RIDEAU VALLEY
CONSERVATION AUTHORITY

Technical Memo

January 12, 2009

To: Bruce Reid, P.Eng.
Director, Watershed Sciences and Engineering Services

From: Ferdous Ahmed, Ph.D., P.Eng.
Senior Water Resources Engineer

Subject: **Quantifying the Importance of Wetlands in the Management of Floods and Droughts in the Rideau Valley Watershed**

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Executive Summary

This study was undertaken to discern and quantify the hydrological functions of wetlands within the context of Rideau River watershed.

Using numerical modeling techniques, we have quantified the potential cumulative effect of the loss of non-PSWs (locally significant wetlands and un-evaluated wetlands) on peak flood discharges and minimum dry weather flows at selected locations within the watershed. The knowledge gained form this analysis will form the basis of future decisions by RVCA with respect to the application of its Interference with Wetlands regulations on wetlands that are not designated provincially significant.

It was found that the flood risk will increase if non-PSWs are removed. The 1:100 year flood flow will increase by about 4% at the local scale if all non-PSWs are removed. At present, all wetlands (PSWs and non-PSWs) within RVCA probably reduce the 1:100 year flood by roughly 10%. The impact of non-PSW removal on flood diminishes downstream of long channels and lakes.

The 1-day low flow is likely to increase if non-PSWs are removed. The impact of non-PSW removal on low flow diminishes significantly downstream of long channels and lakes. However, no definite inferences should be drawn without further investigation.

It is recommended that, in addition to PSWs, all non-PSWs within RVCA be brought under regulation and protected.

Introduction

This study was undertaken to discern, quantify and demonstrate the value of the hydrological functions of wetlands in a Rideau River watershed context.

Using numerical modeling techniques, we have quantified the potential cumulative effect of the loss of Non-PSWs (locally significant wetlands and un-evaluated wetlands) on peak flood discharges and minimum dry weather flows at selected locations within the watershed. The knowledge gained form this analysis will form the basis of future decisions by RVCA with respect to the application of its Interference with Wetlands regulations on wetlands that are not designated provincially significant.

Wetlands within RVCA

There are three categories of wetlands in the Rideau watershed – see Figure 1 and Table 1. A total of 639.6 km^2 or about 15% of the watershed is covered by wetlands. The distribution and density of wetlands vary significantly from place to place; however, according to the current information (Fall 2008), the overall distribution is as follows:

- Provincially Significant Wetland (PSW) – covering 384.1 km^2 or 9.0% of the watershed area – delineated and recognized by the Ministry of Natural Resources (MNR) – already covered by RVCA regulations – not at risk of being lost
- Locally Significant Wetland (LSW) – 28.8 km^2 or 0.7% of the watershed area – not covered by RVCA regulations – at risk of being lost
- Non-Evaluated Wetland (NEW) – 226.7 km^2 or 5.3% of the watershed area – not covered by RVCA regulations – at risk of being lost

The last two categories – LSWs and NEWs – together are usually called non-PSWs. 6.0% of the watershed area or about 255.5 km^2 are within non-PSWs. Therefore, the total wetland area within RVCA – both PSWs and Non-PSWs – is 15%, or about 639.6 km^2.

It is the non-PSWs that are not currently protected by RVCA regulations and are at risk of being lost. The hydrological functions of non-PSWs, and the effect of their removal, have been investigated here.

Overview of Wetland Hydrology

The single most important or notable hydrologic characteristic of wetlands is water storage – they are shallow depressions on the landscape where runoff from rainfall or snowmelt is trapped, either in the pore spaces within the accumulating sediments and organic matter of the wetland, or in open water area within the wetland.

Storage of runoff in wetlands results in an overall reduction in runoff volume following rainfall and snowmelt events, and contributes to an overall attenuation of the hydrograph (the duration of the runoff event is longer, and the maximum flow rate is less, than it would otherwise be). Downstream flood discharges and levels are therefore lower than they would be without the presence of wetlands.

Another aspect of flow modification is the impact on low flow. The presence of wetland can affect the low flow in two ways: most of the time it reduces the low flow, but it can also increase it (Bullock and Acreman, 2003). The duration of low flow can also be affected either way. All these depend on the nature and complexity of the basin-wetland-stream system.

Water that is trapped in shallow wetland depressions after a rain or snowmelt event is not held there forever – it slowly seeps into the ground, replenishing ground water reserves and eventually emerging again at the surface as groundwater discharge (or baseflow) to a watercourse or water body at a topographically lower location; simultaneously it evaporates to the atmosphere, eventually to fall to the surface again as precipitation. Without the storage of runoff in wetlands, regional groundwater resources will gradually diminish over time, and drought events will gradually increase in frequency and severity.

In summary, then, the main four hydrologic functions are:

- Flood attenuation
- Low flow modification
- Groundwater recharge
- Baseflow sustenance

Out of these, flood attenuation and low flow modification have been studied here with the available watershed model. Groundwater recharge and baseflow sustenance are more difficult to quantify and are beyond the scope of the present study.

Benefits of wetlands, other than hydrological functions, include water quality enhancement, biodiversity, unique habitat for fauna and flora, and the intrinsic ecological value as part of the broader environment. These aspects are more difficult to quantify and analyze. However, any decision on wetland should take them into account in some way, however crude.

