that of the Tay lower basin, the Lanark station is preferred because its surficial soil deposits and land uses are more similar to those of the Tay lower basin. While the drainage area of the Clyde subwatershed at Lanark is about twice that of the Tay lower basin (614 versus 304 km^2), it is well within the same order of magnitude.

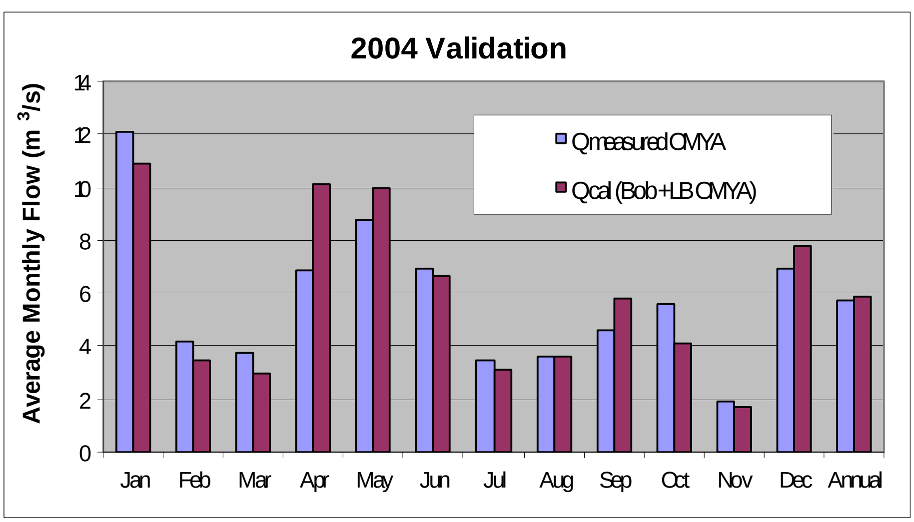
Streamflows from the Lanark gauge are available for the time period considered in this study (1971-2005) and are used to calculate average monthly streamflows for the LB for each year of the record by multiplying the monthly average values by an area pro-rating factor of 304 / 614. Monthly streamflows for the LB were then averaged over the period of 1971 to 2000 for the water budgeting exercise, and over the period 1986-2005 for the water supply estimation.

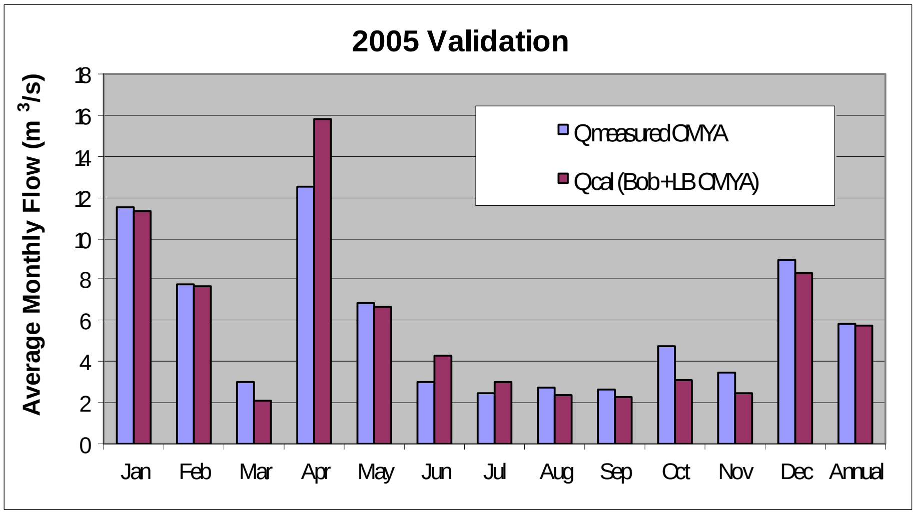
The graph below illustrates the resulting total streamflows at Perth obtained by this method for the period of 1971 to 2000. Bobs Lake average monthly streamflows for the period considered (1994-2007) are also plotted to illustrate the predominance of this component in the total summer flows.



Method Validation

The same "two component method" was used to estimate average monthly streamflows at the OMYA site for comparison with the measured streamflows for 2004 and 2005. In the calculations, actual monthly streamflows at Bobs Lake, measured during 2004 and 2005, are used. The LB contribution is calculated from the Lanark gauge using 2004 and 2005 data, but this time using a smaller area pro-ration factor, to represent the smaller catchment size. Comparison of the calculated against measured monthly streamflows is presented below.





For both years, the calculated and measured annual average streamflows are essentially the same. On a monthly basis, there's generally good agreement between the two sets of average monthly flows. The largest differences occur in the six months (December to May) when runoff / snowmelt contributions are high. Having an accurate flow estimate however is more important when streamflows are generally lower (June to November) as potential water quantity stress would occur in that period of time when water supply is lower. For these months, the difference in streamflows is small and varies from a maximum difference of 1.7 m^3/s in October 2005 to a low of 0 m^3/s in August 2004. For the majority of months in that period of time, calculated average monthly streamflows are lower than the measured, which is an indication that for the long-term calculation, the calculated streamflows would tend to be conservative, that is to slightly underestimate the actual conditions.

SW supply at Perth for Stress Assessment:

The median monthly flow rates are calculated as the sum of:

- the median Q gauged Bob (1994-2007)
- the median Q ungauged LB (1986-2005)

The reserve amount is calculated as the sum of:

- the 10th percentile for Q gauged Bob (1994-2007)
- the 10th percentile for Q ungauged LB (1986-2005)

APPENDIX A-3
ESTIMATION OF LONG-TERM STREAMFLOWS FOR THE UNGAUGED OTTAWA RVCA (WEST AND EAST) SUBWATERSHEDS

Estimation of Long-term Streamflow for the ungauged Ottawa RVCA (West and East) Subwatersheds

The Ottawa RVCA (West) subwatershed and Ottawa RVCA (East) subwatershed are ungauged. There is no long-term streamflow data available from Water Survey of Canada or the City of Ottawa for these subwatersheds therefore surface water flows had to be estimated. Average flows were estimated by pro-rating to a streamflow gauge on Black Creek (#02HC027) in Toronto and adjusting for precipitation differences between Ottawa and Toronto. Black Creek drains an area of relatively high imperviousness and has a complete period of record (at least from 1971 onwards). Ottawa RVCA subwatersheds have a much higher degree of imperviousness than the other subwatersheds in the Region therefore a gauge outside of the Region was required. No gauges in the neighbouring Regions were comparable in the level of imperviousness and strength of data record.

The connected impervious area is the important factor in calculating streamflows for urban areas (Ed Watt, 2009). For the Black Creek subwatershed, the ratio of runoff (flow per unit area) to net water input (precipitation minus depression storage) was selected for a summer month when baseflow is very small. Summer runoff will be generated by the connected impervious areas (unless there is a large rainfall event in the month). Hence, the ratio of runoff to net water input is assumed to equal the percentage of connected imperviousness to the total drainage area (e.g. subwatershed). This ratio and how much smaller it is than the total imperviousness of the drainage area were calculated for the Black Creek subwatershed and applied to the Ottawa RVCA subwatersheds. This method assumes that runoff from connected impervious areas is rainfall minus depression storage for the non-winter periods. For the winter periods, gauged flows from Black Creek adjusted for precipitation differences between Ottawa and Toronto were pro-rated to the connected impervious area. The total monthly runoff was taken as the sum of the flow per unit area for the connected impervious areas and the flow per unit area times the remaining area. This assumes that the runoff per unit area for the remaining areas does not change from “natural” conditions. The effect of urbanization over “natural” conditions was therefore taken as the increase in runoff from areas that are paved and connected. The flows from the remaining areas were estimated by pro-rating to the Carp River Near Kinburn gauge as it represents relatively “natural” conditions. The above methodology was suggested by Ed Watt of XCG Consultants (2009).

The same method as above was applied using Buells Creek data (02MB010) in Brockville instead of Black Creek data. The flows for the Ottawa RVCA (West) subwatershed were estimated within 2% for the two data sets. The Buells Creek data is very limited so it could only be used as supportive information.

Median flows (Q_{P50}), required for the surface water supply term in the stress assessments, were estimated by taking the ratio of the median flow to the average flow from the Carp gauge and multiplying this by the average flows estimated above for the Ottawa RVCA subwatersheds. The same approach was used to estimate the 90th percentile flows for the surface water reserve term.

APPENDIX B

PRECIPITATION
AND
ACTUAL EVAPOTRANSPIRATION DATA

Table B.1 Average Precipitation for MVC and RVCA Subwatersheds (Individual and Cumulative Drainage Areas)

CA	Subwatershed	Drainage Area (km^2)	Average Precipitation (mm)												
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
INDIVIDUAL DRAINAGE AREA															
MVC	Mississippi R. Marble Lake	359	79	53	73	69	75	85	77	82	90	77	83	75	919
	Mississippi R. High Falls	874	87	53	76	68	74	85	79	78	90	74	87	77	928
	Clyde R. near Lanark	617	74	53	70	68	75	81	78	79	86	73	77	75	889
	Fall River at Bennett Lake	281	75	55	71	70	75	78	74	77	89	74	81	79	900
	Miss. R. at Fergusons Falls	532	69	54	68	69	75	77	75	78	87	74	76	78	879
	Mississippi R. at Appleton	272	67	56	69	70	76	77	78	81	86	76	75	79	890
	Indian R. near Blakeney	212	67	54	67	68	75	78	78	80	84	75	73	76	876
	Mississippi R. at Galetta	588	67	55	67	67	75	78	79	81	82	76	73	76	877
	Mississippi River (Outlet)	29	66	53	66	65	74	65	79	82	79	77	71.5	73.6	851
	Carp River at Kinburn	255	68	56	70	68	77	80	82	84	84	78	75	79	902
	Carp River (Outlet)	48	67	54	67	66	75	66	80	83	80	78	72.8	75.1	864
	Ottawa MVC	283	68	55	69	68	76	68	82	85	82	79	74.7	77.9	884
RVCA	Tay River at Perth	676	74	57	71	72	76	77	73	78	90	76	82	81	906
	Rideau R. above Smiths Falls	572	72	58	70	72	77	76	75	80	91	78	81	82	912
	Below Merrickville	715	71	58	71	72	77	76	80	83	92	78	81	83	924
	Kemptville Creek	413	74	59	73	74	78	78	85	85	96	79	83	85	949
	Below Manotick	764	72	58	74	72	78	80	87	84	92	78	79	84	939
	Jock near Richmond	524	70	57	72	71	77	79	84	83	88	78	77	82	917
	Rideau at Ottawa	143	71	58	73	71	79	83	87	87	89	79	78	83	938
	Rideau Ungauged	43	71	58	73	71	79	71	87	88	88	81	79	83	928
	Ottawa RVCA (West)	120	70	57	72	70	78	70	86	86	87	80	77	82	916
	Ottawa RVCA (East)	263	71	59	72	72	80	72	88	91	90	82	80	83	941

CA	Subwatershed	Drainage Area (km^2)	Average Precipitation (mm)												
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
CUMULATIVE DRAINAGE AREA															
MVC	Mississippi R. Marble Lake	359	79	53	73	69	75	85	77	82	90	77	83	75	919
	Mississippi R. High Falls	1,234	85	53	75	68	74	85	78	79	90	74	86	76	925
	Clyde R. near Lanark	617	74	53	70	68	75	81	78	79	86	73	77	75	889
	Fall River at Bennett Lake	281	75	55	71	70	75	78	74	77	89	74	81	79	900
	Miss. R. at Fergusons Falls	2,664	78	54	72	69	75	82	77	79	88	74	81	77	905
	Mississippi R. at Appleton	2,936	77	54	72	69	75	81	77	79	88	74	81	77	904
	Indian R. near Blakeney	212	67	54	67	68	75	78	78	80	84	75	73	76	876
	Mississippi R. at Galetta	3,736	75	54	71	68	75	80	78	79	87	75	79	77	898
	Mississippi River (Outlet)	3,765	75	54	71	68	75	80	78	79	87	75	79	77	898
	Carp River at Kinburn	255	68	56	70	68	77	80	82	84	84	78	75	79	902
	Carp River (Outlet)	303	68	56	70	68	76	78	82	84	83	78	75	78	896
	Ottawa MVC	283	68	55	69	68	76	68	82	85	82	79	75	78	884
RVCA	Tay River at Perth	676	74	57	71	72	76	77	73	78	90	76	82	81	906
	Rideau R. above Smiths Falls	1248	73	57	70	72	76	76	74	79	90	77	82	82	909
	Below Merrickville	1963	73	58	71	72	76	76	76	81	91	77	81	82	914
	Kemptville Creek	413	74	59	73	74	78	78	85	85	96	79	83	85	949
	Below Manotick	3140	72	58	72	72	77	77	80	82	92	78	81	83	925
	Jock near Richmond	524	70	57	72	71	77	79	84	83	88	78	77	82	917
	Rideau at Ottawa	3,808	72	58	72	72	77	78	81	82	91	78	80	83	924
	Rideau Ungauged	3,851	72	58	72	72	77	78	81	82	91	78	80	83	924
	Ottawa RVCA (West)	120	70	57	72	70	78	70	86	86	87	80	77	82	916
	Ottawa RVCA (East)	263	71	59	72	72	80	72	88	91	90	82	80	83	941

1. Climate Data (1971-2000) (McKenney et al., 2002, 2006). Refer to Section 3 of Tier 1 report for more details.

Table B.2 Average Actual Evapotranspiration for MVC and RVCA Subwatersheds (Individual & Cumulative Drainage Areas)

CA	Subwatershed	Drainage Area (km^2)	Average Actual Evapotranspiration (AET) (mm)												
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
INDIVIDUAL DRAINAGE AREA															
MVC	Mississippi R. Marble Lake	359	0	0	0	25	75	109	123	106	70	31	1	0	540
	Mississippi R. High Falls	874	0	0	0	25	75	111	123	107	70	32	1	0	545
	Clyde R. near Lanark	617	0	0	0	26	76	111	125	107	70	32	1	0	549
	Fall River at Bennett Lake	281	0	0	0	27	76	112	126	109	72	34	4	0	561
	Miss. R. at Fergusons Falls	532	0	0	0	28	76	112	127	108	72	34	3	0	560
	Mississippi R. at Appleton	272	0	0	0	29	78	113	130	111	73	34	4	0	572
	Indian R. near Blakeney	212	0	0	0	28	77	113	128	108	71	33	2	0	560
	Mississippi R. at Galetta	588	0	0	0	29	78	114	129	108	72	33	3	0	566
	Mississippi River (Outlet)	29	0	0	0	30	79	115	131	110	72	33	3.0	0	573
	Carp River at Kinburn	255	0	0	0	29	78	114	130	111	72	33	3	0	571
	Carp River (Outlet)	48	0	0	0	30	79	115	131	110	72	33	2.8	0	572
	Ottawa MVC	283	0	0	0	30	79	115	130	111	72	33	3.2	0	573
RVCA	Tay River at Perth	676	0	0	0	28	76	112	128	110	73	34	5	0	567
	Rideau R. above Smiths Falls	572	0	0	0	30	77	113	129	110	73	35	6	0	574
	Below Merrickville	715	0	0	0	30	78	113	131	112	73	35	7	0	580
	Kemptville Creek	413	0	0	0	31	78	114	131	112	74	35	11	0	586
	Below Manotick	764	0	0	0	30	79	114	131	112	73	34	5	0	577
	Jock near Richmond	524	0	0	0	30	78	114	130	112	73	34	4	0	575
	Rideau at Ottawa	143	0	0	0	29	79	114	126	108	72	33	4	0	565
	Rideau Ungauged	43	0	0	0	29	79	114	114	95	72	33	3.8	0	539
	Ottawa RVCA (West)	120	0	0	0	29	79	114	115	97	72	33	3.8	0	544
	Ottawa RVCA (East)	263	0	0	0	29	79	113	125	106	71	33	3.6	0	560

CA	Subwatershed	Drainage Area (km^2)	Average Actual Evapotranspiration (AET) (mm)												
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
CUMULATIVE DRAINAGE AREA															
MVC	Mississippi R. Marble Lake	359	0	0	0	25	75	109	123	106	70	31	1	0	540
	Mississippi R. High Falls	1,234	0	0	0	25	75	110	123	106	70	32	1	0	543
	Clyde R. near Lanark	617	0	0	0	26	76	111	125	107	70	32	1	0	549
	Fall River at Bennett Lake	281	0	0	0	27	76	112	126	109	72	34	4	0	561
	Miss. R. at Fergusons Falls	2,664	0	0	0	26	76	111	125	107	71	33	2	0	550
	Mississippi R. at Appleton	2,936	0	0	0	26	76	111	125	107	71	33	2	0	552
	Indian R. near Blakeney	212	0	0	0	28	77	113	128	108	71	33	2	0	560
	Mississippi R. at Galetta	3,736	0	0	0	27	76	112	126	108	71	33	2	0	555
	Mississippi River (Outlet)	3,765	0	0	0	27	76	112	126	108	71	33	2	0	555
	Carp River at Kinburn	255	0	0	0	29	78	114	130	111	72	33	3	0	571
	Carp River (Outlet)	303	0	0	0	29	79	114	130	111	72	33	3	0	571
	Ottawa MVC	283	0	0	0	30	79	115	130	111	72	33	3	0	573
RVCA	Tay River at Perth	676	0	0	0	28	76	112	128	110	73	34	5	0	567
	Rideau R. above Smiths Falls	1248	0	0	0	29	77	113	129	110	73	35	5	0	570
	Below Merrickville	1963	0	0	0	29	77	113	129	111	73	35	6	0	574
	Kemptville Creek	413	0	0	0	31	78	114	131	112	74	35	11	0	586
	Below Manotick	3140	0	0	0	30	78	113	130	111	73	35	7	0	576
	Jock near Richmond	524	0	0	0	30	78	114	130	112	73	34	4	0	575
	Rideau at Ottawa	3,808	0	0	0	30	78	113	130	111	73	34	6	0	576
	Rideau Ungauged	3,851	0	0	0	30	78	113	130	111	73	34	6	0	575
	Ottawa RVCA (West)	120	0	0	0	29	79	114	115	97	72	33	4	0	544
	Ottawa RVCA (East)	263	0	0	0	29	79	113	125	106	71	33	4	0	560

1. AET was calculated based on Thornthwaite & Mather 1957 tables and equations. See Section 3 of Tier 1 report.

APPENDIX C

GROUNDWATER RECHARGE METHODOLOGY
COMPARISON OF GROUNDWATER RECHARGE ESTIMATES TO BASEFLOW ESTIMATES

Modified MOEE 1995 Groundwater Recharge Methodology

The MOEE published a methodology (MOEE, 1995) on estimating groundwater recharge for development sites based on infiltration factors multiplied by the water surplus (precipitation – evapotranspiration). The infiltration factors for slope, soil and land cover (see table on last page for MOEE published values) were used to customize a set of factors for the Mississippi-Rideau Source Protection Region. The sum of these factors multiplied by the water surplus is the resulting groundwater recharge. The details for the Region are given below.

Infiltration Factors for Slope

A 25m Digital Elevation Model updated in 2006 by the Province of Ontario was used to divide slope into three classes: flat, rolling and hilly, with different slope ranges, based on the amount of land area in each range. The slope classes were selected as follows:

- Flat Land: <1.5% slope range (35.5% of study area)
- Rolling Land: 1.5-3% slope range (21% of study area)
- Hilly Land:>3% slope range (43.4% of study area)

The infiltration factors for each slope class were interpolated from the MOEE published values. These factors were used by developing a relationship between slope and the infiltration factors. The resulting relationship is charted below (see graph showing MOEE slope class evaluation)**.** Using the MOEE slope relationship, the infiltration factors were selected at the mid-point of the slope range except for Hilly Land (>3%), which exceeded the published slope range. The infiltration factor for Hilly Land was selected at approximately the middle of the land area distribution, which was at a slope of 10%, rather than the mid-point of the slope range, which would have been less representative of the land area and off the graph. The infiltration factors for each slope were determined to be:

- Flat Land = 0.172
- Rolling Land = 0.120
- Hilly Land = 0.073

Infiltration Factors for Soil

Infiltration factors for soil permeability were evaluated using the surficial geology data from the Ministry of Northern Development and Mines (available through Ministry of Natural Resources). The surficial soils in the Region include clay, diamicton (till), fill, gravel, organic deposits, bedrock (Paleozoic and Precambrian), sand, and silt. Each soil also has a permeability category. There were ten categories of permeability: low, low-medium, medium, medium-high, high, variable (till, fill, sand and bedrock), and unknown (where there is no soils data). Assumptions were made as to the permeability for those classified as “variable”. Infiltration factors were assigned to each soils permeability category using the MOEE published values as a guide. The MOEE published values were only available for three types of soil: clay, clay-loam, and sandy loam so new values were created for the remaining soil types. The final set of infiltration factors used for the Region is given below:

- Low (clay, silt) = 0.1
- Low-Medium (till, sand-silt) = 0.15
- Medium (till, silty-sand) = 0.2
- Medium-High (sands) = 0.3

- High (gravel, sands, organic deposits) = 0.4
- Variable (till) = 0.2 (assumed Medium)
- Variable (fill) = 0.4 (assumed High)
- Variable (sand) = 0.35 (assumed between Medium-High and High)
- Variable (bedrock) = see below
- Unknown (no data available) = not included in evaluation

The MOEE published values did not include a permeability value for bedrock so a separate set of infiltration factors were created for bedrock. The infiltration factors for Precambrian and Paleozoic bedrock were lower than the factors for clay. Precambrian is the less porous than Paleozoic and was therefore assigned the lower infiltration factor while Paleozoic tends to have more fractures and be more porous so it was assigned a higher infiltration factor.

- Precambrian Bedrock = 0.02
- Paleozoic Bedrock = 0.05

There is no soils data in the western area of the Region (2%). This area was not included in the recharge calculations for the Conceptual Water Budget. However, for the Tier 1, this area was assumed to be Precambrian Bedrock (infiltration value of 0.02) and was therefore included.

Infiltration Factors for Land Cover

Using land cover data from the MNR, land cover was divided into infiltration categories based on the MOEE methodology. The infiltration factors for land cover from the MOEE did not cover areas such as urban and aggregate so a separate category for these areas was assigned. The following factors were assigned:

- Low infiltration - urban, aggregate = 0.05
- Medium infiltration - agriculture, pasture, abandoned fields, wetland = 0.1
- High infiltration - forest and plantation = 0.2

Determining the Combined Infiltration Coefficient

The above maps for slope, land cover, and soil permeability was overlaid to determine the combined infiltration coefficient by summing the infiltration factors for slope, land cover and soil permeability as follows:

$$\text{Combined Infiltration Coefficient} = \sum \text{Infiltration Factors (slope, land cover, soil)}$$

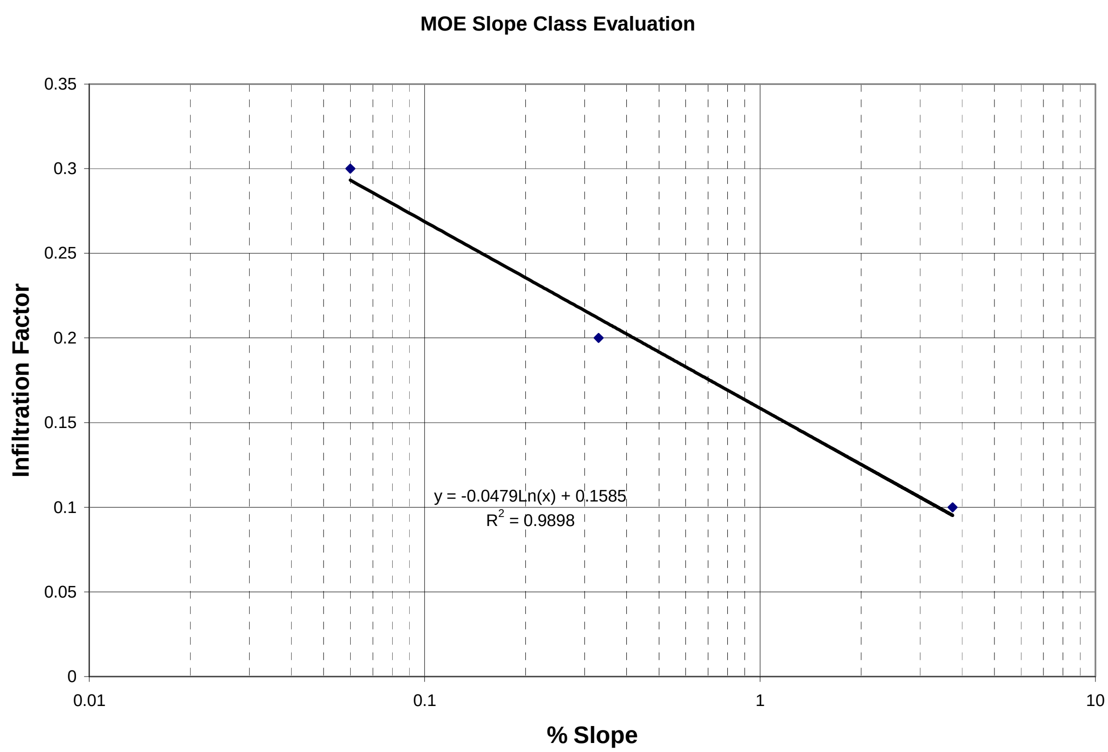
Determining the Groundwater Recharge Volume

The groundwater recharge volume was calculated by multiplying the water surplus (Precipitation – ET) by the Combined Infiltration Coefficient from above as follows:

$$(P - ET) \times \sum \text{Infiltration Factors (slope, land cover, soil)} = \text{Groundwater Recharge Volume}$$

MOEE Infiltration Factors (after Table 2 "MOEE Hydrogeological Technical Information Requirements", from MOEE, 1995)

Description	**Infiltration Factor**
TOPOGRAPHY (SLOPE)	
Flat land, average slope not exceeding 0.6 m per km (0.06%)	0.30
Rolling land, average slope of 2.8 m to 3.8 m per km (0.3%-0.4%)	0.20
Hilly land, average slope of 28 m to 47 m per km (2.8%-4.7%)	0.10
SOIL PERMEABILITY	
Tight impervious clay	0.1
Medium combinations of clay and loam	0.2
Open sandy loam	0.4
LAND COVER	
Cultivated Land	0.1
Woodland	0.2



MOEE Slope Class Evaluation (courtesy of Quinte Source Protection Region)

Comparison of Groundwater Recharge Estimates to Baseflow Estimates

The table below provides a comparison between groundwater recharge rates calculated using the MOEE 1995 Method (modified to suit the Region as described above) and baseflow separation techniques.

Subwatershed (Gauge ID)	Annual Streamflow at Gauge (mm/yr)[1]	Baseflow Index (BFI) [2]			Baseflow Estimate (mm/yr)			Recharge Estimate using MOE 1995 Method (mm/yr) [3]	Difference between MOE & Ave USGS Baseflow
		Middle	Lowest	Highest	Middle	Lowest	Highest		
Clyde River Near Lanark (02KA010)	357	0.6	0.42	0.7	214	150	250	124	-17%
Carp River Near Kinbun (02KF011)	326	0.6	0.42	0.7	196	137	229	148	8%
Fall River At Bennett Lake (02KF014/18)	383	0.6	0.42	0.7	227	161	268	129	-20%
Tay River At Perth[4] (02LA024)	363	0.55	0.4	0.65	200	145	236	121	-17%

1 - Annual Streamflow depth for al gauged subwatersheds over 1971-2000 period
2 - Baseflow Index from USGS Baseflow Method (Neff et al. 2005)
3 – Recharge Estimates in the Mississippi-Rideau Region from GIS based MOE 1995 Method
4 - Surface water flow affected by water control structure e.g. dams

Description / Comments
A- This table compares estimated long-term annual baseflows with estimated long-term annual recharges. B- Local long-term annual baseflows are obtained by multiplying the local long-term annual streamflows by a baseflow index obtained from Neff et al. (2005). C- A potential baseflow range is obtained by adding a 10% uncertainty component to the lowest and highest baseflow estimate. D- The annual recharge estimate is the average of recharge calculated at 25 m x 25 m scale a subwatershed. E- The MOEE (1995) annual recharge estimate, used for the groundwater supply term in the stress assessment, is conservative, i.e. it likely underestimates supply.

APPENDIX D

WATER USAGE BY DUCKS UNLIMITED FOR WILDLIFE CONSERVATION

Water Usage by Ducks Unlimited for Wildlife Conservation

In the Region, there are approximately 60 Ontario PTTWs for the specific purpose of wildlife conservation. These permits allow a maximum daily use of surface water. There are no permits associated with groundwater use. These permits were required by the Ontario MOE in association with the creation and maintenance of wetlands by damming or impounding existing flow channels located in headwater catchments.

Several of these wetlands were created about 20 to 25 years ago. Once established, these headwater wetlands essentially function like natural wetlands or beaver ponds; water levels fluctuate along the year with runoff events, with water levels being at their maximum after the Spring freshet and going down in summer time. No pumping from groundwater or adjacent surface water streams is done to maintain a given water level within the wetlands (personal communication, Mr. Erling Armson, Biologist, Ducks Unlimited Canada). Once established, the wetlands mimic natural wetlands function and provide hydrologic functions that are integrated to the long-term hydrologic regime within a subwatershed;

As part of any new wetland creation or restoration project, an outlet structure or dam is designed with the requirement of allowing a portion of the runoff to flow out and a portion to be retained within the wetland. Design criteria require the wetland and outlet structure to be sized so that a 50 storm event does not overtop the dam or impoundment (personal communication, Mr. Rick Robb, Head Habitat Asset, Ducks Unlimited Canada).

Based on MOE directives, the maximum taking is calculated as the potential maximum runoff volume detained, held in storage within the wetland, in any single given day. This volume often corresponds to the 50 year runoff volume generated by all of the upstream catchment draining to the wetland, taken into storage and slowly released back downstream through the control structure. Therefore, the taking is not representative of actual daily use, but a 50-year runoff event. There are a number of beaver dams and natural deadfall obstructions throughout some parts of the Region that will have characteristics similar to those of the created wetlands;

It can be conceived that on the year a wetland is created, a small temporary change in the available water supply downstream could occur. On subsequent years, once the wetland is established, the influence of the constructed wetland may be limited to an alteration of the hydrologic regime, and may even tend to augment water supply downstream in summer time since wetlands are known to regulate water movement in a watershed.

APPENDIX E

MUNICIPAL DRINKING WATER SURVEYS

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Mississippi Valley Conservation

RIDEAU VALLEY CONSERVATION AUTHORITY

Almonte Drinking Water System

In order to complete our Tier 1 Water Budget we require the following information from your municipality. We would appreciate it if you could provide us with your responses by **Tuesday, March 24, 2009**. Please return completed forms to Emily Saumure at emily.saumure@mrsourcewater.ca.

Questions 1 and 2 are taken directly from the "Technical Rules: Assessment Report", *Clean Water Act (2006) Part III.3*

1. Since January 1, 1990 was the groundwater level in the vicinity of the municipal well not at a level sufficient for the normal operation of the well? If so, please describe.

2. Since January 1, 1990 was the operation of a well pump terminated because of an insufficient quantity of water being supplied to the well? If so, please describe.

3. Our records show that your average pumping rate from 2000-2005 was 668,000 m^3/year. Have your pumping rates changed substantially? If yes, please provide us with this new data.

2008 rates were 666,630 m^3/year.

Please fill in your contact information below:

Name:

Title:

Email:

Telephone:

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Mississippi Valley Conservation

RIDEAU VALLEY CONSERVATION AUTHORITY

Carleton Place Drinking Water System

In order to complete our Tier 1 Water Budget we require the following information from your municipality. We would appreciate it if you could provide us with your responses by **Tuesday, March 31, 2009**. Please return completed forms to Emily Saumure at emily.saumure@mrsourcewater.ca.

Questions 1 and 2 are taken directly from the "Technical Rules: Assessment Report", *Clean Water Act (2006) Part III.3*

1. Since January 1, 1990 was any part of the intake not below the water's surface during normal operation of the intake? If so, please describe.

   No

2. Since January 1, 1990 was the operation of a surface water intake pump terminated because of an insufficient quantity of water being supplied to the intake? If so, please describe

   No

3. Our records show that your average pumping rate from 2000-2005 was 2,306,000 m^3/year. Have your pumping rates changed substantially? If yes, please provide us with this new data.

   2008 treated flow. - 1,730,522 m^3. This drop in demand is aresult of an extensive leak detection program and the resulting elimination of significant leaks in the distribution system.

Please fill in your contact information below:

Name: DAVE YOUNG
Title: DIRECTOR of Public WORKS
Email: dyoung@carletonplace.ca
Telephone: 613-257-6209

Carp Drinking Water System

In order to complete our Tier 1 Water Budget we require the following information from your municipality. We would appreciate it if you could provide us with your responses by **Wednesday, March 25, 2009**. Please return completed forms to Emily Saumure at emily.saumure@mrsourcewater.ca.

Questions 1 and 2 are taken directly from the "Technical Rules: Assessment Report", *Clean Water Act (2006) Part III.3*

1. Since January 1, 1990 was the groundwater level in the vicinity of the municipal well not at a level sufficient for the normal operation of the well? If so, please describe.