Methodology

As shown in Table 2, the overall methodology involves six modeling scenarios. The output flow series from these scenarios has been analyzed to discern the impacts of non-PSW removal on flood and low flows.

Scenario A, the base condition, is essentially the Mike11 model of the entire Rideau Basin that was calibrated and validated in 2007 (RVCA, 2007a). Figure 2 shows the discretization and river network of the model. This model was run for a long time period, from December 16, 1943 to December 31, 2003, as permitted by the availability of climate data at Ottawa Airport. Since the structure (i.e., dam) operation data was not available for the whole period, it was assumed to follow the "rule curve" where applicable or a typical year's data elsewhere. The first one year of simulation were ignored in the subsequent analysis in order to avoid the influence of initial conditions. Thus, all analyses are based on the simulated results from January 1, 1945 to December 31, 2003.

Scenario A is assumed to represent the existing condition – the way the watershed is now. The 59 years of simulation period is considered long enough for the statistical analyses and the conclusions drawn therefrom. The same applies to all other scenarios, which are based on and are variations of Scenario A.

Scenario B (Table 2) is a hypothetical situation where all non-PSWs have been "lost", which really means that, by virtue of being drained and filled, they no longer serve the functions of storage and infiltration. In most cases, the wetlands are replaced by agricultural fields or, in some cases, urban development. This is a basic assumption in the present analysis.

In order to incorporate the effect of the loss of non-PSWs in the model, the rainfall-runoff or NAM module has been modified. The hydrologic response of the land use change (non-PSW to agricultural or urban) at the single basin scale (roughly in the order of 35 km^2 – Figure 2) has therefore been modeled here. After studying the model structure (DHI, 2003, 2004)[1], three NAM

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[1] We also contacted the local DHI office in Kitchener, Ontario on how to incorporate wetland impacts in the model.

parameters (Table 3) have been identified, which, when suitably modified, can simulate the effect of the type of land use change under consideration. They are:

- Maximum Water Content in Surface Storage, $U_{\max}$ [mm]: $U_{\max}$ defines the maximum water content in the surface storages. This storage is interpreted as including the water content in the interception storage, in surface depression storages and in the uppermost layer of the ground. As a rule, $U_{\max} = 0.1\ L_{\max}$ can be used unless special basin characteristics or hydrograph behavior indicate otherwise. The presence of wetland means higher value of $U_{\max}$.
- Maximum Water Content in Root Zone Storage, $L_{\max}$ [mm]: This parameter depends on the vegetative transpiration and soil classification. It can be estimated by multiplying the difference between field capacity and the wilting point of actual soil (water holding capacity of soil) with the effective root depth. Since the model is lumped, in order to find one representative value for the basin, these values were weighted according to soil type and land use. From the root zone, water generally rises to the surface by capillary action of the soil pores and plant stems, and evaporates. The presence of wetland prevents this mechanism, and therefore reduces the value of $L_{\max}$.
- Overland Flow Runoff Coefficient, $CQOF$ [dimensionless]: $CQOF$ determines the distribution of excess rainfall into overland flow and infiltration. It depends on soil and moisture content in saturated and unsaturated zones. $CQOF$ is a dimensionless number with a value between 0 and 1. Small values are expected for flat catchments with coarse sandy soils and a large unsaturated zone. Large values are for catchments with low permeable soils such as clay and bare rocks. $CQOF$ was computed based on available soil texture information and the presence of water bodies. The presence of wetlands slows down the overland runoff process, and therefore results in lower values of $CQOF$.

Since the primary impact of wetland is manifested through enhanced surface storage, reduced unsaturated zone depth, and reduced infiltration during runoff events, the loss of non-PSWs was modeled by a decrease in $U_{\max}$, an increase in $L_{\max}$, and an increase in $CQOF$. The change in each parameter – obviously related to the amount of wetland lost – was computed as follows:

$$changed\,U_{\max} = original\,U_{\max}\left(1 - \frac{nonPSW\;area}{watershed\;area}\right)$$

$$changed\,L_{\max} = original\,L_{\max}\left(1 + \frac{nonPSW\,area}{watershed\,area}\right)$$

$$changed\,CQOF = original\,CQOF\left(1 + 2\frac{nonPSW\,area}{watershed\,area}\right)$$

This computational procedure was somewhat subjective and was arrived at after a number of test runs. However, considering the model structure and the information available in the current literature, it is considered to be appropriate and useful for the present investigation. The original and changed parameters for all basins are listed in Table 3. The original parameters are the ones determined during calibration of the original model (RVCA, 2007a), and are used in Scenarios A, C1 and D1 with all wetlands intact. The changed parameters are used when the lost non-PSWs are simulated, i.e., in Scenarios B, C2 and D2.

The primary model output that was used here was the simulated daily flow series or hydrographs.

In addition to visual inspection of the hydrographs, the time series was also used for the standard frequency analyses. The flood frequency was conducted on the daily flow values using CFA and the low flow frequency analysis was conducted on the daily low flows using LFA. Both CFA and LFA are standard software available from Environment Canada and are widely used in Canada.

Impact on Flood Flow

Scenarios A and B have been compared to discern the impact of non-PSW removal on flood flows. As shown in Figure 2, the simulated data (time series of flow) has been extracted at key locations (HD points), which includes gauge locations, flood damage centers, and sub-watershed outlets. Additional data was extracted from several basins[2] with high wetland concentration (RR points). All data extraction locations are listed in Table 4.

Flood frequency analysis was performed on the simulated data series for Scenarios A and B, and the floods with specific return periods were estimated (Tables 5 and 6 and Figure 3). The

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[2] The entire Rideau watershed is composed of 8 sub-watersheds (as listed in Table 1). Each sub-watershed is again divided into a number of sub-sub-watersheds. These sub-sub-watersheds are the smallest hydrologic units, and, for brevity, are called basins in this report. For instance, the basin scale refers to the scale associated with the sub-sub-watersheds.

results indicate an increase of flood peak as a consequence of losing non-PSWs. The 3-parameter log-normal distribution was fitted to all data set, for consistency and also because this distribution was found to better fit the streamflow data in Ontario.

Typical hydrographs during high flow events (Figures 4a-c) were also inspected to gain insight into the propagation of impacts along the river network system. In this particular case during the spring freshet of 1993, the peak flow increased by about 5% in the Jock River and by 1% in the Kemptville Creek; but has decreased by about 1% in the Rideau River at Carleton University. This illustrates the complexity of the hydrologic response at the basin scale and its change along the river system. It also indicates that the impact of non-PSW removal may manifest differently at different locations in the system. However, through the statistical analyses done here, it has been ensured that the conclusions are valid in a statistical sense.

Results of flood frequency analysis at gauge locations are presented in Figures 5a-c. They indicate that the Jock sub-watershed is impacted most by the loss of non-PSWs, with an estimated 6.2% increase in the 1:100 year flood. The Kemptville sub-watershed shows a mere 1% increase, and the Rideau watershed a 2.8% increase. Such wide differences in impacts are obviously related to the area of wetland under consideration, but may also be attributed to the various other factors such as proximity of wetlands to the gauge station (Jock), elongated shape of the basin (Kemptville), and routing along rivers and lakes (Rideau).

The increase in the 1:100 year flood flow as a function of the percentage of non-PSW and drainage area is shown in Figures 6a-c. Despite a lot of scatter, Figure 6a indicates an overall increasing trend of the increase in the 1:100 year flood with increasing value of non-PSW area at the basin scale (RR points); a similar trend along the river is also evident (HD points). In Figure 6b, we notice a wide variation in the increase in flood for the local basins (RR points), perhaps a reflection of the variation in wetland concentration, and a relatively narrower variation for larger sub-watersheds (HD points).

Figure 6c shows the 1:100 flood flow with and without non-PSWs, i.e., for Scenarios A and B respectively. The increase in flood as a result of non-PSW is clear at the basin scale, as only the RR points are plotted. A best fit line indicates that on average the 1:100 year flood will increase by 4% as a result of non-PSW removal.

Since non-PSW comprises only 6% of the watershed area as compared to 9% comprising of the PSWs, it is likely that all wetlands contribute towards an overall 10% reduction in flood flows. As far as hydrologic functions are concerned, there is no distinction between PSWs and non-PSWs. Therefore, both of them are equally important; and both should be treated in the same way when it comes to preserving the hydrologic functions.

The geographical distribution of the increase of the 1:100 year flood (as a result of non-PSW removal) is graphically shown in Figure 3. Several observations can be made from this figure and Table 6. In most of the cases, the removal of non-PSW causes an increase in the flood – sometimes detectable and sometimes almost insignificant (±1%). In a couple of cases (Poonamali and Barnes Creek), somewhat contrary to intuition, a decrease in flood was indicated.

In the Jock sub-watershed, the non-PSW is concentrated in the headwaters (Goodwood Marsh). As expected, the impact was highest at the upstream end (a 13.02% increase in flood) and gradually diminished in the downstream direction.

Within the Kemptville sub-watershed, three basins (K3, K4 and K5) had similar concentration of non-PSW (about 13%) but exhibited a varied increase of flood (1 to 6%). This could not be readily attributed to any reason, but perhaps indicates watershed variability and the uncertainty of the computational process (watershed modeling plus the statistical analysis). It is interesting to note that the combined effect of K3 and K4 (5.94% and 0.99% increase in flood) was somewhat subdued in the river (0.32% at K2). Again this is hard to explain, but one can speculate about the timing of basin response and channel routing.

The basins (U3 and U4) in the Upper Rideau basin showed large increase in flood peaks (about 10%). However, the mitigating effect of channel and lake routing is also evident in the lower values of flood increases at the lake outlets (U1 and U2). This indicates that the adverse effect of non-PSW removal will diminish substantially after traveling through large lakes. This leads the conclusion that the removal of non-PSW above Smiths Falls will is not likely to increase the flood hazard downstream.

The same trend is observed in the Tay sub-watershed, where the lakes effectively eliminated the effect of non-PSW removal on the peak flood. However, the effect somewhat increased in the downstream direction, a trend opposite to what was observed in Kemptville sub-watershed. Again, this may be due to the differences in hydrologic response time and channel routing.

The mitigating effect of lakes was also evident in the Middle Rideau sub-watershed, where the increase in flood peaks was almost negligible (M2, M3, M4 and M5). The flood peak was actually seen to decrease by 2.08% at Andrewsville (M1).