   ____no____

2. Since January 1, 1990 was the operation of a well pump terminated because of an insufficient quantity of water being supplied to the well? If so, please describe.
   NO

3. Our records show that your average pumping rate from 2000-2005 was 114,000 m^3/year. Have your pumping rates changed substantially? If yes, please provide us with this new data.

   __2008 total=123,115 m3

<u>Please fill in your contact information below:</u>

Name: Penny Wilson
Title: Water Quality Supervisor
Email: penny.wilson@ottawa.ca
Telephone:613-580-2424 ex 22839

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Mississippi Valley Conservation

RIDEAU VALLEY CONSERVATION AUTHORITY

Kemptville Drinking Water System

In order to complete our Tier 1 Water Budget we require the following information from your municipality. We would appreciate it if you could provide us with your responses by **Tuesday, March 24, 2009**. Please return completed forms to Emily Saumure at emily.saumure@mrsourcewater.ca.

Questions 1 and 2 are taken directly from the "Technical Rules: Assessment Report", *Clean Water Act (2006) Part III.3*

1. Since January 1, 1990 was the groundwater level in the vicinity of the municipal well not at a level sufficient for the normal operation of the well? If so, please describe.

   ______No____

2. Since January 1, 1990 was the operation of a well pump terminated because of an insufficient quantity of water being supplied to the well? If so, please describe.

   _______No____

3. Our records show that your average pumping rate from 2000-2005 was 545,000 m^3/year. Have your pumping rates changed substantially? If yes, please provide us with this new data.

   _________No____

<u>Please fill in your contact information below:</u>

Name: James Beeler
Title: Chief Superintendent of Environmental Services
Email: jbeeler@magma.ca
Telephone: 613-25807400

Kings Park - Richmond Drinking Water System

In order to complete our Tier 1 Water Budget we require the following information from your municipality. We would appreciate it if you could provide us with your responses by **Wednesday, March 25, 2009**. Please return completed forms to Emily Saumure at emily.saumure@mrsourcewater.ca.

Questions 1 and 2 are taken directly from the "Technical Rules: Assessment Report", *Clean Water Act (2006) Part III.3*

1. Since January 1, 1990 was the groundwater level in the vicinity of the municipal well not at a level sufficient for the normal operation of the well? If so, please describe.

   ______NO____

2. Since January 1, 1990 was the operation of a well pump terminated because of an insufficient quantity of water being supplied to the well? If so, please describe.

   NO____

3. Our records show that your average pumping rate from 2000-2005 was 67,900 m^3/year. Have your pumping rates changed substantially? If yes, please provide us with this new data.

   ____2008 total=69,729 m3

<u>Please fill in your contact information below:</u>

Name: Penny Wilson
Title: Water Quality Supervisor
Email: penny.wilson@ottawa.ca
Telephone: 613-580-2424 ex 22839

Merrickville Drinking Water System

In order to complete our Tier 1 Water Budget we require the following information from your municipality. We would appreciate it if you could provide us with your responses by **Tuesday, March 31, 2009**. Please return completed forms to Emily Saumure at emily.saumure@mrsourcewater.ca.

Questions 1 and 2 are taken directly from the "Technical Rules: Assessment Report", *Clean Water Act (2006) Part III.3*

1. Since January 1, 1990 was the groundwater level in the vicinity of the municipal well not at a level sufficient for the normal operation of the well? If so, please describe.

   Water levels have always been sufficient.

2. Since January 1, 1990 was the operation of a well pump terminated because of an insufficient quantity of water being supplied to the well? If so, please describe.

   _Never a problem.

3. Our records show that your average pumping rate from 2000-2005 was 188,000 m^3/year. Have your pumping rates changed substantially? If yes, please provide us with this new data.

   Not significantly

Please fill in your contact information below:

Name: Ryan C. Morton
Title: Environmental Services Manager
Email: environment.merrickville-wolford.ca
Telephone: 613-229-2406

Munster Drinking Water System

In order to complete our Tier 1 Water Budget we require the following information from your municipality. We would appreciate it if you could provide us with your responses by **Wednesday, March 25, 2009**. Please return completed forms to Emily Saumure at emily.saumure@mrsourcewater.ca.

Questions 1 and 2 are taken directly from the "Technical Rules: Assessment Report", *Clean Water Act (2006) Part III.3*

1. Since January 1, 1990 was the groundwater level in the vicinity of the municipal well not at a level sufficient for the normal operation of the well? If so, please describe.

   ______NO____

2. Since January 1, 1990 was the operation of a well pump terminated because of an insufficient quantity of water being supplied to the well? If so, please describe.

   ________NO______________________________________

3. Our records show that your average pumping rate from 2000-2005 was 158,000 m^3/year. Have your pumping rates changed substantially? If yes, please provide us with this new data.

   _____2008 total=224,395 m3

<u>Please fill in your contact information below:</u>

Name: Penny Wilson
Title: Water Quality Supervisor
Email: penny.wilson@ottawa.ca
Telephone: 613-580-2424 ex 22839

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Mississippi Valley Conservation

RIDEAU VALLEY CONSERVATION AUTHORITY

Perth Drinking Water System

In order to complete our Tier 1 Water Budget we require the following information from your municipality. We would appreciate it if you could provide us with your responses by **Tuesday, March 31, 2009**. Please return completed forms to Emily Saumure at emily.saumure@mrsourcewater.ca.

Questions 1 and 2 are taken directly from the "Technical Rules: Assessment Report", *Clean Water Act (2006) Part III.3*

1. Since January 1, 1990 was any part of the intake not below the water's surface during normal operation of the intake? If so, please describe.

   No

2. Since January 1, 1990 was the operation of a surface water intake pump terminated because of an insufficient quantity of water being supplied to the intake? If so, please describe.

   No

3. Our records show that your average pumping rate from 2000-2005 was 1,764,000 m^3/year. Have your pumping rates changed substantially? If yes, please provide us with this new data.

   Our rates for 2007 and 2008 were 1,399,087 and 1,177,244 m^3/year respectively. The recent reduction is largely attributable to local industry operating at reduced /zero capacity. In the short term, it is not foreseen that water consumption will reach the 2000-2005 average.

Please fill in your contact information below:

Name: Dr Greg Mariotti
Title: Superintendent of Utilities
Email: gmariotti@town.perth.on.ca
Telephone: 613-267-1072

Smiths Falls Drinking Water System

In order to complete our Tier 1 Water Budget we require the following information from your municipality. We would appreciate it if you could provide us with your responses by **Tuesday, March 31, 2009**. Please return completed forms to Emily Saumure at emily.saumure@mrsourcewater.ca.

Questions 1 and 2 are taken directly from the "Technical Rules: Assessment Report", *Clean Water Act (2006) Part III.3*

1. Since January 1, 1990 was any part of the intake not below the water's surface during normal operation of the intake? If so, please describe.

   ____**No**____

2. Since January 1, 1990 was the operation of a surface water intake pump terminated because of an insufficient quantity of water being supplied to the intake? If so, please describe.

   ___**No, we do not have intake pumps, raw water flows by gravity to the plant**.

3. Our records show that your average pumping rate from 2000-2005 was 3,465,000 m^3/year. Have your pumping rates changed substantially? If yes, please provide us with this new data.

   No____

Please fill in your contact information below:

Name: **SARAH COOKE**
Title: **COMPLIANCE COORDINATOR**
Email: **scooke@smithsfalls.ca**
Telephone: **613-283-0552**

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Mississippi Valley Conservation
RIDEAU VALLEY CONSERVATION AUTHORITY

Westport Drinking Water System

In order to complete our Tier 1 Water Budget we require the following information from your municipality. We would appreciate it if you could provide us with your responses by **Tuesday, March 24, 2009**. Please return completed forms to Emily Saumure at emily.saumure@mrsourcewater.ca.

Questions 1 and 2 are taken directly from the "Technical Rules: Assessment Report", *Clean Water Act (2006) Part III.3*

1. Since January 1, 1990 was the groundwater level in the vicinity of the municipal well not at a level sufficient for the normal operation of the well? If so, please describe.

   Well #2 has been in operation since 1973; Well #3 has been in operation only since 1995. In both cases, there have not been groundwater levels low enough to impact the operation of the wells through that time period.

2. Since January 1, 1990 was the operation of a well pump terminated because of an insufficient quantity of water being supplied to the well? If so, please describe.

   The operation of a well pump has not been terminated due to an insufficient quantity of water being supplied to the well since 1990.

3. Our records show that your average pumping rate from 2000-2005 was 133,000 m^3/year. Have your pumping rates changed substantially? If yes, please provide us with this new data.

   ___The average pumping flow rate from 2006 to 2008 was 140,525 m3/year.

Please fill in your contact information below:
Name: Scott Bryce
Title: Clerk/Treasurer
Email: Westport@rideau.net
Telephone: 613 273 2191

APPENDIX F

PTTW TABLES

Table F-1 Permits to Take Water Used in Surface Water Stress Assessments

Permit ID	Specific Purpose	Max. Permitted Taking (m^3/d)	C.F.	Consumptive Demands (m^3 per month)											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MISSISSIPPI VALLEY CONSERVATION															
Mississippi River Below Marble Lake															
87-P-4046	Other - Water Supply	135.93	0.2	-	-	-	-	747.59	747.59	747.59	747.59	747.59	747.59	-	-
99-P-4029	Other - Water Supply	270.00	0.2	1,643	1,643	1,643	1,643	1,643	1,643	1,643	1,643	1,643	1,643	1,643	1,643
Mississippi River At High Falls															
97-P-4023	Aquaculture	72.00	0.1	219.00	219.00	219.00	219.00	219.00	219.00	219.00	219.00	219.00	219.00	219.00	219.00
97-P-4023	Aquaculture	1,654	0.1	5,032	5,032	5,032	5,032	5,032	5,032	5,032	5,032	5,032	5,032	5,032	5,032
97-P-4023	Aquaculture	2,974	0.1	9,045	9,045	9,045	9,045	9,045	9,045	9,045	9,045	9,045	9,045	9,045	9,045
Clyde River Near Lanark															
95-P-4021	Fish Ponds	50,000	0.25	-	-	-	-	-	-	-	12,500	-	-	-	-
99-P-4016	Other – Recreation	13,000	0.1	39,542	39,542	39,542	39,542	39,542	39,542	39,542	39,542	39,542	39,542	39,542	39,542
Fall River At Bennett Lake															
0268-6QHQCJ	Aquaculture	15,120	0.1	45,990	45,990	45,990	45,990	45,990	45,990	45,990	45,990	45,990	45,990	45,990	45,990
Mississippi River At Fergusons Falls															
2326-6DBQ5Q	Golf Course Irrigation	4.55	0.7	-	-	-	97.28	97.28	97.28	97.28	97.28	97.28	97.28	-	-
2326-6DBQ5Q	Golf Course Irrigation	272.76	0.7	-	-	-	-	-	-	5,728	5,728	5,728	-	-	-
7705-	Golf Course		0.7												

Permit ID	**Specific Purpose**	**Max. Permitted Taking (m^3/d)**	**C.F.**	**Consumptive Demands (m^3 per month)**											
				Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
6AJSZ7	Irrigation	818.28		-	-	-	-	-	-	-	8,687	17,375	-	-	-
98-P-4077	Golf Course Irrigation	151.40	0.7	-	-	-	1,590	3,179	3,179	3,179	3,179	3,179	1,590	-	-
8120-6EQQVT	Pits and Quarries	867.38	0.25	6,596	6,596	6,596	6,596	6,596	6,596	6,596	6,596	6,596	6,596	6,596	6,596
8120-6EQQVT	Pits and Quarries	7,855	0.25	59,734	59,734	59,734	59,734	59,734	59,734	59,734	59,734	59,734	59,734	59,734	59,734
03-P-4005	Tender Fruit	163.66	0.8	-	-	-	-	-	1,964	3,928	3,928	-	-	-	-
Mississippi River At Appleton															
64-P-0349	Golf Course Irrigation	1,637	0.7	-	-	-	-	34,368	34,368	34,368	34,368	34,368	-	-	-
8060-6AXJGM	Golf Course Irrigation	257.56	0.7	-	-	-	-	-	5,529	5,529	5,529	-	-	-	-
8060-6AXJGM	Golf Course Irrigation	292.99	0.7	-	-	-	-	-	6,290	6,290	6,290	-	-	-	-
6882-686R5M	Municipal	12,000	0.2	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000	73,000
Indian River Near Blakeney															
0180-6FERC9	Other - Dewatering	3,600	0.25	-	-	26,800	26,800	26,800	26,800	26,800	26,800	26,800	26,800	26,800	-
Mississippi River At Galetta															
88-P-4021C	Market Gardens /Flowers	368.23	0.9	-	-	-	-	-	-	10,053	10,053	-	-	-	-
88-P-4021C	Market Gardens /Flowers	589.16	0.9	-	-	-	-	-	-	2,651	2,651	-	-	-	-
6200-648J3R	Power Production	2.94×10^6	0.1	8.9×10^6	8.9×10^6	8.9×10^6	8.9×10^6	8.9×10^6	8.9×10^6	8.9×10^6	8.9×10^6	8.9×10^6	8.9×10^6	8.9×10^6	8.9×10^6
8715-6F6NQD	Power Production	1.21×10^6	0.1	3.7×10^6	3.7×10^6	3.7×10^6	3.7×10^6	3.7×10^6	3.7×10^6	3.7×10^6	3.7×10^6	3.7×10^6	3.7×10^6	3.7×10^6	3.7×10^6

Permit ID	Specific Purpose	Max. Permitted Taking (m^3/d)	C.F.	Consumptive Demands (m^3 per month)											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
92-P-4091	Power Production	3.50×10^6	0.1	1.1×10^6	1.1×10^6	1.1×10^6	1.1×10^6	1.1×10^6	1.1×10^6	1.1×10^6	1.1×10^6	1.1×10^6	1.1×10^6	1.1×10^6	1.1×10^6
6074-5ZMHWY	Snow-making	5,891	0.5	91,311	45,656	-	-	-	-	-	-	-	-	-	45,656
Mississippi River (Outlet)															
No permits	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carp River Near Kinburn															
01-P-4014	Golf Course Irrigation	1,227	0.7	-	-	-	-	24,057	24,057	24,057	24,057	24,057	-	-	-
4384-6CXLQ3	Golf Course Irrigation	191.64	0.7	-	-	-	2,057	4,114	4,114	4,114	4,114	4,114	2,057	-	-
4384-6CXLQ3	Golf Course Irrigation	191.64	0.7	-	-	-	2,057	4,114	4,114	4,114	4,114	4,114	2,057	-	-
02-P-4048	Pits and Quarries	6,255	0.25	47,567	47,567	47,567	47,567	47,567	47,567	47,567	47,567	47,567	47,567	47,567	47,567
5007-6CQL87	Pits and Quarries	660.00	0.25	4,826	4,826	4,826	4,826	4,826	4,826	4,826	4,826	4,826	4,826	4,826	4,826
5007-6CQL87	Pits and Quarries	1,584	0.25	-	-	-	-	-	-	5,544	-	-	-	-	-
91-P-4022	Pits and Quarries	16.27	0.25	124	124	124	124	124	124	124	124	124	124	124	124
91-P-4022	Pits and Quarries	16.27	0.25	124	124	124	124	124	124	124	124	124	124	124	124
Carp River (Outlet)															
No permits	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ottawa MVC															
1733-6GDJGB	Golf Course Irrigation	685.00	0.7	-	-	-	-	-	14,385	14,385	14,385	14,385	-	-	-
1733-	Golf Course		0.7												

Permit ID	Specific Purpose	Max. Permitted Taking (m^3/d)	C.F.	Consumptive Demands (m^3 per month)											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
6GDJGB	Irrigation	697.00		-	-	-	-	-	14,637	14,637	14,637	14,637	-	-	-
1733-6GDJGB	Golf Course Irrigation	712.00	0.7	-	-	-	-	-	14,952	14,952	14,952	14,952	-	-	-
1733-6GDJGB	Golf Course Irrigation	825.00	0.7	-	-	-	-	-	17,325	17,325	17,325	17,325	-	-	-
RIDEAU VALLEY CONSERVATION AUTHORITY															
Tay River At Perth															
98-P-4054	Aesthetics	300.00	0.25	-	-	-	-	-	-	562.50	562.50	562.50	562.50	-	-
3377-6E3RQC	Golf Course Irrigation	240.00	0.7	-	-	-	-	2,520	5,040	5,040	5,040	2,520	-	-	-
98-P-4020	Golf Course Irrigation	526.87	0.7	-	-	-	-	-	9,220	9,220	9,220	9,220	-	-	-
5464-6MHL84	Municipal	9,092	0.2	55,310	55,310	55,310	55,310	55,310	55,310	55,310	55,310	55,310	55,310	55,310	55,310
03-P-4107	Other – Commercial	1,483	1	45,108	45,108	45,108	45,108	45,108	45,108	45,108	45,108	45,108	45,108	45,108	45,108
Rideau River Above Smiths Falls															
00-P-4048	Golf Course Irrigation	600.07	0.7	-	-	-	-	-	3,150	3,150	3,150	3,150	-	-	-
Rideau River Below Merrickville															
2360-6FBL34	Golf Course Irrigation	65.46	0.7	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394	1,394
2360-6FBL34	Golf Course Irrigation	98.19	0.7	-	-	-	1,057	2,115	2,115	2,115	2,115	2,115	2,115	-	-
2360-6FBL34	Golf Course Irrigation	1,273	0.7	-	-	-	13,708	27,416	27,416	27,416	27,416	27,416	27,416	-	-
88-P-4010	Municipal	18,100	0.2	110,108	110,108	110,108	110,108	110,108	110,108	110,108	110,108	110,108	110,108	110,108	110,108
Kemptville Creek Near Kemptville															
No	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Permit ID	Specific Purpose	Max. Permitted Taking (m^3/d)	C.F.	Consumptive Demands (m^3 per month)											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
permits															
Rideau River Below Manotick															
2266-6HYR2B	Golf Course Irrigation	408.00	0.7	-	-	-	-	4,284	8,568	8,568	8,568	8,568	4,284	-	-
5421-6JKQXQ	Golf Course Irrigation	327.31	0.7	-	-	-	-	6,874	6,874	6,874	6,874	6,874	6,874	-	-
5421-6JKQXQ	Golf Course Irrigation	478.29	0.7	-	-	-	-	10,044	10,044	10,044	10,044	10,044	10,044	-	-
5421-6JKQXQ	Golf Course Irrigation	8,052	0.7	-	-	-	-	169,089	169,089	169,089	169,089	169,089	169,089	-	-
7701-6QDNYP	Golf Course Irrigation	1,500	0.7	-	-	-	-	31,500	31,500	31,500	31,500	31,500	31,500	-	-
7701-6QDNYP	Golf Course Irrigation	1,500	0.7	-	-	-	-	31,500	31,500	31,500	31,500	31,500	31,500	-	-
8745-6P7H6D	Golf Course Irrigation	1,499	0.7	-	-	-	-	32,052	32,052	32,052	32,052	32,052	16,026	-	-
8745-6P7H6D	Golf Course Irrigation	2,498	0.7	-	-	-	-	53,420	53,420	53,420	53,420	53,420	26,710	-	-
2350-5ZZKM4	Other - Industrial	9,818	1	-	-	-	-	294,538	294,538	294,538	294,538	294,538	-	-	-
99-P-4034	Other – Misc.	1,364	1	-	-	-	-	-	-	20,457	40,914	20,457	-	-	-
68-P-0004	Other - Recreation	92.90	0.1	-	-	-	-	-	-	287.99	287.99	287.99	-	-	-
00-P-4122	Sod Farm	4,582	0.9	-	-	-	125,786	125,786	125,786	125,786	125,786	125,786	125,786	-	-
Jock River Near Richmond															
97-P-4015	Aggregate Washing	5,500	0.25	-	-	-	-	-	-	-	36,667	36,667	36,667	-	-
04-P-4010	Golf Course Irrigation	1,200	0.7	-	-	-	-	-	-	-	11,200	22,400	-	-	-
8616-	Golf Course		0.7												

Permit ID	**Specific Purpose**	**Max. Permitted Taking (m^3/d)**	**C.F.**	**Consumptive Demands (m^3 per month)**											
				Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
6PUKRQ	Irrigation	780.09		-	-	-	-	16,746	16,746	16,746	16,746	16,746	16,746	-	-
94-P-4015	Golf Course Irrigation	200.00	0.7	-	-	-	-	-	-	-	-	2,100	-	-	-
92-P-4096	Pits and Quarries	1,309	0.25	9,956	9,956	9,956	9,956	9,956	9,956	9,956	9,956	9,956	9,956	9,956	9,956
0004-5ZMGZC	Tender Fruit	0.11	0.8	-	-	-	-	-	2.43	1.22	-	-	-	-	-
0004-5ZMGZC	Tender Fruit	3,814	0.8	-	-	-	-	-	81,357	40,678	-	-	-	-	-
8053-6ARJX9	Tender Fruit	220.64	0.8	-	-	-	-	-	-	-	3,530	-	-	-	-
Rideau River At Ottawa															
00-P-4021	SWMF	68,000	0.1	206,833	206,833	206,833	206,833	206,833	206,833	206,833	206,833	206,833	206,833	206,833	206,833
95-P-4059	Fruit Orchards	908.40	0.8	-	-	-	-	-	-	3,634	3,634	-	-	-	-
0202-6A5QGE	Golf Course Irrigation	3,816	0.7	-	-	-	-	-	73,452	73,452	73,452	73,452	-	-	-
1314-68UQSY	Golf Course Irrigation	1,391	0.7	-	-	-	29,908	29,908	29,908	29,908	29,908	29,908	29,908	-	-
1314-68UQSY	Golf Course Irrigation	1,391	0.7	-	-	-	29,908	29,908	29,908	29,908	29,908	29,908	29,908	-	-
8628-6C9KR5	Golf Course Irrigation	757.00	0.7	-	-	-	8,152	16,305	16,305	16,305	16,305	16,305	16,305	-	-
8628-6C9KR5	Golf Course Irrigation	3,270	0.7	-	-	-	-	-	-	-	-	66,386	-	-	-
01-P-4024	SWMF	46,900	0.1	142,654	142,654	142,654	142,654	142,654	142,654	142,654	142,654	142,654	142,654	142,654	142,654
01-P-4024	SWMF	1.40E+05	0.1	424,617	424,617	424,617	424,617	424,617	424,617	424,617	424,617	424,617	424,617	424,617	424,617
01-P-4024	SWMF	1.77E+05	0.1	538,375	538,375	538,375	538,375	538,375	538,375	538,375	538,375	538,375	538,375	538,375	538,375

Permit ID	Specific Purpose	Max. Permitted Taking (m^3/d)	C.F.	Consumptive Demands (m^3 per month)											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1818-666RPS	Dewatering	900.00	0.25	6,825	6,825	6,825	6,825	6,825	6,825	6,825	6,825	6,825	6,825	6,825	6,825
1818-666RPS	Dewatering	1,325	0.25	10,046	10,046	10,046	10,046	10,046	10,046	10,046	10,046	10,046	10,046	10,046	10,046
1818-666RPS	Dewatering	1,332	0.25	10,101	10,101	10,101	10,101	10,101	10,101	10,101	10,101	10,101	10,101	10,101	10,101
Rideau River (Outlet)															
No permits	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ottawa RVCA (West)															
No permits	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ottawa RVCA (East)															
03-P-4029	Commercial	688.40	1	-	-	-	-	20,652	20,652	20,652	20,652	20,652	20,652	-	-
95-P-4005	Tender Fruit	2,182	0.8	-	-	-	-	-	-	-	17,457	-	-	-	-

Table F-2 Permits to Take Water Used in Groundwater Stress Assessments

Permit ID	Specific Purpose	Max. Permitted Taking (m^3/d)	C.F.	Consumptive Demands (m^3 per month)											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mississippi River Below Marble Lake															
90-P-4030	Campground	9.46	0.2	0	0	0	0	39	39	39	39	39	0	0	0
90-P-4030	Campground	15.46	0.2	0	0	0	0	64	64	64	64	64	0	0	0
Mississippi River At High Falls															
97-P-4023	Aquaculture	72.00	0.1	223	202	223	216	223	216	223	223	216	223	216	223
Clyde River Near Lanark															
No Permits															
Fall River At Bennett Lake															
92-P-4090	Campground	87.84	0.2	0	0	0	520	537	520	537	537	0	0	0	0
Mississippi River At Fergusons Falls															
98-P-4059	Other - Industrial	454.6	0.25	1042	1042	1042	1042	1042	1042	1042	1042	1042	1042	1042	1042
8120-6EQQVT	Pits and Quarries	7855	0.25	60880	54988	60880	58916	60880	58916	60880	60880	58916	60880	58916	60880
Mississippi River At Appleton															
6481-63SLLL	Water Supply	60.00	0.2	372	336	372	360	372	360	372	372	360	372	360	372
6481-63SLLL	Water Supply	60.00	0.2	372	336	372	360	372	360	372	372	360	372	360	372
03-P-4016	Campground	79.00	0.2	490	442	490	474	490	474	490	490	474	490	474	490
03-P-4016	Campground	71.00	0.2	0	0	0	0	443	443	443	443	443	0	0	0
6850-5ZHKHY	Campground	48.30	0.2	299	270	299	290	299	290	299	299	290	299	290	299
6850-5ZHKHY	Campground	48.30	0.2	299	270	299	290	299	290	299	299	290	299	290	299
03-P-4014C	Communal	60.00	0.2	372	336	372	360	372	360	372	372	360	372	360	372
8060-6AXJGM	Golf Course Irrigation	257. 6	0.7	0	0	0	0	0	4147	4147	4147	4147	0	0	0
Indian River Near Blakeney															
0180-6FERC9	Dewatering	3600	0.25	20100	20100	20100	20100	20100	20100	20100	20100	20100	20100	20100	20100

Permit ID	Specific Purpose	Max. Permitted Taking (m^3/d)	C.F.	Consumptive Demands (m^3 per month)											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mississippi River At Galetta															
6074-5ZMHWY	Snowmaking	5891	0.5	60874	60874	0	0	0	0	0	0	0	0	0	60874
98-P-4057	Other -Misc.	454.6	1	4167	4167	4167	4167	4167	4167	4167	4167	4167	4167	4167	4167
Mississippi River (Outlet)															
98-P-4061	Construction	454.6	0.75	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125
Carp River Near Kinburn															
3051-6A3MKS	Water Supply	5891	0.2	0	0	0	0	35350	35350	35350	35350	35350	0	0	0
6642-6V4T8Y	Remediation	5509	0.25	3980	3756	2644	4153	5641	5808	5538	4833	4902	5590	5327	5075
5214-6WNJGY	Other - Dewatering	7776	0.25	60264	54432	60264	58320	60264	58320	60264	60264	58320	60264	58320	60264
01-P-4014	Golf Course Irrigation	4.09	0.7	89	80	89	86	89	86	89	89	86	89	86	89
4384-6CXLQ3	Golf Course Irrigation	46.48	0.7	1009	911	1009	976	1009	976	1009	1009	976	1009	976	1009
4384-6CXLQ3	Golf Course Irrigation	84.39	0.7	0	0	0	0	1831	1772	1831	1831	1772	1831	0	0
4384-6CXLQ3	Golf Course Irrigation	54.72	0.7	0	0	0	0	1187	1149	1187	1187	1149	1187	0	0
3051-6A3MKS	Water Supply	50.01	0.2	310	280	310	300	310	300	310	310	300	310	300	310
3051-6A3MKS	Water Supply	8.00	0.2	50	45	50	48	50	48	50	50	48	50	48	50
95-P-4062	Heat Pumps	45.82	0.1	95	95	95	95	95	95	95	95	95	95	95	95
95-P-4062	Heat Pumps	45.82	0.1	95	95	95	95	95	95	95	95	95	95	95	95
98-P-4053	Other - Commercial	160.0	1	4960	4480	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960
5007-6CQL87	Pits and Quarries	660.0	0.25	4826	4826	4826	4826	4826	4826	4826	4826	4826	4826	4826	4826
5007-6CQL87	Pits and Quarries	1584	0.25	462	462	462	462	462	462	462	462	462	462	462	462
Carp River (Outlet)															
87-P-4060	Campground	107.7	0.2	0	0	0	652	673	652	673	673	652	0	0	0
Ottawa MVC															

Permit ID	Specific Purpose	Max. Permitted Taking (m^3/d)	C.F.	Consumptive Demands (m^3 per month)											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
6070-6WVM25	Golf Course Irrigation	712.0	0.7	0	0	0	0	0	11214	11214	11214	11214	0	0	0
6070-6WVM25	Golf Course Irrigation	697.0	0.7	0	0	0	0	0	10978	10978	10978	10978	0	0	0
6070-6WVM25	Golf Course Irrigation	825.0	0.7	0	0	0	0	0	12994	12994	12994	12994	0	0	0
6070-6WVM25	Golf Course Irrigation	685.0	0.7	0	0	0	0	0	10789	10789	10789	10789	0	0	0
91-P-4026	Other Water Supply	414.7	0.2	774	774	774	774	774	774	774	774	774	774	774	774
91-P-4026	Other Water Supply	3409	0.2	6364	6364	6364	6364	6364	6364	6364	6364	6364	6364	6364	6364
00-P-4002	Golf Course Irrigation	55.00	0.7	1194	1078	1194	1155	1194	1155	1194	1194	1155	1194	1155	1194
00-P-4002	Golf Course Irrigation	55.00	0.7	1194	1078	1194	1155	1194	1155	1194	1194	1155	1194	1155	1194
00-P-4002	Golf Course Irrigation	55.00	0.7	1194	1078	1194	1155	1194	1155	1194	1194	1155	1194	1155	1194
00-P-4002	Golf Course Irrigation	2727	0.7	0	0	0	0	0	23867	23867	23867	23867	0	0	0
91-P-4026	Other Water Supply	4546	0.2	28185	25458	28185	27276	28185	27276	28185	28185	27276	28185	27276	28185
1733-6GDJGB	Golf Course Irrigation	712.0	0.7	0	0	0	0	0	14952	14952	14952	14952	0	0	0
1733-6GDJGB	Golf Course Irrigation	697.0	0.7	0	0	0	0	0	14637	14637	14637	14637	0	0	0
1733-6GDJGB	Golf Course Irrigation	325.0	0.7	0	0	0	0	0	6825	6825	6825	6825	0	0	0
1733-6GDJGB	Golf Course Irrigation	460.0	0.7	0	0	0	0	0	9660	9660	9660	9660	0	0	0
1733-6GDJGB	Golf Course Irrigation	685.0	0.7	0	0	0	0	0	14385	14385	14385	14385	0	0	0

Permit ID	Specific Purpose	Max. Permitted Taking (m^3/d)	C.F.	Consumptive Demands (m^3 per month)											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1733-6GDJGB	Golf Course Irrigation	325.0	0.7	0	0	0	0	0	6825	6825	6825	6825	0	0	0
1733-6GDJGB	Golf Course Irrigation	325.0	0.7	0	0	0	0	0	6825	6825	6825	6825	0	0	0
1733-6GDJGB	Golf Course Irrigation	825.0	0.7	0	0	0	0	0	17325	17325	17325	17325	0	0	0
1733-6GDJGB	Golf Course Irrigation	650.0	0.7	0	0	0	0	0	13650	13650	13650	13650	0	0	0
RIDEAU VALLEY CONSERVATION AUTHORITY															
Tay River At Perth															
4742-6ABPK9	Heat Pumps	172.8	0.1	536	484	536	518	536	518	536	536	518	536	518	536
4742-6ABPK9	Heat Pumps	432.0	0.1	1339	1210	1339	1296	1339	1296	1339	1339	1296	1339	1296	1339
4742-6ABPK9	Heat Pumps	432.0	0.1	1339	1210	1339	1296	1339	1296	1339	1339	1296	1339	1296	1339
97-P-4018	Industrial	15.36	0.25	119	108	119	115	119	115	119	119	115	119	115	119
97-P-4018	Industrial	15.36	0.25	119	108	119	115	119	115	119	119	115	119	115	119
97-P-4018	Industrial	15.36	0.25	119	108	119	115	119	115	119	119	115	119	115	119
97-P-4018	Industrial	86.40	0.25	670	605	670	648	670	648	670	670	648	670	648	670
97-P-4018	Industrial	86.40	0.25	670	605	670	648	670	648	670	670	648	670	648	670
97-P-4018	Industrial	164.2	0.25	1272	1149	1272	1231	1272	1231	1272	1272	1231	1272	1231	1272
97-P-4018	Industrial	164.2	0.25	1272	1149	1272	1231	1272	1231	1272	1272	1231	1272	1231	1272
97-P-4018	Industrial	164.2	0.25	1272	1149	1272	1231	1272	1231	1272	1272	1231	1272	1231	1272
97-P-4018	Industrial	164.2	0.25	1272	1149	1272	1231	1272	1231	1272	1272	1231	1272	1231	1272
Rideau River Above Smiths Falls															
87-P-4059	Other -Water Supply	54.72	0.2	339	306	339	328	339	328	339	339	328	339	328	339
3628-6AZJAK	Other - Industrial	210.0	0.25	1628	1470	1628	1575	1628	1575	1628	1628	1575	1628	1575	1628
3628-6AZJAK	Other - Industrial	210.0	0.25	1628	1470	1628	1575	1628	1575	1628	1628	1575	1628	1575	1628
Rideau River Below Merrickville															
2360-6FBL34	Golf Course Irrigation	65.46	0.7	1421	1283	1421	1375	1421	1375	1421	1421	1375	1421	1375	1421