In the Lower Rideau basin, the impact at the local basin scale (L4, L5 and L6) was fairly predictable; i.e., the impact increased with increasing amount of non-PSW lost. However, being at the downstream end of the system, it also absorbs the impacts from upstream. The influence coming from Middle Rideau (0% at M5) and Kemptville (1% at K1) sub-watersheds is fairly low level, and their effect in the Lower Rideau sub-watershed is almost undetectable (0% at L3). However, it appears that the effect from local drainage areas accumulates along the river – from 0% at Kars (L3) to 0.23% at Long Island (L2) to 2.25% at Carleton University (L1). Some of this can be attributed to the inflow from Jock sub-watershed, but to what extent is not known.

The diminishing impacts down long channels and lakes imply that the channels and lakes are important in mitigating the adverse effect of wetland removal. In other words, it is equally important to preserve the stream valleys and lakes.

Impact on Low Flow

Since low flow volume (low flow rate times low flow duration) is necessarily small compared to lake or reservoir storage (such as the case in the upper portion of the Rideau), the impact of wetland is very unlikely to propagate downstream of lakes, and even if it does, the effect will diminish to a great extent and will be hard to detect.

Therefore, our effort was directed towards quantifying the effect of non-PSW removal in the non-regulated part of the Rideau sub-watershed (below Smiths Falls) and the Tay sub-watershed (below Bolingbroke). We intuitively assumed that the effect will hardly propagate downstream of Rideau and Bobs Lake respectively. Comparing Scenarios C1 to C2 (Table 2) enables us to quantify the effect of non-PSW removal within the local basins (downstream of Smiths Falls) on low flow. Similarly, a comparison of D1 and D2 will reveal the impact of non-PSW removal within the local basins (downstream of Bolingbroke) in the Tay sub-watershed.

At selected stations listed in Tables 7a-b, the annual lowest 1-day flow values were picked form the simulated flow series. They were then analyzed by LFA to determine the low flow values for specific return periods. The LFA uses the Weibull (also known as Gumble III) distribution to fit the data. The results are summarized in Table 8 and graphically shown in Figures 7 to 10. LFA results based on observed data at the gauge locations were taken from an earlier study (RVCA, 2007b) and are included here for comparison purposes.

The most obvious observation regarding the low flow is that the removal of non-PSW will increase the value of 1-day low flow, by up to 50%. This is consistent with observations elsewhere (Bullock and Acreman, 2003) on wetlands fed by river systems (as opposed to groundwater-fed or depression-type wetlands).

Looking more closely at Table 7a, the increase in low flow along Rideau varies substantially, from 45.39% at Andrewsville (M1) to 12.73% at Carleton (L1). The absence of any detectable impacts on Jock (J1) and Kemptville (K1) may be attributed, at least partly, to Richmond Fen and Oxford Mills Dam respectively. Another factor may be the fact that the present model was calibrated for the high flow and may not give very reliable results in the low flow range; this is apparent in the substantial difference of model results from the observed data points in Figures 8 and 9. The confluence of the Taylor and Stevens creeks (L4) shows no impact, which may be due to the smaller percentage of non-PSW (4.50%) removed compared to PSW (20.86%) that remained intact, and to the routing effect in the streams.

Figure 7 indicates that the model (Scenario A) underestimates the low flow compared to the observation. It also shows that, as expected, the bulk of the low flow is generated upstream of Smiths Falls (compare A to C1 or B to C2). However, the impacts of non-PSW removal in both cases (A to B, and C1 to C2) are comparable, substantiating our earlier assumption that the lakes will cut out the impact to a large extent. The general impact is an increase in 1-day low flow, by about 12%.

In the Tay sub-watershed, the impact is again an increase in the low flow (Table 7b). The increase is 15% at Perth (T1) and 31.93% at Port Elmsley (T2). The higher value at T2 may be due to the concentration of non-PSW at this location. Impacts on the local basins (T3, T4 and T5) reveal an interesting pattern: the higher the area of non-PSW compared to PSW, the higher the impact of non-PSW removal on the low flow. The Otty/Jebbs Creek basin (T3; 1.5% PSW and 7.68% non-PSW) shows a 50% increase in low flow, compared to Blueberry Creek basin (T5; 30% PSW and 6.56% non-PSW) with zero impact and the Tay B basin (T4; 15% PSW and 8.52% non-PSW) with a 33.33% increase. One can also conclude that the impact is more prominently felt at the local scale compared to the larger scale with stream routing.

Figure 10 indicates that, as expected, the bulk of the low flow is generated upstream of Bolingbroke (compare A to D1 or B to D2). However, the impacts of non-PSW removal in both cases (A to B, and D1 to D2) are comparable, pointing again to the mitigating effect of large lakes and reservoir control. The general impact is an increase in 1-day low flow, by about 15%.

The low flow analyses and their interpretation, as discussed above, should be used with caution and should not be generalized without further investigation. First of all, the original calibration of the Mike11 model was geared toward high flows, and therefore may not simulate the low flows with great accuracy. Second, the cutting off of the regulated part of the Rideau or Tay sub-watershed, achieved by a zero-flow upstream boundary condition in the model, has certainly altered the nature of low flow (magnitude, duration, and occurrence). To what extent this has affected the analyses and inferences of this study is not known. Therefore, although the main inference (that the low flow will increase as a result of non-PSW) is likely to remain valid, specific numbers associated with it (such as % increase, etc) will come out differently in a more rigorous study. Thirdly, only the daily flow was analyzed here – not the 7-day or 15-day flows, which are important in studying the effects of prolonged low flow conditions on ecology and agriculture.