Permit ID	Specific Purpose	Max. Permitted Taking (m^3/d)	C.F.	Consumptive Demands (m^3 per month)											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2360-6FBL34	Golf Course Irrigation	98.19	0.7	1964	1964	1964	1964	1964	1964	1964	1964	1964	1964	1964	1964
3663-6TJRXR	Cooling Water	909.2	0.25	7046	6364	7046	6819	7046	6819	7046	7046	6819	7046	6819	7046
6238-6A9L76	Dewatering	7855	0.25	60880	54988	60880	58916	60880	58916	60880	60880	58916	60880	58916	60880
4728-62W4ZB	Pits and Quarries	5433	0.25	42109	38034	42109	40750	42109	40750	42109	42109	40750	42109	40750	42109
03-P-4040	Cooling Water	1090	0.25	4133	4133	4133	4133	4133	4133	4133	4133	4133	4133	4133	4133
03-P-4040	Cooling Water	1090	0.25	4133	4133	4133	4133	4133	4133	4133	4133	4133	4133	4133	4133
03-P-4015	Communal	196.4	0.2	1218	1100	1218	1178	1218	1178	1218	1218	1178	1218	1178	1218
03-P-4015	Communal	196.4	0.2	1218	1100	1218	1178	1218	1178	1218	1218	1178	1218	1178	1218
00-P-4047	Golf Course Irrigation	172.7	0.7	0	0	0	3628	3749	3628	3749	3749	3628	3749	0	0
00-P-4047	Golf Course Irrigation	600.0	0.7	0	0	0	12600	13020	12600	13020	13020	12600	13020	0	0
87-P-4023	Food Processing	909.2	1	28185	25458	28185	27276	28185	27276	28185	28185	27276	28185	27276	28185
87-P-4068	Other Water Supply	98.19	0.2	147	147	147	147	147	147	147	147	147	147	147	147
Kemptville Creek Near Kemptville															
No Permits															
Rideau River Below Manotick															
93-P-4088	Institutional	693.9	0.25	5378	4857	5378	5204	5378	5204	5378	5378	5204	5378	5204	5378
93-P-4088	Institutional	3967	0.25	30744	27769	30744	29753	30744	29753	30744	30744	29753	30744	29753	30744
6636-6QPRFG	Other - Dewatering	11100	0.25	86025	77700	86025	83250	86025	83250	86025	86025	83250	86025	83250	86025
2366-6K2QEQ	Other - Remediation	33.33	0.25	258	233	258	250	258	250	258	258	250	258	250	258
5611-6AYNPX	Tender Fruit	131.83	0.8	0	0	0	0	0	0	1055	1055	0	0	0	0
5611-6AYNPX	Tender Fruit	220.9	0.8	0	0	0	0	0	0	1767	1767	0	0	0	0
04-P-4027	Aggregate Washing	4546	0.25	0	0	32832	32832	32832	32832	32832	32832	32832	32832	32832	0
03-P-4004	Sod Farm	817.6	0.9	0	0	0	0	0	2759	2759	2759	2759	0	0	0

Permit ID	Specific Purpose	Max. Permitted Taking (m^3/d)	C.F.	Consumptive Demands (m^3 per month)											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
03-P-4004	Sod Farm	272.5	0.9	0	0	0	0	0	5519	5519	5519	5519	0	0	0
03-P-4004	Sod Farm	545.1	0.9	0	0	0	0	0	11038	11038	11038	11038	0	0	0
6253-6HZRFM	Remediation	22.00	0.25	171	154	171	165	171	165	171	171	165	171	165	171
8745-6P7H6D	Golf Course Irrigation	38.00	0.7	825	745	825	798	825	798	825	825	798	825	798	825
8745-6P7H6D	Golf Course Irrigation	10.00	0.7	217	196	217	210	217	210	217	217	210	217	210	217
8745-6P7H6D	Golf Course Irrigation	2498	0.7	0	0	0	0	48969	48969	48969	48969	48969	48969	0	0
2350-5ZZKM4	Other - Industrial	9817	0.7	85907	85907	85907	85907	85907	85907	85907	85907	85907	85907	85907	85907
5421-6JKQXQ	Golf Course Irrigation	327.3	0.7	7103	6415	7103	6874	7103	6874	7103	7103	6874	7103	6874	7103
5421-6JKQXQ	Golf Course Irrigation	8051	0.7	174726	157817	174726	169089	174726	169089	174726	174726	169089	174726	169089	174726
5421-6JKQXQ	Golf Course Irrigation	478.2	0.7	10379	9374	10379	10044	10379	10044	10379	10379	10044	10379	10044	10379
5421-6JKQXQ	Golf Course Irrigation	39.27	0.7	852	770	852	825	852	825	852	852	825	852	825	852
5421-6JKQXQ	Golf Course Irrigation	65.46	0.7	1421	1283	1421	1375	1421	1375	1421	1421	1375	1421	1375	1421
2266-6HYR2B	Golf Course Irrigation	6.00	0.7	0	0	0	0	128	124	128	128	124	128	0	0
Jock River Near Richmond															
2366-6K2QEQ	Other - Remediation	33.33	0.25	258	233	258	250	258	250	258	258	250	258	250	258
2366-6K2QEQ	Other - Remediation	33.33	0.25	258	233	258	250	258	250	258	258	250	258	250	258
2366-6K2QEQ	Other - Remediation	33.33	0.25	258	233	258	250	258	250	258	258	250	258	250	258
2366-6K2QEQ	Other - Remediation	33.33	0.25	258	233	258	250	258	250	258	258	250	258	250	258

Permit ID	Specific Purpose	Max. Permitted Taking (m^3/d)	C.F.	Consumptive Demands (m^3 per month)											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2366-6K2QEQ	Other - Remediation	33.33	0.25	258	233	258	250	258	250	258	258	250	258	250	258
1184-6AZJ6T	Aquaculture	381.5	0.1	1183	1068	1183	1145	1183	1145	1183	1183	1145	1183	1145	1183
1184-6AZJ6T	Aquaculture	381.5	0.1	1183	1068	1183	1145	1183	1145	1183	1183	1145	1183	1145	1183
1184-6AZJ6T	Aquaculture	381.5	0.1	1183	1068	1183	1145	1183	1145	1183	1183	1145	1183	1145	1183
04-P-4023	Aggregate Washing	4546	0.25	0	0	33462	32382	33462	32382	33462	33462	32382	33462	32382	0
03-p-4096	Pits and Quarries	54.55	0.25	17	17	17	17	17	17	17	17	17	17	17	17
98-P-4060	Pits and Quarries	3927	0.25	20160	5501	14066	22235	20500	7936	12092	7507	4952	6658	6862	1826
00-P-4028	Pits and Quarries	7364	0.25	42193	42193	42193	42193	42193	42193	42193	42193	42193	42193	42193	42193
03-P-4079	Pits and Quarries	6480	0.25	50220	45360	50220	48600	50220	48600	50220	50220	48600	50220	48600	50220
7551-6AHK8M	Other - Dewatering	6480	0.25	0	0	400	4082	697	1247	421	912	3231	6531	7026	8475
04-P-4003	Pits and Quarries	17729	0.25	137402	124105	137402	132970	137402	132970	137402	137402	132970	137402	132970	137402
98-P-4058	Other - Industrial	454.6	0.25	1042	1042	1042	1042	1042	1042	1042	1042	1042	1042	1042	1042
03-P-4032	Communal	120.0	0.2	744	672	744	720	744	720	744	744	720	744	720	744
5717-6EQJN3	Other Water Supply	277.9	0.2	1723	1556	1723	1668	1723	1668	1723	1723	1668	1723	1668	1723
5717-6EQJN3	Other Water Supply	576.0	0.2	3571	3226	3571	3456	3571	3456	3571	3571	3456	3571	3456	3571
03-P-4073	Communal	60.00	0.2	372	336	372	360	372	360	372	372	360	372	360	372
03-P-4073	Communal	60.00	0.2	372	336	372	360	372	360	372	372	360	372	360	372
0004-5ZMGZC	Tender Fruit	0.11	0.8	0	0	0	0	0	0	1	1	0	0	0	0
0004-5ZMGZC	Tender Fruit	0.11	0.8	0	0	0	0	0	0	2	2	0	0	0	0

Permit ID	Specific Purpose	Max. Permitted Taking (m^3/d)	C.F.	Consumptive Demands (m^3 per month)											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
04-P-4010	Golf Course Irrigation	3.10	0.7	0	0	66	64	66	64	66	66	64	66	64	0
04-P-4010	Golf Course Irrigation	0.50	0.7	0	0	11	10	11	10	11	11	10	11	10	0
04-P-4010	Golf Course Irrigation	33..00	0.7	0	0	0	0	0	231	231	231	231	0	0	0
04-P-4010	Golf Course Irrigation	33.00	0.7	0	0	0	0	0	231	231	231	231	0	0	0
04-P-4010	Golf Course Irrigation	33.00	0.7	0	0	0	0	0	231	231	231	231	0	0	0
8616-6PUKRQ	Golf Course Irrigation	805.2	0.7	0	0	0	17048	17616	17048	17616	17616	17048	0	0	0
8616-6PUKRQ	Golf Course Irrigation	780.1	0.7	0	0	0	16517	17067	16517	17067	17067	16517	0	0	0
8616-6PUKRQ	Golf Course Irrigation	32.73	0.7	0	0	0	693	716	693	716	716	693	0	0	0
1206-639JPC	Golf Course Irrigation	785.5	0.7	0	0	0	13747	13747	13747	13747	13747	13747	0	0	0
1206-639JPC	Golf Course Irrigation	130.9	0.7	0	0	0	2291	2291	2291	2291	2291	2291	0	0	0
6513-5ZCKP9	Golf Course Irrigation	785.5	0.7	0	0	0	0	0	3299	3299	3299	3299	0	0	0
6513-5ZCKP9	Golf Course Irrigation	130.9	0.7	0	0	0	0	0	550	550	550	550	0	0	0
97-P-4115C	Golf Course Irrigation	40.91	0.7	888	802	888	859	888	859	888	888	859	888	859	888
97-P-4115C	Golf Course Irrigation	98.19	0.7	2131	1925	2131	2062	2131	2062	2131	2131	2062	2131	2062	2131
97-P-4115C	Golf Course Irrigation	58.92	0.7	1278	1155	1278	1237	1278	1237	1278	1278	1237	1278	1237	1278
Rideau River At Ottawa															

Permit ID	Specific Purpose	Max. Permitted Taking (m^3/d)	C.F.	Consumptive Demands (m^3 per month)											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
00-P-4135	Pits and Quarries	2000	0.25	15500	14000	15500	15000	15500	15000	15500	15500	15000	15500	15000	15500
97-P-4009	Pits and Quarries	7200	0.25	55800	50400	55800	54000	55800	54000	55800	55800	54000	55800	54000	55800
94-P-4007	Heat Pumps	227.1	0.1	704	636	704	681	704	681	704	704	681	704	681	704
97-P-4098	Cooling Water	566.8	0.25	4393	3968	4393	4251	4393	4251	4393	4393	4251	4393	4251	4393
0670-65HR7F	Communal	535.7	0.2	3321	3000	3321	3214	3321	3214	3321	3321	3214	3321	3214	3321
0670-65HR7F	Communal	587.5	0.2	3643	3290	3643	3525	3643	3525	3643	3643	3525	3643	3525	3643
0670-65HR7F	Communal	941.8	0.2	5839	5274	5839	5651	5839	5651	5839	5839	5651	5839	5651	5839
3686-6PHKVW	Aggregate Washing	200.0	0.25	0	0	1444	1444	1444	1444	1444	1444	1444	1444	1444	0
3686-6PHKVW	Aggregate Washing	5300	0.25	0	0	38278	38278	38278	38278	38278	38278	38278	38278	38278	0
04-P-4033	Golf Course Irrigation	588.0	0.7	0	0	0	12179	12585	12179	12585	12585	12179	0	0	0
04-P-4033	Golf Course Irrigation	336.0	0.7	0	0	0	6959	7191	6959	7191	7191	6959	0	0	0
03-P-4094	Golf Course Irrigation	1591	0.7	0	0	0	32485	32485	32485	32485	32485	32485	0	0	0
03-P-4094	Golf Course Irrigation	818.3	0.7	0	0	0	14320	14320	14320	14320	14320	14320	0	0	0
4520-67WQ53	Golf Course Irrigation	588.0	0.7	0	0	0	12179	12585	12179	12585	12585	12179	0	0	0
4520-67WQ53	Golf Course Irrigation	336.0	0.7	0	0	0	6959	7191	6959	7191	7191	6959	0	0	0
90-P-4019	Other – Misc.	3456	1	28645	28645	28645	28645	28645	28645	28645	28645	28645	28645	28645	28645
1314-68UQSY	Golf Course Irrigation	618.2	0.7	0	0	11631	11631	11631	11631	11631	11631	11631	11631	0	0
Rideau River (Outlet)															
3757-6MUQV8	Dewatering	395.8	0.25	231	231	231	231	231	231	231	231	231	231	231	231
5253-653NSM	Dewatering	100.0	0.25	88	88	88	88	88	88	88	88	88	88	88	88

Permit ID	Specific Purpose	Max. Permitted Taking (m^3/d)	C.F.	Consumptive Demands (m^3 per month)											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ottawa RVCA (West)															
1358-6KSS85	Dewatering	1308	0.25	10144	9163	10144	9817	10144	9817	10144	10144	9817	10144	9817	10144
1358-6KSS85	Dewatering	176.4	0.25	1367	1235	1367	1323	1367	1323	1367	1367	1323	1367	1323	1367
1358-6KSS85	Dewatering	4233	0.25	32810	29635	32810	31752	32810	31752	32810	32810	31752	32810	31752	32810
6144-6K4MW8	Remediation	326.9	0.25	2533	2288	2533	2452	2533	2452	2533	2533	2452	2533	2452	2533
5125-6YNJSR	Remediation	172.8	0.5	2678	2419	2678	2592	2678	2592	2678	2678	2592	2678	2592	2678
5578-6VQMV9	Other Water Supply	980.0	0.2	3495	3495	3495	3495	3495	3495	3495	3495	3495	3495	3495	3495
5578-6VQMV9	Other Water Supply	110.0	0.2	682	616	682	660	682	660	682	682	660	682	660	682
5578-6VQMV9	Other Water Supply	190.0	0.2	678	678	678	678	678	678	678	678	678	678	678	678
5578-6VQMV9	Other Water Supply	6.00	0.2	37	34	37	36	37	36	37	37	36	37	36	37
5578-6VQMV9	Other Water Supply	35.0	0.2	217	196	217	210	217	210	217	217	210	217	210	217
5578-6VQMV9	Other Water Supply	0.45	0.2	1	1	1	1	1	1	1	1	1	1	1	1
5578-6VQMV9	Other Water Supply	41.00	0.2	254	230	254	246	254	246	254	254	246	254	246	254
5578-6VQMV9	Other Water Supply	4.50	0.2	14	14	14	14	14	14	14	14	14	14	14	14
01-P-4001	Other Misc.	65.46	0.1	203	183	203	196	203	196	203	203	196	203	196	203
01-P-4001	Other Misc.	65.46	0.1	203	183	203	196	203	196	203	203	196	203	196	203
03-P-4049	Groundwater	65.46	0.5	1015	916	1015	982	1015	982	1015	1015	982	1015	982	1015
98-P-4094	Groundwater	326.9	0.5	5067	4576	5067	4903	5067	4903	5067	5067	4903	5067	4903	5067
95-P-4010	Schools	480.0	0.25	3720	3360	3720	3600	3720	3600	3720	3720	3600	3720	3600	3720
Ottawa RVCA (East)															
95-P-4027	Golf Course Irrigation	757.0	0.7	0	0	0	15140	15140	15140	15140	15140	15140	15140	0	0
3128-6AWJR4	Other -	113.6	0.25	881	796	881	852	881	852	881	881	852	881	852	881

Permit ID	Specific Purpose	Max. Permitted Taking (m^3/d)	C.F.	Consumptive Demands (m^3 per month)											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Dewatering														
3128-6AWJR4	Other - Dewatering	2618	0.25	20293	18329	20293	19639	20293	19639	20293	20293	19639	20293	19639	20293
3128-6AWJR4	Other - Dewatering	5891	0.25	45660	41241	45660	44187	45660	44187	45660	45660	44187	45660	44187	45660
04-P-4009	Gardens	54.55	0.9							1551	1551				
04-P-4009	Gardens	54.55	0.9	0	0	0	0	0	1477	1526	1526	1477	0	0	0
04-P-4009	Gardens	81.83	0.9							2327	2327				
2237-6QLLL2	Other- Water Supply	2.73	0.2	17	15	17	16	17	16	17	17	16	17	16	17
2237-6QLLL2	Other Water Supply	2725	0.2	9721	9721	9721	9721	9721	9721	9721	9721	9721	9721	9721	9721
2237-6QLLL2	Other Water Supply	34.07	0.2	211	191	211	204	211	204	211	211	204	211	204	211
7228-636RLE	Tender Fruit	36.00	0.8	0	0	0	0	0	0	288	288	0	0	0	0
7228-636RLE	Tender Fruit	43.20	0.8	0	0	0	0	0	0	346	346	0	0	0	0
7228-636RLE	Tender Fruit	216.0	0.8	0	0	0	0	0	0	1728	1728	0	0	0	0
0486-6DEQWL	Golf Course Irrigation	346.5	0.7	0	0	0	0	7416	7177	7416	7416	7177	0	0	0

APPENDIX G

Infiltration to Sewer Systems

Infiltration to Sewer Systems

If water distribution and sewage collection systems were 100% efficient, including zero loss from users (i.e. watering lawns), the water pumped into a distribution system through the surface water intake or the groundwater well would be equal to the amount of water that is treated by the sewage treatment system, before the water is released to the environment. However, 100% efficiency is never achieved. The Conceptual Water Budget identified greater flows from some municipal sewer systems (Almonte, Carp, Kemptville and Perth) compared to the amount of water pumped into the system, which could suggest that municipal sewer systems may receive shallow groundwater. If the municipal sewer systems do receive groundwater, they are then acting in a manner analogous to that of a tile drainage system, and are effectively removing shallow groundwater.