In this sense, we consider our low flow analysis only the first step towards understanding the watershed dynamics. The inferences are tentative and qualitative. Should the need for more reliable and quantitative answers arise, we recommend that a more rigorous study be undertaken. Such a study would require, at the minimum, a model better calibrated for low flows, better definition of low flow channel, and accounting for the duration of low flow. Taking into account the implications of low flow hydrology to ecology and agriculture will be necessary to understand the low flow within a broader and more useful perspective.

Limitations of the Study

As with any scientific study, the present one has limitations. The main two limitations are the scope of the study (narrowly defined aspects of wetland hydrology) and the tools used (numerical modeling).

Any study has to necessarily focus on a narrow, but hopefully well defined, aspect of a problem. However, the broader context has to be kept in mind at all stages, especially when interpreting results and drawing conclusions. In the present case, the hydrological function is only one of many functions of a wetland, such as water quality improvement, nutrient removal, providing habitats, increasing biodiversity, etc. All of which – needless to say – are intertwined in a complicated way. Even floods and droughts act and affect the physical and biological environment in profoundly different ways; only more so are the response and reaction of flora and fauna to the imposed stresses (Lake, 2007).

The modeling exercise done here is comparable to other published modeling done using Mike11/Mike SHE platform (e.g., Refsgaard, 1997; Refsgaard and Henriksen, 2004). However, all models involve uncertainties and approximations (Beven, 1993), which should be kept in mind when analyzing and interpreting model results.

Major Findings

1. Flood risk will increase if non-PSWs are lost due to interference.
2. The 1:100 year flood flow, on average, will increase by about 4% at the local scale if all non-PSWs are removed.
3. The 1:100 year flood at the City of Ottawa will increase by about 2.25%.
4. At present, all wetlands (PSWs and non-PSWs) within RVCA probably reduce the 1:100 year flood by roughly 10%.
5. The impact on flood diminishes downstream of long channels and lakes.
6. The 1-day low flow is likely to increase if non-PSWs are removed. However, no definite inferences should be drawn without further investigation.

Policy Implications

1. The present analysis has quantified the potential cumulative effect on in-stream peak flood flows that could result from interference with non-PSWs in ways that alter their hydrologic functions (storage, attenuation and infiltration). It has been demonstrated that the loss of non-PSWs would collectively have a quantifiable adverse effect on the control of flooding. Based on these findings, the present analysis supports application of the interference with wetlands provision of the Section 28 regulation in accordance with the MNR-CO guidelines.
2. It is therefore recommended that, in addition to the PSWs, all non-PSWs within RVCA be brought under regulation and protected.
3. The long term objective of the regulation program should therefore be to plot regulation limits around all wetlands, as well as hazardous lands and river stream valleys, and administer the regulations within such areas as the mapping is amended.
4. The risk or likelihood of non-PSWs being interfered with (in the absence of regulations) has not been considered here; nor has the potential cost of establishing the regulations limits. However, it would be logical to bring the non-PSWs under regulation in order of area (i.e., the largest first).

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Figure 1: Wetland Areas in RVCA

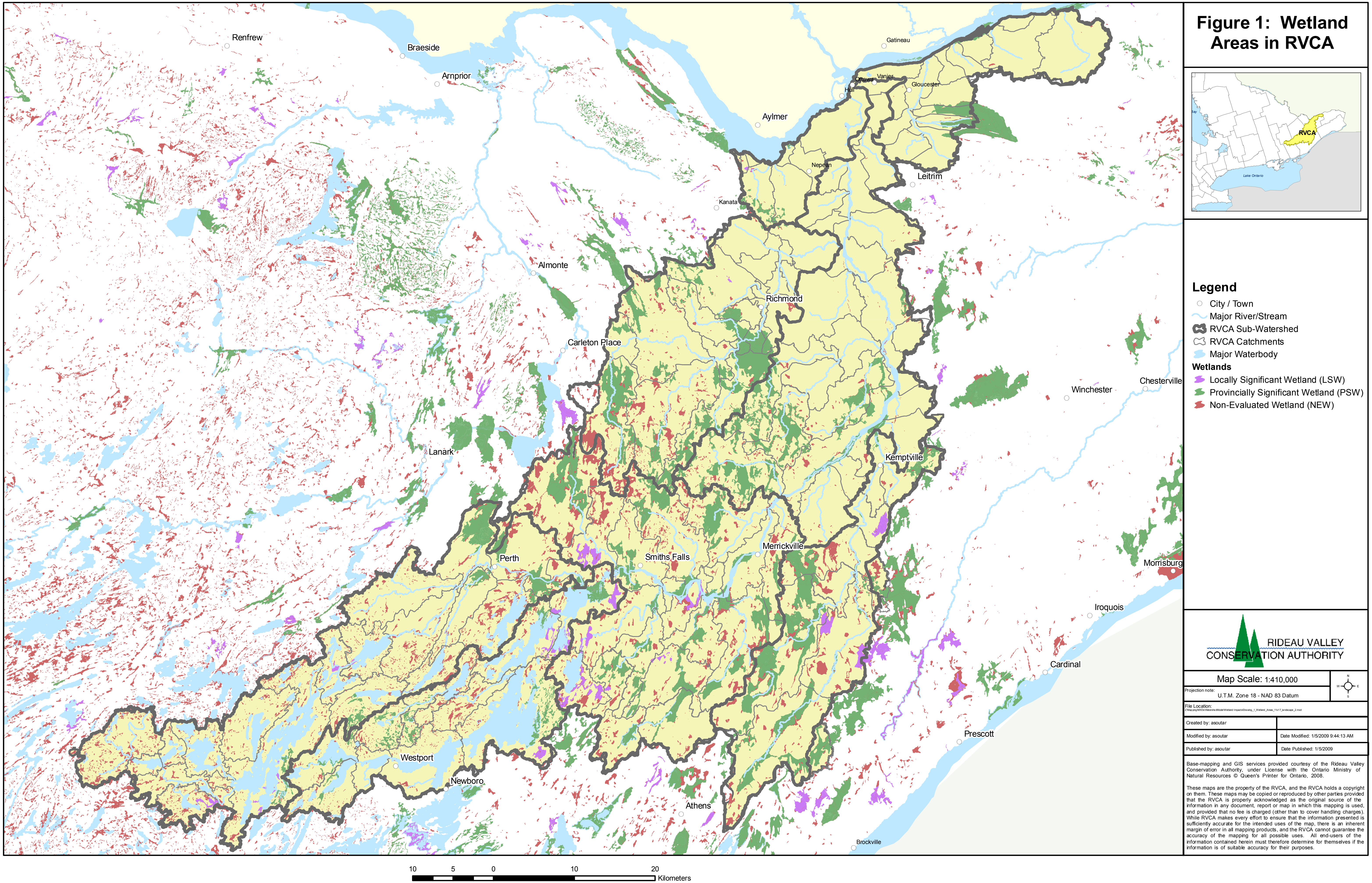

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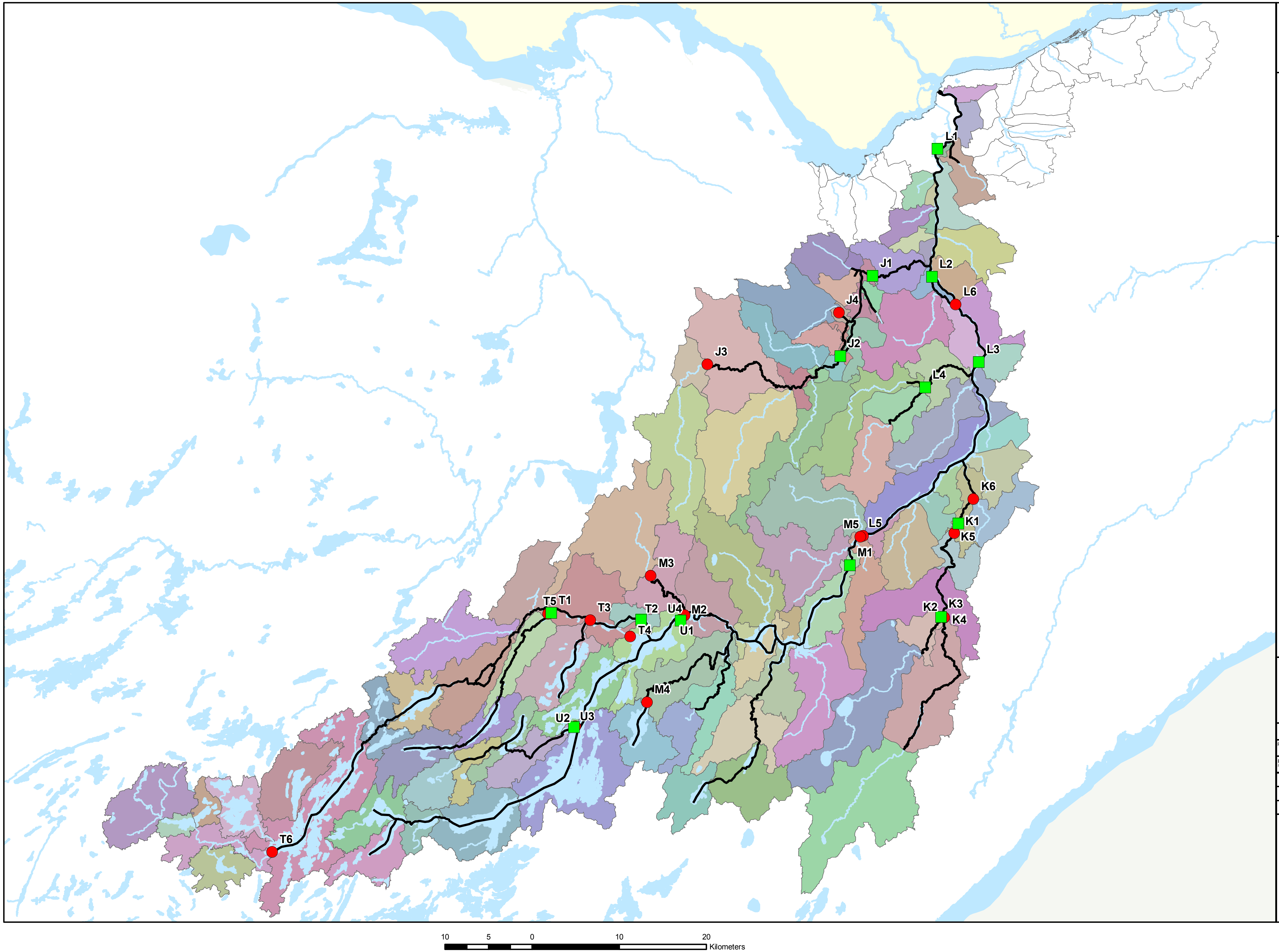
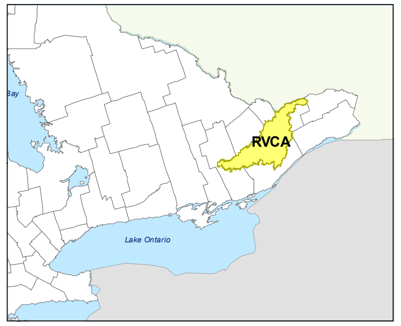
Figure 2: Mike 11 Model Schematic