The addition of groundwater to the sewer system has environmental and economical impacts. Draining groundwater lowers the water table and affects the amount of baseflow to surface water bodies. Economically, the added sewer flow must be treated before it is released, which increases the cost of water treatment for municipalities.

The percent difference between pumping inflows and sewage flows were calculated by subtracting the pumping inflows from the sewage flows for the municipal systems and dividing by the pumping inflows [these differences are listed in Table G.1]. A calculated positive difference indicates more sewage flow and a calculated negative difference indicates a loss of water from the distribution system (e.g. leaking water distribution system), or a gain of water to the sewer collection system. Table G.1 shows the average monthly pumped water (m^3/month) and average monthly sewage output (m^3/month) for the years with the most recent data (2005 and 2008).

Table G.1 Calculated Percent Difference of Pumping Inflows and Sewage Flows

Source	Municipal System[1]	Average Monthly Pumped Water (m^3/month)	Average Monthly Sewage Flow (m^3/month)	Percent Difference	Year for Pumped Water Data	Year for Sewage Data
Ground water	Almonte	61,194	101,930	67%	2008	2008
	Carp	10,260	21,834	113%	2008	2008
	Kemptville	48,670	80,732	66%	2008	2008
	Merrickville	14,772	12,611	-15%	2005	2005
Surface Water	Carleton Place	209,835	176,955	-16%	2005	2005
	Perth	104,992	197,401	88%	2008	2008
	Smiths Falls	258,593	296,694	15%	2005	2005

1 – Other municipal systems were not accounted for since data was not readily available or applicable.

The large positive percent differences for Almonte, Carp, Kemptville and Perth, indicate more sewage flow than pumping inflow. These differences could possibly be due to groundwater infiltrating into the sewer systems; However, before the difference between pumped volume and sewage flows can be identified as groundwater infiltration, other potential inflows to the sewer systems must be identified. For example, higher sewage flows may be due to storm water entering either a combined sewer system or a sanitary system. A combined sewer system uses the same network of sewers for sanitary and storm sewage flows. A sanitary sewer is design to only contain raw sewage, with the storm water diverted through a separate system.

Relatively higher sewage flows in combined systems are primarily due to storm water and melt water. However, even if the sewer collection system does not have combined sewers, storm water can still infiltrate into sanitary sewers through manhole covers and other short-circuiting pathways. As an example of this the Town of Kemptville, which does not have a combined system, reported higher sewage flows during storm events. In order to minimize the wet weather flows, the Town cleaned and re-lined portions of the sewer system. Also, Perth, which has 98% of the Town without a combined system, noticed higher flows during storm events and sealed manhole covers to reduce flows.

Other communities have also identified the relatively higher sewage flows and are working at reducing extraneous flows. For example, Almonte does not have a combined system, but in order to address the relatively large sewage flows in the sanitary sewers the Town has started to clean and video approximately 1/5 of the sewer system each year as a means to identify water entering or leaving the sewage system. Almonte has replaced and re-lined sections of their sewer system, which should lower the percent difference in future years.

For all of the above reasons, it is standard practice when designing sanitary sewers to add a flow rate for extraneous flows. The Municipal Works Design Manual of the Municipal Engineers Association has the following [s.1.3.4.1]: "Sanitary sewers must be sized to allow for infiltration which is simply the entry of ground or other non-sewage water into the system. This is over and above the design figures for sanitary sewage obtained from population counts. This type of infiltration usually results from the quality of workmanship in the installation of sewers and drains (both on public road allowances and private property) as well as manufacturing tolerances in pipe gaskets and joints, connections, etc." Municipalities typically have provisions in their design guidelines for extraneous flows into sanitary sewers. For example, the Sewer Design Guidelines for the City of Ottawa require the addition of 0.28 L/s/effective gross area for extraneous flows [s.4.4.1.1]. Some caution must be used before applying this figure to rural villages, as it has been derived based on an urban environment, but even taking this caution into account, the larger differences in Table G.1 fall within design values once extraneous flows are factored in.

In conclusion, it is difficult to quantify the amount of groundwater that infiltrates into sewer systems (and how it affects the Tier 1 water budget and stress assessment), since storm water can play a significant role. The difference between the inflows and flows in Table G.1 represents the maximum amount of groundwater that is infiltrating into the sewer systems. Storm water entering the sewage system likely plays a significant role in the difference between pumping inflows and sewage flows. However, municipalities should continue with their efforts to minimize water infiltration to sewers in order to lower the amount of water that must be treated and to minimize drainage of the shallow groundwater system.

APPENDIX H

Peer Review Record

And

Comments Summary

Mississippi-Rideau Source Protection Region

<u>Tier 1 Peer Review Record</u>

August 6, 2009

Beginning in the Fall of 2005 the Mississippi-Rideau Source Protection Region (SPR) and the Cataraqui Source Protection Area (Cataraqui) and the Quinte Source Protection Region formed a joint team for peer review of the Conceptual Water Budgets. In addition to the formation of the peer review team, the Regions shared resources and developed many of the methodologies used in the Tier 1 Water Budget and Stress Assessment.

The Conceptual Water Budget for the Mississippi-Rideau SPR was finalized in March, 2007. The joint peer review team and knowledge sharing continued between the three Regions into the Tier 1 process. The Tier 1 work plan and methodology for the SPR was proposed in October 2007 and was accepted by the Province. The first draft for the Tier 1 report was distributed to the peer review team in March 2008 and presented at a peer review meeting in April 2008. The peer review team did not have any significant issues with the methodology presented in the draft report.

New direction from the Province regarding the acceptable methodologies to be used in Tier 1 was presented to all Source Protection Regions beginning in June 2008. The new direction mandated the methodology to be carried out in the Tier 1 studies. Furthermore, The Technical Rules regarding assessment reports was released in December 2008. This document provided further refinements to the methodologies that were to be used in the Tier 1 Stress Assessments.

From December 2008 until June 2009 the Tier 1 report was updated to conform with the mandated methodologies outlined by the Province. During this time the Province and peer review team was consulted on the methodologies to ensure the report conformed to required and acceptable methods. The draft report was provided to the peer review team, neighbouring Regions and the Province on June 16, 2009. A revised draft of the Tier 1 report was presented to the peer review team and the Province on July 24, 2009.

The comments on both drafts from all reviewers are addressed in Table H-1 (starting on p. H-1) and Table H-2 (starting on p. H-14).

In addition to these comments, a comment from a member of the Mississippi-Rideau Source Protection Committee from the Conceptual Water Budget that is also related to the Tier 1 report is also presented in Appendix H.

Table H-1 Comments on Tier 1 Water Budget and Stress Assessment (Preliminary Draft, June 16, 2009)

No.	Reviewer	Reference	Comment	Response
1	Cataraqui	Figure 2.2-2	In the list of watershed areas, to minimize confusion, perhaps the entire Mississippi should be order together, with the tributaries being added in at the bottom (or top)? The jump in drainage areas might confuse people. And then the same with the Rideau. Though Table 2.2-1 kind of alleviates this with the "Upstream Subwatersheds" column.	The subwatersheds in the table on Figure 2.2-2 have now been re-ordered to show the main stem of the river followed by the tributaries.
2	Cataraqui	Figure 2.2-2	Ungauged is also spelt wrong (the "u" and "a" are switched)	Fixed
3	Cataraqui	Section 3.1.2	Are you sure you used the 1971-2000 data? I remember we went through this question, what range is the data we got, is it 30 year, or 60 year, or longer. Just want to confirm again.	The climate data from the Forestry Service used in the Tier 1 analysis was supposedly from 1971-2000. As a check, this data was compared to data from 1931-2000. The values between the two data sets were different. The Forestry Service is now checking the data. If the data is from a different period, it will be noted in the Assessment Report. Either way it should have little to no bearing on the stress assessment.
4	Cataraqui	Figure 3.1-1	The isolines and the colour shading don't match. Perhaps the breakpoints between the 2 should be made the same? The isolines are 25 mm spacing, and the shading is 10 mm to 49 mm. Maybe the shading should be a constant interval as well.	The coloured shading is now at a 25 mm interval. This interval is consistent with the isoline spacing. As recommended by Bill Hogg, the isolines have been removed from the figure as they do not line up with the contours, likely due to smoothing results and elevation differences in the model.
5	Cataraqui	Figure 3.1-1	The 875 mm text about the "LANARK" text also looks like it's 87.5. It might just be the space between the 7 and the 5 showing the line, but it could be confusing to some looking quickly at the map.	Fixed
6	Cataraqui	Page 10, Section 3.1.2, last para.	"…was obtained MNR for…", there should be a "from" in there.	Fixed
7	Cataraqui	Section 3.1.3	Given that you've got field data from the Tay watershed, maybe it should be mentioned? Just a note saying that the MOEE method shows a low of 40 mm recharge in the Tay watershed, field measurements by Queen's researchers have shown that the range of R may be as low as 5-10% of annual P, which would be 40-90 mm. Matching the MOEE method numbers.	Text was added to Section 3.1.3 to compare the calculated recharge using the MOEE (1995) method at a 25 m x 25 m scale to the site scale estimation of recharge by Novakowski et al. (2007)
8	Cataraqui	Section 3.1.3	Maybe also a mention that the baseflow numbers do not take into account regulation, which is a big issue in your watersheds.	Text was added to Section 3.1.3 to discuss the effect of baseflow regulation. All regulated subwatersheds were removed from Appendix C except for the Tay subwatershed. However, the Tay (a regulated subwatershed) was left in Appendix C for comparison purposes with the Novakowski et al. (2007) study.

No.	Reviewer	Reference	Comment	Response
9	Cataraqui	Section 3.2	Perhaps a mention that much of the Nepean outcrops outside the Rideau watershed, and might be recharged there, even if it is a very long travel time from the CRCA to the water supplies. With the exception of Westport.	Text was added to Section 3.2 regarding regional groundwater flow directions.
10	Cataraqui	Section 3.3	Perhaps there is a need to mention that the 1970-2000 period happens to be one of the wettest 30 year period in recent history, which could overestimate the supply (and underestimate the demand) within the water budget work	Section 3.1.2 (1st para) now includes the following: "Based on analyses done for Mekis and Hogg (1999), the 1971-2000 period appears to be the wettest of the 20th century (B.Hogg, 2007), which may affect water budgets."
11	Cataraqui	Section 3.3	The "residual" term would also include any withdrawals from the system too.	Text added to this effect in Section 3.3
12	Cataraqui	Page 22	You break the other town text with spaces between paragraphs, but Smith Falls does not have a space after Perth	Fixed
13	Cataraqui	Page 28, paragraph after equation definitions	This adding of the demand into the supply assumes that the demand has occurred constantly over the period of record of the supply, this is of course generally not the case, and does introduce additional uncertainty into the calculation. Perhaps it should be mentioned?	Text has been added to this affect in Section 7.0 after the equation definitions.
14	Cataraqui	Page 33, second paragraph	Is the dam only 2 m downstream, or is that a misprint?	The dam (is actually a weir) and is 2 m downstream of the intake.
15	Cataraqui	Figure 7.4-1	Since there are GW supply wells in some of the Moderate and Significant SW subwatersheds, is there any connection between the 2?	Text was added to Section 7.4 to clarify the groundwater/surface water connection.
16	Cataraqui	Figure 7.4-1	Is it Almonte that might have a contribution from the river?	Text was added to Section 7.4 to clarify the groundwater/surface water connection.
17	Cataraqui	Figure 7.4-1	It might be something to mention, they may not officially be GUDI, but if they can be affected by low streamflows, it should be mentioned. If the river flow in the Mississippi or Carp is really low, can GW be redirected to discharge to the river, when otherwise it wouldn't? Resulting in less water available to the wells? Is it even possible? Just asking the question.	Text was added to Section 7.4 to clarify the groundwater/surface water connection.
18	Cataraqui	Page 36, second paragraph	Perhaps the Buells Creek or West Branch Little Cataraqui Creek gauges would be useful too, as they are closer to Ottawa, and also have a high area of imperviousness	Flows from Black Creek gauge (Toronto) were used in the first draft report (June 2009) to estimate flows for Ottawa RVCA West and East (see Appendix A). Adjustments were made for precipitation differences. Flows from the Buells Creek gauge in Brockville were then used to estimate flows and compare them to the Toronto gauge results using the same methodology. Differences between the annual mean depth of runoff for the two approaches were minor (2%) therefore the Buells Creek gauge supports the original method but will not be used as the flow rate as it has limited data. The Black Creek gauge

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				has a continuous record whereas the Buells Creek gauge record has large gaps (2 complete years from WSC). The majority of the Buells Creek flows had to be estimated from stage discharge curves using uncorrected water level data. All data for Black Creek is verified by WSC. The drainage area to Little Catarqui Creek gauge is too small for our study purposes. The data is very limited as well.
19	Cataraqui	Appendix C	The baseflow seperation techniques will be sidetracked for regulated systems, as noted. And those are the ones with the highest difference to the USGS numbers. This should be considered in your average (maybe a weighted average instead), and your main body text.	All regulated subwatersheds were removed from Appendix C except for the Tay subwatershed. The Tay was left in Appendix C for comparison purposes with the Novakowski et al. (2007) study.
20	Darin Burr (Dillon Consulting Limited)	General	A) The subwatersheds used in the analysis are very big. I guess this is because the assessment areas were tied to gauge data; however, it is not surprising that the analysis would not identify any significant stress for groundwater systems. In other words the method does not lend itself to identifying groundwater stresses. I note that South Nation/RRCA used much smaller subwatersheds in their analysis, and groundwater stresses were identified. I would expect that your watershed and their watershed would have produced similar results. I think it would be worthwhile to find out why the SN/RRCA identified moderate and significant stresses east of the Rideau, but the M-R analysis found mainly low stresses west of the Rideau. My guess is because their approach estimated recharge at the quaternary watershed (as they had a HSPF model), while the M-R relied on interpreting gauge data which is tied to a larger watershed. I suggest that M-R also decrease the size of the subwatersheds to see if the results of the analysis would be any different. B) Was consideration given to cases where water was taken from a confined aquifer, and returned to a separate unconfined aquifer (which would not recharge the confined aquifer?). For example, wells that tap into the Oxford and March Fm, but penetrate through Leda clay and/or till would discharge to the unconnected watertable aquifer. If the aquifers are considered the same, you would underestimate the stress in the deep aquifer. One way around this would be to identify which wells pump from the deep aquifer, and which ones pump from the shallow aquifer. C) The use of subwatersheds for the analysis is also problematic for Kemptville, as the Golder capture zones extend to the southwest and encompass three subwatersheds. It would be useful to plot the 25 year TOT	A) The Tier 1 subwatersheds (approved in Conceptual WB) were delineated based on the gauge locations instead of the MNR quaternary SWS (subwatersheds) mainly because of the gauge data. There are 20 MNR quaternary SWS in the SPR compared to 22 Tier 1 SWS therefore the Tier 1 SWS are effectively smaller. Two of the MNR quaternary SWS are greater than 1,000 km^2. The largest MNR SWS is 1,922 km^2 and extends from the Mississippi River headwaters to the outlet. Comparatively, the largest Tier 1 SWS is only 874 km^2. In addition, one of the MNR SWS straddles the boundary between MVC and RVCA. This SWS would have had to have been modified to use for Tier 1. The Raison-South Nation subwatersheds were smaller because they used a fifth order stream. Ours were fourth order streams (as recommended by the Province). The smaller Raison-South Nation subwatersheds likely contributed to their stress levels. There is no indication of stresses at the municipal systems that would require us to adjust the sizes. B) The interpretation of the Technical Rules is that all groundwater in each subwatershed is available to be pumped. Therefore, we cannot separate shallow and deep takings. However, this may be a significant issue at a local scale particularly concerning several takings in the Nepean aquifer. C) The town of Kemptville is actually located in the Rideau River Below Manotick subwatershed. The WHPA for the Kemptville wells may partially extend into the Jock Near Richmond subwatershed, but the majority of the WHPA is in the same subwatershed. The method for the Tier 1 is mandated by the Technical Rules. The Technical Rules were interpreted to maintain the same subwatersheds for both of the groundwater and surface water analyses. However, this may lead to problems quantifying the stress since it is unlikely that all of the groundwater in a subwatershed is available to