Legend

- Major Waterbody
- RVCA Catchments
- Major River/Stream
- Hydrodynamic Line

Data Extraction Points

- 🟩 HD
- 🔴 RR

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Map Scale: 1:410,000

Projection note:
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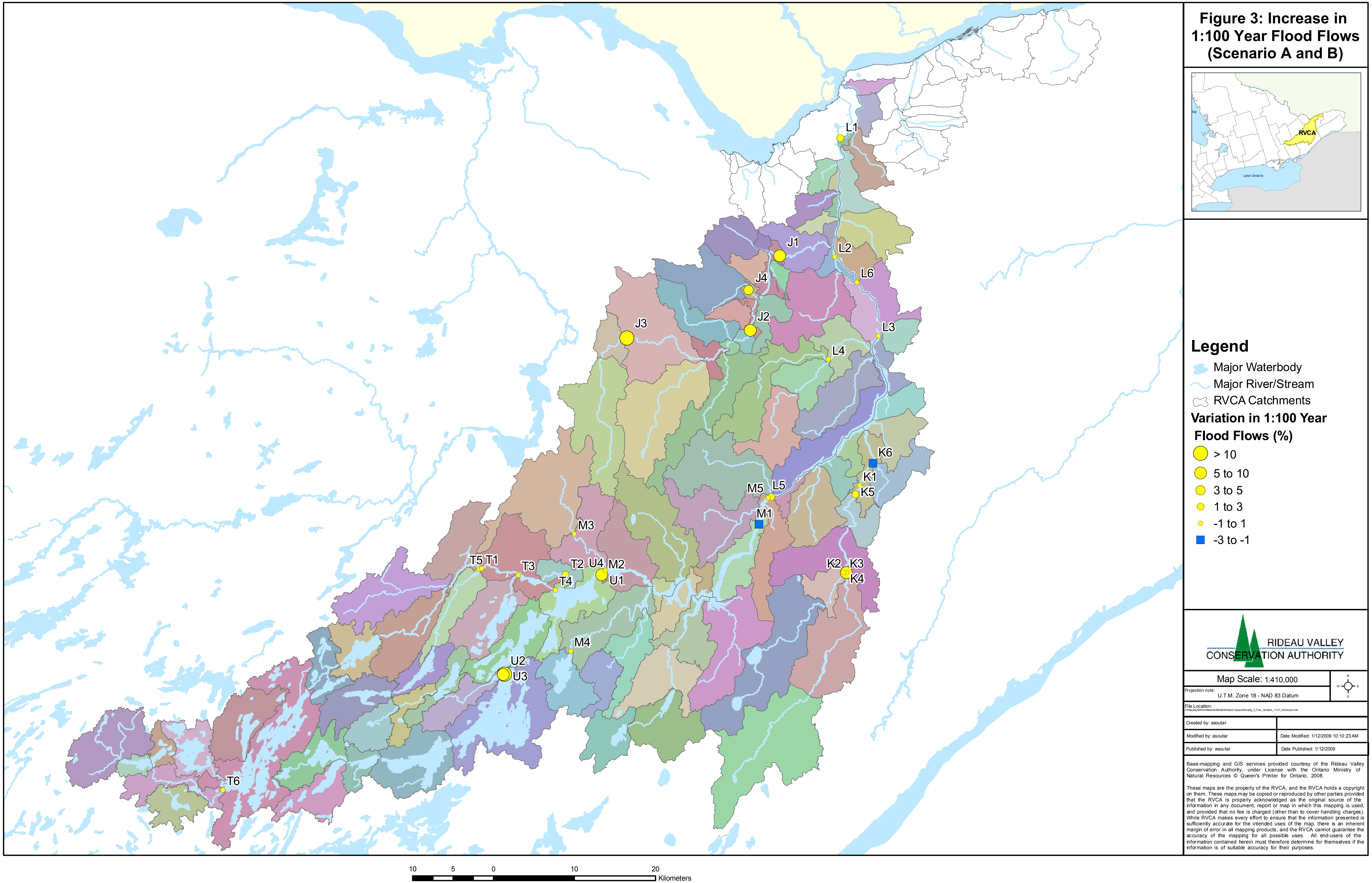
Figure 3: Increase in 1:100 Year Flood Flows (Scenario A and B)



Legend

- Major Waterbody
- Major River/Stream
- RVCA Catchments

Variation in 1:100 Year Flood Flows (%)