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			zones for the wellheads as you had originally done in the first drat report. This figure could be used in the discussion of uncertainty.	each well.
21	Darin Burr (Dillon Consulting Limited)	Tables 5.5-1 & 5.6-1	It would be useful if more detailed appendices could be provided that detail how the water demand volumes in Table 5.5-1 and Table 5.6-1 are calculated, as these tables show totals only. It is difficult to trace back how these numbers were derived. For example, for each subwatershed, appendices should include the number of permits and volume totals, type of agricultural permits, and population/number of wells per subwatershed.	New PTTW Tables (11x17) have been created in Appendix H showing Permit #, Specifc Purpose, Maximum Permitted Daily Taking, Consumption Factor, and Monthly Consumptive Demands (Jan-Dec). Added number of private wells in Table 5.7-1.
22	Darin Burr (Dillon Consulting Limited)	Tables 5.5-1 & 5.6-1	I am not sure the units in Table 5.5-1 and Table 5.6-1 are correct. They say 1000 m3/s. Taking the subwatershed Rideau River Below Manotick, which includes the pumping wells at Kemptville, it says that for January there was 19.329 (1000 m3/s). That translates to over 4 billion m3/day, but the Kemptville average water taking (2006 data from Golder report) is only 1491 m3/day?	Values are correct however title for table re-written and additional text provided in report for clarity.
23	Darin Burr (Dillon Consulting Limited)	Table 5.6-1	The last column of these tables says "Annual" in the heading, but I am not sure how this value was calculated.	Text was added to Section 5.7 to describe the calculation of annual demand.
24	Darin Burr (Dillon Consulting Limited)	p. 26, top paragraph	The referenced tables should be Table 5.6-1 and not 5.7-1.	Corrected
25	Ed Watt (XCG Consultants)	General	I have had a quick look at the revised report. It is well-organized and reads quite well. I have no suggestions regarding the text.	-
26	Ed Watt (XCG Consultants)	Graphs	The water budget graphs have been changed since the draft of March, 2008, and not for the better. In every case, the precipitation graph rises from zero to the January value and falls from the December value to zero, which begs the question, “WHY”. The March, 2008 presentation was much better.	This was a graphic presentation error. Corrected

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27	Ed Watt (XCG Consultants)	Tables 5.5-1 & 5.6-1	There are far too many significant figures in the demand tables.	The PTTW is given in m^3/d. This is converted to m^3/s. The number of significant digits was preserved to allow for an accurate comparison of permit pumping rates in m^3/s in this report and the Provincial data base.
28	MNR	Page 1, last paragraph	"It is designed to screen out unstressed subwatersheds using existing information collect~~ing~~**ed** for the Conceptual Water …"	Fixed
29	MNR	(pg2, Section 1.2, 1^{st} paragraph)	"The purpose of the Tier 1 is to identify subwatersheds that may be limited in surface water or groundwater supply **relative to demand**, otherwise called water quantity stress."	Fixed
30	MNR	(pg15, formula)	The 'GWnet' term should be defined.	Fixed
31	MNR	General	Consider replacing 'MNR' with 'The Province' with regard to direction given. An example is pg20, 3^{rd} paragraph (e.g. ~~MNR~~ **The Province** has directed …)	Fixed
32	MNR	(pg20)	I do not believe the acronym 'OMYA' has been defined in the document.	OMYA is not an acronym. OMYA has been replaced in the text with the proper name Omya Canada Inc (as per personal communciation with Omya staff in 2009).
33	MNR	(pg 22)	Missing a space between the first and second paragraph.	Fixed
34	MNR	(pg24, 2^{nd} paragraph)	Add one sentence which explains why 200L per person per day was chosen.	Text was added to Section 5.4 to describe the origin of the value.
35	MNR	(pg27, Section 6.2, 5^{th} paragraph)	For Tier 1, the monthly recharge volume should be constant (i.e. the annual numbers are divided by 12 months). Recharge/supply must be calculated in this way. This is consistent with the way that Quinte has calculated supply.	The recharge and supply values were constant. Text was added to Section 6.2 to clarify the calculations.
36	MNR	(pg29, 3^{rd} paragraph)	Given that the highest percent demand calculation (81%) is based on 3 power production permits, this may warrant a call to the permit holder to determine if they are using the actual takings and/or the consumptive demand is accurate. This comment would also apply to other large PTTW which could be artificially increasing a % demand value to moderate or significant.	Monitoring is being undertaken at the generating stations as a result of the Mississippi River Water Management Plan (2006) however this data is very limited and not readily available. The most data that is potentially available is one year of water level data with no stage-discharge curve to convert it to flows.
37	MNR	Page 37	On page 37, it is noted that all of the measures of conservatism increases the confidence that the subwatersheds identified as low stress are not experiencing water quantity issues. However, given all of the measures of conservatism applied throughout the document, are you confident that the moderate and significant stress levels are warranted? I have included some examples below. • (pg13, 2^{nd} bullet from the bottom) Qin is reduced to zero • (pg21, 1^{st} paragraph) maximum permitted takings were used	1^{st} Bullet – text removed 2^{nd} Bullet – text clarified to indicate maximum takings were multiplied by the appropriate CF 3^{rd} Bullet – Agricultural takings were arbitrairily divided in two (surface water and groundwater). The conservative overestimation was left in to account for an uneven split of water takings to either groundwater or surface water. 4^{th} Bullet – Galetta Stress (new text added to Section 7.1):

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			• (pg25, 3rd paragraph) using a factor of 1.0 provides a 10 to 20% overestimate of agricultural use. • (pg26, Section 6.1, 3rd paragraph) The smallest value of supply minus reserve over the two periods (1986-2005 and 1971-2000) was selected for the denominator in the percent water demand equation. This approach (comparing the two periods of record and selecting the minimum flow) is more conservative than just looking at one period of record. • (pg27, section 6.2, 3rd paragraph) The calculations and discussion presented above in Section 3.2 showed lateral groundwater flow was negligible. Therefore, lateral groundwater flow was assumed to be zero. Groundwater supply was estimated solely from groundwater recharge. This is a conservative approach that likely leads to an underestimation of groundwater supply. • (pg30, 2nd paragraph) It should be noted here that extra conservatism was built-in to the above calculations. Firstly, to estimate the amount of surface water supply for the percent demand calculations, minimum streamflows were selected from two periods of record … • (pg 36, 4th paragraph) … was selected from two time periods … • (pg37, Section 8.2, 3rd paragraph) 'Anecdotal evidence suggests some large permit holders do not have the capacity to met their maximum allowed taking' • (pg38, 2nd paragraph) The combination of small values for groundwater recharge and no lateral groundwater flows resulted in a relatively small estimate of groundwater supply.'	The percent water demand calculations show that the Mississippi River At Galetta subwatershed has the highest monthly percent water demand in the SPR (80.8%). This is categorized as the only SIGNIFICANT stress level in the SPR. Over 99% of the permitted demand in this subwatershed is from three permits for power production from three generating stations on the Mississippi River. The permitted takings and the consumptive demands from each of the generating stations are an order of magnitude higher than any other permitted taking in the SPR. Consumptive demand was estimated based on the maximum permitted taking multiplied by a consumption factor of 0.1 (10%) as per the Guidance. There is no actual water takings data available for these generating stations. The permitted takings are believed to represent the daily volume of water allowed to be diverted through the generating stations and are therefore not actually lost to downstream purposes. Aside from minor losses due to evaporation from the headponds, the only ability that these stations have to consume water such that it is not available for downstream purposes is through impounded storage. As a result of either physical or legal limitations the total storage volume of water that these stations can collectively remove amounts to 518 ha-m (hectare metres). This volume also accounts for a fourth station on the river that does not have a PTTW (and was therefore not included in the original 80.8%). The 518 ha-m is equivalent to an average monthly withdrawal of 1.9 m^3/s resulting in a percent water demand of 48% (also accounting for other demands within the subwatershed). These stations however operate within tighter "best practice" limits, which can result in a total storage volume of 155 ha.m. This volume is equivalent to an average monthly withdrawal of 0.6 m^3/s, a percent water demand of 21.6%, and a MODERATE stress level. Once the available storage has been used up, no further withdrawal can occur until additional water is released downstream. In comparison, the percent water demand for losses to evaporation only was equivalent to a monthly flow of 0.21 m^3/s, which resulted in a percent water demand of 5.1% and a LOW stress (while still accounting for other demands in the subwatershed). The losses to evaporation represent a true consumptive demand. In comparison, water held in storage is potentially available while evaporative water is lost. The storage approach is the worst-case scenario as it assumes all four generating stations hold back water at the same time. The storage approach is conservative and results in a percent demand that is close to the LOW stress level (criteria is 20%). It can be concluded that the stress level for the Mississippi River At Galetta subwatershed can be reduced to LOW given that the evaporation of water from the head ponds represents the only true consumptive use. This approach was also taken by the Halton Region and Grand River Region.

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				Note that the average stream flow data from 1971-2000 was inadvertently used to define the water supply for Galetta instead of data from 1986-2005, which had a higher flow. This means that the Galetta analysis is actually less conservative in comparison to the remaining subwatersheds. 5th and 9th Bullets – A conservative approach was deemed appropriate give the regional nature of the calculations and uncertainty inherent in calculating groundwater recharge. Despite the conservative approach, only one subwatershed was stressed (Moderate). A detailed examination of this subwatersehd showed numerous commercial PTTWs, as well as agricultural and private takings. Therefore, it is considered to be an appropriate result. 6th and 7th Bullets – Streamflow varies depending on many factors. The minimum difference between the supply and reserve (Q50-Q10) was selected between the two time periods to account for environmental changes. There can be large differences between the two periods. Both periods can be assumed representative of current flow regimes however it was decided that the minimum values would be selected given the nature of the stress assessment. 8h Bullet – the text was removed
38	MVC	General	Overall it seems to read well and reflects our understanding of hydrologic conditions and water supply issues.	-
39	MVC	Sec. 7.3.1	Reference to minimum allowable flow rate on Mississippi should read, "… Mississippi River Water Management Plan requires a minimum flow rate objective of 5 cms be maintained …"	Done
40	MVC	Sec. 8.1	Reference to minimum allowable flow rate on Mississippi should read, "… the minimum flow rate objective along the Mississippi River".	Done
41	MVC	Sec. 9.0	Regulations of rivers … should read "Regulation of rivers…"	Done
42	RVCA	General	I have taken a quick look at the report. It looks good and I did not find anything surprising.	-
43	Michel Robin (University of Ottawa)	General	I have reviewed the report and find it extremely well-written and concise. In my opinion, it provides information that meets the standards given in the Technical Rules for Assessment Reports of the MOE.	-
44	Raisin/South Nation SP	-	No comments provided	-

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	Region			
45	Quinte SP Region	-	No comments provided	-
46	Bill Hogg (Climate)	-	I have reviewed the Tier 1 Water Budget and Water Stress Assessment Preliminary Draft Report and found it to be a well-written document describing an approach consistent with the goals and guidelines for Tier 1 studies employing reasonable assumptions for the meteorological and climate variables. Good job!	-
47	City of Ottawa	Page 1 [2nd para under 1.0, last sentence]	Suggest replacing *"The methods used were obtained from"* with "The methods used are in conformity with the Technical Rules [Part III.3] and were further educated by the". {Reason: to emphasize that the Technical Rules is the primary document that was used, while pointing out that the Guidance was also consulted.}	Fixed
48	City of Ottawa	Page 1 [1st para under 1.1]:	There is a closing parenthesis missing after *"(Q)"*.	Fixed
49	City of Ottawa	Page 1 [2nd para under 1.1, last sentence]:	This paragraph relates to the CWB, but I believe that even in the CWB, supply (for GW) was taken as being equal to recharge, and not to WS [P – ET] as indicated in the last sentence. In this Tier 1 report, supply is defined in Section 6.2 [where, as in the CWB, supply = WS x I_f].	This paragraph is referring to a comparison between the regional water supply (P – ET) and the regional demand (section 6.1.1, CWB). The supply (P- ET) is also known as water surplus. It is not to be confused with GW recharge. The percent demand calculations were not required in the Conceptual Water Budget. They were only required for Tier 1. For Tier 1, GW supply was taken as recharge. SW supply was the streamflow data.
50	City of Ottawa	Page 2 [last long para under 1.2, middle of para]:	Suggest changing *"Water supply is taken from the water budgets"* to "Water supply is taken from the water budget (see Section 6.2)". {Reason: this will make things a little easier to follow.}	Fixed
51	City of Ottawa	Page 3 [3rd para]:	This paragraph should begin with "Section 4.0 presents", in order to match the other paragraphs in this section. Also, I believe that *"ratio of the water supply to the water takings (demand)"* should be semantically rendered "ratio of the water takings (demand) to the water supply". The concept of "reserve" could possibly be mentioned here as well.	Fixed
52	City of Ottawa	Page 8 [4th para]:	*"King's"* should be spelled "Kings" (no apostrophe). This occurs at various locations in the report, and can be resolved using the find/replace tool.	Fixed
53	City of Ottawa	Page 11 [1st para]:	The last sentence starting with *"PET…"* appears to be redundant.	Sentence deleted

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54	City of Ottawa	Page 12 [1st para under 3.1.3]:	Slope and cover are two distinct components of the overall infiltration factor, yet they are grouped together when discussing the range of values. Perhaps these should be separated in the narrative, as was done for the soil component.	Infiltration factors for slope are now provided in the text (separate from the factors for land cover).
55	City of Ottawa	Page 12 [2nd para under 3.1.3]:	The MOEE (1995) method is not related to septic system design per se, but rather to the impact of these systems. Therefore, I suggest the following modifications. In the 1st sentence *"capacity for septic systems"* should be changed to "capacity for nitrate dilution for septic system effluent". There is a statement in this paragraph about the MOE method being conservative, but you may want to check with Clyde Hammond on this point. I have been working a long time with this method and I don't recall too much talk about it being conservative (but it is possible that it is). *"for assessing the suitability of septic system design"* should be changed to "for assessing the impact of septic systems". There is mention that professional judgement was used to estimate the infiltration coefficients for soil types that were not published in the MOEE (1995) method—since this is a very important part of the water budget in this SPR [wetlands, etc.], I suggest that the rationale for the values selected be presented in this report.	All text changes were made. The text regarding the conservative approach was taken from the MOEE (1995) report page 4-61.
56	City of Ottawa	Page 12 [last para]:	There is a statement that some recharge will go to AET. This is not possible as recharge is a subset of the WS and the WS already has AET factored out (WS = P – AET). Perhaps we could say that some recharge will go towards replenishing deep bedrock aquifers.	The baseflow method does not use water surplus. The text was updated to clarify this point.
57	City of Ottawa	Page 13 [1st para]:	The difference between MOEE (1995) and baseflow is said to be 12%, but is App. "C" I calculate it as ~33%.	The appendix and text in Section 3.1.3 were update to remove all regulated subwatersheds from Appendix C except for the Tay subwatershed. The Tay was left in Appendix C for comparison purposes with the Novakowski et al. (2007) study.
58	City of Ottawa	Page 13 [Section 3.2]:	Section 3.5.3.4 of the CWB mentions a few things that may be helpful to do in the Tier 1. Most of these were done, but groundwater dating was not done. I am wondering if we should not have a statement regarding GW dating in this report. We could possibly say that this is difficult to do because most wells are open holes and don't receive water from only one aquifer in many cases. There is also the cost and time factors involved in doing these studies.	Text was added to Section 3.2
59	City of Ottawa	Page 13 [1st para]:	a. The equation would be easier to read if the "ins" and "outs" were subscripted, as they were in the CWB and in the Guidance. b. I am also wondering why SW was changed to Q. The CWB and the Guidance has this component as SW. Keeping the same nomenclature would help maintain continuity.	a. Done b. Q was changed to SW to be consistent with the CWB. The term "streamflow" was changed to Surface Water on water budget graphs to be consistent with the main body of the report.
60	City of	Page 13 [2nd	There is no definition for GWnet. One can easily infer that it is GWin – GWout, but	The definition was added in Section 3.2

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	Ottawa	para]:	seeing it is introduced here for the first time it may be good to define it explicitly. The other thing is that, at the end of 3.2, it is shown that GWnet drops out, so it may be better to leave it out of this equation and to say "see below for GW flow component".	
61	City of Ottawa	Page 14:	I do not understand the second full bullet regarding the negligible factors. For example, recharge is the only form of supply so how can it be negligible? I also do not understand the statement regarding anthropogenic fluxes (is this saying that all the anthropogenic consumption finds its way back into the subwatershed?).	The text was clarified to discuss other internal fluxes of water
62	City of Ottawa	Page 14 [1st para under "Groundwater"]:	The Nepean is only found on about half the SPR, but this section seems to generalize K and I using the parameters from the Nepean only. In the 5th line add "a" between *"from"* and *"sand"*. In the last sentence change *"flow in the SPR is assumed"* to "flow in the east half of the SPR [where the Nepean aquifer is present] is assumed".	Text was added to Section 3.2 to clarify the extent of the Nepean and the assumptions made to lateral groundwater flow. The other text changes listed in this comment were also made.
63	City of Ottawa	Page 14 [2nd para under "Groundwater"] :	Change *"SPR"* to "Nepean Formation".	Change not made. The purpose is to look at the hydraulic gradient across the region, assuming a continuous groundwater flow system.
64	City of Ottawa	Page 14 [3rd para under "Groundwater"] :	Add "east half of the" in front of the first mention of *"SPR"*.	Text was added to Section 3.2 to clarify the extent of the Nepean Formation.
65	City of Ottawa	Page 14 [4th para under "Groundwater"] :	I question prorating the flow based on the Nepean data only, as half the SPR is Precambrian.	Text was added to Section 3.2 regarding the assumptions regarding the calculation of groundwater flow.
66	City of Ottawa	Page 15 [1st para]:	Notwithstanding my above concern, prorating should technically be based on the width of the subwatershed normal to the flow lines, not on the area. This fact can be easily seen if one takes an extreme example of a narrow subwatershed compared to a wide subwatershed. In the end it will not make a difference, because we are taking GW_{in} to be equal to GW, but the calculations should still be based on the proper prorating method. *"Section 6.2.2"* should be "Section 6.2".	The original method assumed the lateral groundwater flow was sourced from each subwatershed. The method has been updated in Section 3.2 using the cross-sectional area of the Nepean Formation in each subwatershed.
67	City of Ottawa	Page 15 [2nd para under 3.3]:	A0 The paragraph begins with *"The difference"*, but I am not sure what this refers to (which difference?).	a) The difference is the difference between the inputs and the outputs (now added to text). b) On an annual basis, storage can be assumed to be zero so only a residual value for error

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			b) The paragraph says that errors and uncertainty are lumped in the "Residual" and this is shown in the equation; however, the rest of the report treats Delta S and "Residual" as separate entities. c) Again GWnet is in this equation, but since it is zero it can drop out.	and uncertainty is given. On a monthly basis, storage is not zero so the storage term is shown with the residual. The equation on page 16 now shows the residual term. c) GW net is now removed from the equation.
68	City of Ottawa	Page 16 [2nd para]:	a) Mention is made of evapotranspiration in the first line, but the numbers quoted for comparison between watersheds only include precipitation. b) Add "the" before "Tay River" in the last sentence.	a) Text now includes values for ET b) Done
69	City of Ottawa	Page 17 [2nd para]:	a) There is a typo in the first mention of the word "degree". b) Also, *"to a lesser degree"* should likely be explained a little.	a) Corrected b) Text is corrected. Fall River is not regulated. Kemptville Creek is regulated.
70	City of Ottawa	Page 17 [last para]:	*a)* *"17 to 22 mm"* should likely be changed to "17-18 and 22-26 mm" in order to better reflect the table. *b)* Also, for consistency *"Tay River"* should be changed to "Tay River At Perth"; and *"Smiths Falls"* to " "Rideau River Above Smiths Falls".	a) Fixed b) Fixed.
71	City of Ottawa	Page 20 [para just under 4)]:	*"the by Grand River"* should be change to "by the Grand River".	Fixed
72	City of Ottawa	Page 20 [last para]:	In the third line *"errors"* should probably be changed to "mistakes", as GIS coordinates are quite precise and what we are worried about (I think) is that there would be human error (mistakes) in keying-in the wrong numbers.	Done
73	City of Ottawa	Page 21 [2nd para under 5.2]:	I am not sure why *"an MNR directive"* is inserted here.	MNR directive removed and new sentence written "This approach was recommended by the Province."
74	City of Ottawa	Page 21 [last para]:	a) *"growth"* should be changed to "grow". B) Also, is a 1.5% yearly growth rate over 25 years the same as multiplying by 1.5?	a) Fixed. b) The text is clarified as Carleton Place future demand estimates are based on an annual growth rate of 1.5%, which is equal to a 49% population difference over 25 years. The monthly municipal water use was multiplied by 1.49.
75	City of	Page 22 [1st	Should 2033 be 2031?	Projections done by the Town of Perth to 2031 were assumed for 2033. This is explained

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	Ottawa	para]:		in Section 5.2.1.
76	City of Ottawa	Page 22:	For many of the systems the increase in population is quite different than the increase in pumping rate. I am sure that there are engineering reasons for this, and perhaps we should mention a few. Also, if both Kings Park and Munster have nearly reached their designed maximums, why do we add 5% to Munster.	Text was added to Section 5.2.1 to provide examples of why the anticipated increase in pumping rate may not be the same and the anticipated increase in population. The Munster pumping increases was raised to 5% in the calculations and text.
77	City of Ottawa	Page 23 [1st para]:	All the systems seem to have numbers associated with growth except Lanark. Any reason?	The Lanark municipal GW system is currently being designed and is not operational. All pumping rates are anticipated pumping rates based on the design of the system.
78	City of Ottawa	Page 25 [under 5.6]:	I think that *"Table 5.6-1"* should say "Table 5.5-1". Also, I think that there is a unit issue in these tables. If the values are in *"1000s of m^3/s"* then the demand would dramatically exceed the supply!	Table number was incorrect. Fixed number. The numbers are in m^3/s x 1000 (divide by 1,000 to get back to m^3/s). Table title and text are modified to make it clearer.
79	City of Ottawa	Page 26 [1st para]:	*"Table 5.7-1"* should be changed to "Table 5.7-1". Also, see above comment regarding the units.	Table number was incorrect. Fixed number.
80	City of Ottawa	Page 27 [2nd para under 6.2]:	I think that the 1st sentence should be softened to: "The groundwater supply in the Technical Rules is interpreted as the sum…" {I spoke with Dru about this.}	Text changed.
81	City of Ottawa	Page 27 [4th para under 6.2]:	*"recharge is constant"* should likely be changed to "recharge is assumed to be constant".	Text changed.
82	City of Ottawa	Page 27 [5th para under 6.2]:	*"are equal"* should likely be changed to "are assumed to be equal". Also, the Guidance says that the GW reserve can be either 10% of the supply or 10% of the discharge. This Tier 1 assessment chose 10% of the supply. Perhaps a sentence could explain why this value was chosen.	Text changed. Text was added to Section 6.2 to explain why groundwater reserve was calculated using the groundwater supply, and not groundwater discharge or baseflow.
83	City of Ottawa	Page 31 [1st para]:	In the last sentence I believe that *"rational"* should say "rationale".	Fixed
84	City of Ottawa	Table 2.1-1:	Typo in *"King's"*.	Fixed
85	City of	Table 3.3-1:	Why do we show GWnet, as the values are always zero?	GW_{net} (zero) removed from tables.

No.	Reviewer	Reference	Comment	Response
	Ottawa			
86	City of Ottawa	Tables 5.5-1 and 5.6-1:	Issue with the units (see earlier comment).	The numbers are in m^3/s x 1000 (divide by 1,000 to get back to m^3/s). Table title and text are modified to make it clearer.
87	City of Ottawa	Graphs 3.4-1 to 3.4-22:	I suggest removing GWnet from these graphs (as we should remove it from the table), as it is always zero.	GW_{net} (zero) removed from figures.
88	M-R Source Protection Committee	This comment was received from a member of the SPC reviewing the Conceptual WB in 2008. It applies to both the Conceptual and the Tier 1.	Sewer Infrastructure Deficiencies: Data in the report indicates that sanitary sewer systems in some groundwater-serviced areas are potentially draining groundwater at relatively significant rates. Specifically, Table 3.7-5 indicates that the average monthly sewage discharges for Perth, Almonte and Kemptville are roughly 30% greater than the average monthly water takings. Assuming the data is correct, these increased flows in the sewer system can be attributed to inflow and infiltration (I/I) of groundwater (and surface runoff that would otherwise become groundwater) into the sewer system due to leaking sewer mains and sewer appurtenances. These increased rates of flow are significant enough to be considered a 'demand' on the water budget since they are short-circuiting flows from groundwater to surface water discharge. In addition to short-circuiting normal groundwater flows, leaking sewers carry clean groundwater to wastewater treatment facilities; treatment of this water is a very inefficient use of those facilities. [It should be noted that I/I also occurs in the City of Ottawa system and, most likely, other surface-supplied systems. There is therefore a groundwater 'demand' in these surface-supplied systems. The significance of this 'demand' depends on infrastructure and groundwater table conditions.] The condition, efficiency and use of infrastructure are very important factors in the volume of water demanded by communities. This water budget report is one of several background documents that will form the basis for policy in the MRSPR. The report therefore needs a 'hook' in the text that raises issues of infrastructure condition, its importance in water demand and its potential impact on water availability.	See response in Appendix G

Table H-2 Comments on Second Draft of Report (July 24, 2009)

No.	Reviewer	Comment(s) in Table H-1	Reference to Second Draft of Report (July 24, 2009)	Comment	Response
1	Cataraqui	1, 2	Figure 2.2-2	List changed, looks fine.	-
2	Cataraqui	3	Section 3.1.2	Agreed. More is needed to determine specifically what the period of record of the data is, but it shouldn't make a big difference to the overall stress assessment.	-
3	Cataraqui	4 and 5	Figure 3.1-2	Isolines removed, looks fine.	-
4	Cataraqui	6	Page 10, Section 3.1.2 last paragraph, 2nd sentence	Text changed, looks fine.	-
5	Cataraqui	7 and 8	Section 3.1.3	Text added, looks good, and explains some additional details about the method, and uncertainty.	-
6	Cataraqui	9	Section 3.2	Text added, looks fine.	-
7	Cataraqui	10 and 11	Section 3.3	Wet period text added, looks good. "Residual" text added, looks good.	-
8	Cataraqui	12	Page 22	Spaces added, looks fine.	-
9	Cataraqui	13	Page 28, paragraph after equation definitions	Text added, looks good.	-
10	Cataraqui	14	Page 33, second paragraph	No change made, distance confirmed. I was thinking this might have been a typo.	-
11	Cataraqui	15-17	Figure 7.4-1	The added text looks good to explain these items. However, the second line in the second paragraph on page 40 says "(Carp system for Kinburn and the Almonte system in Galetta)". I'm assuming that you're referring to the Kinburn and Galetta subwatersheds, but since they are also small villages, you should probably clarify that, otherwise it's confusing.	Text clarified to show complete subwatershed names.
12	Cataraqui	18	Page 36, second paragraph	No changes to the text, but glad that you were able to compare to a more local watershed, and find the same details. Looks good.	-
13	Cataraqui	19	Appendix C	Regulated systems removed from the text, looks fine.	-
14	Darin Burr (Dillon Consulting Limited)	20-24	General	My remaining comments are below. Overall, the report is well written.	-

No.	Reviewer	Comment(s) in Table H-1	Reference to Second Draft of Report (July 24, 2009)	Comment	Response
15	Darin Burr (Dillon Consulting Limited)	-	Table H-1 above	Reference to Dillon in the Comment sheet (Table H-1) should say "Dillon Consulting Limited".	Corrected
16	Darin Burr (Dillon Consulting Limited)	(22)	Tables 5.6-1 & 5.7-1	I believe the term m3/s x 1000 in the table is still confusing. Do you mean "m3/s divide by 1000", or "1/1000th m3/s". I would suggest using the term L/s in the table instead or at least put in brackets on the header that it also means L/s.	The demand values have been multiplied by 1,000. They have to be divided by 1,000 to get back to m^3/s. Tables 5.6-1 and 5.7-1 now have a footnote explaining that the table units are equivalent to L/s. This is also explained now in Sections 5.6 and 5.7.
17	Darin Burr (Dillon Consulting Limited)	(23)	Table 5.6-1	It would be clearer if the word Annual was change to "Annual Average" or "Weighted Annual Average" or a footnote placed in the table explaining how annual is calculated.	The annual demand was calculated by a weighted average of the monthly demands to account for the different number of days in each month. A footnote was added to Table 5.7-1 explaining how this was calculated.
18	Ed Watt (XCG Consultants)	25-27	Various	Figures (graphs) are now OK as I indicated in an earlier message. I am not sure that I understand the response to my comment re: significant figures (Comment #27), but it is not a big deal.	-
19	MNR	28-37	Various	*No additional comments.*	-
20	MVC	38-41	Various	Comments #38-41 have been addressed.	-
21	Michel Robin (University of Ottawa)	43	-	*Did not review.*	-
22	Raisin/South Nation SP Region	44	-	*No additional comments.*	-
23	Quinte SP Region	45	-	*No additional comments.*	-
24	Bill Hogg (Climate)	46	-	I have reviewed the revised Mississippi-Rideau Tier 1 Water Budget Report and find it to be a well-written document consistent with provincial guidelines and employing reasonable methodology and assumptions for dealing with the climate and meteorological parameters. Congratulations on a job well done.	-
25	City of	47-87	-	You did a great job at incorporating the peer review comments into the report, and I see that you made a few other changes along the way to improve the report. In the	-

No.	Reviewer	Comment(s) in Table H-1	Reference to Second Draft of Report (July 24, 2009)	Comment	Response
	Ottawa			end, a very good report has been made even better. I just have a few comments on the second draft of the Tier 1 report [dated July 24, 2009], but these comments are strictly related to where my own original comments occasioned a changed to the report.	
26	City of Ottawa	(54)	Page 12, 1st para under 3.1.3:	The ranges for the infiltration factors do not exactly match those found in Table 2 of the MOEE Technical Information document. The source and rationale for the values could perhaps be expanded. Also, "Fill" could be changed to "Open Sandy Loam" to better match Table 2.	M. Kearney was consulted over the phone. It was agreed that a detailed methodology can be added into Appendix C taken from Appendix F of the Conceptual Water Budget with minor revisions noted for Tier 1 to address this comment.
27	City of Ottawa	-	Page 13, 2nd para:	a) There seems to be a discrepancy between the first sentence, which mentions 40 mm/yr, and the later sentence that mentions 121 mm/yr [for what seems to point to the same information]. b) Also, the "be" before "vary" should be removed.	a) Text was added to clarify the comparison of the calculated groundwater recharge rate of 40 mm per year in some cells to the subwatershed average 121 mm per year. b) Fixed
28	City of Ottawa	-	Page 15, 1st para under "Groundwater Flux":	Insert a space between "a" and "laterally".	Fixed
29	City of Ottawa	(65 and 66)	Pages 16 and 17	My comments were incorporated in a certain manner, but I still have an issue with the lateral flow within the Precambrian bedrock. Since we do not have good data on the lateral flow in this formation, we should exclude this part of the SPR in the prorating exercise. This is perfectly justifiable because the prorating in the area where the Nepean Formation is present indicates that lateral flow is only a small portion [5%] of the recharge. The report can therefore make a qualitative statement regarding the west half of the SPR, and say that if in the [high yielding] Nepean lateral flow can be ignored, then it can also be ignored in the [lower yielding (on average)] Precambrian. This will affect the 3rd full para on page 16, by changing "SPR" to "Nepean Formation"; modifying the 4th full para [last sentence] to say that only the part of the SPR with the Nepean present will be prorated; modifying the last para on page 16 to indicate that lateral groundwater flow is assumed to be evenly distributed in the Nepean only; changing the first para on page 17 accordingly; and also the last line of the 2nd para of page 17.	Text was clarified to indicate the prorating was only conducted on subwatersheds that contained the Nepean Formation aquifer. M. Kearney was consulted to ensure the text was sufficiently clear.
29	City of Ottawa	-	Page 17, second para under 3.3:	The word "too" in the penultimate sentence can be dropped.	Fixed
30	M-R Source Protection Committee	88	Appendix G	-	The Tier 1 report will be circulated to the Source Protection Committee once it has been approved by the Province. The Committee will have the opportunity to review the report and provide comments at that time.