- ● > 10
- ● 5 to 10
- ● 3 to 5
- ● 1 to 3
- ● -1 to 1
- ■ -3 to -1

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Map Scale: 1:410,000

Projection note:
U.T.M. Zone 18 - NAD 83 Datum

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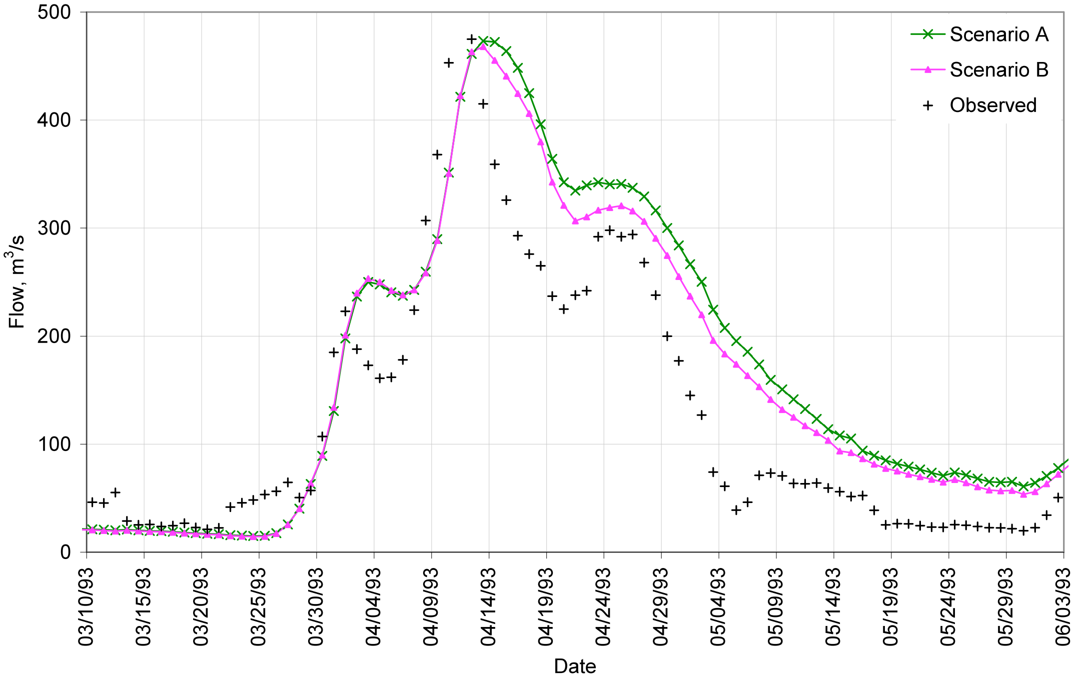

Figure 4a: Flood hydrograph – Rideau River at Carleton University (02LA004)

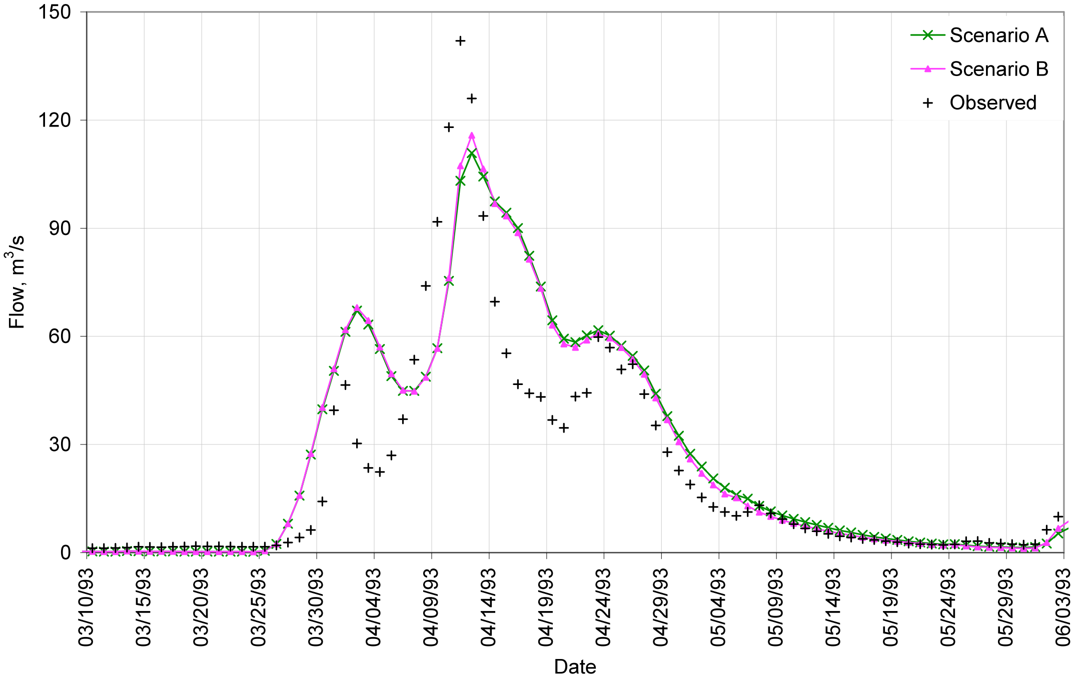

Figure 4b: Flood hydrograph – Jock River at Moodie Drive (02LA007)

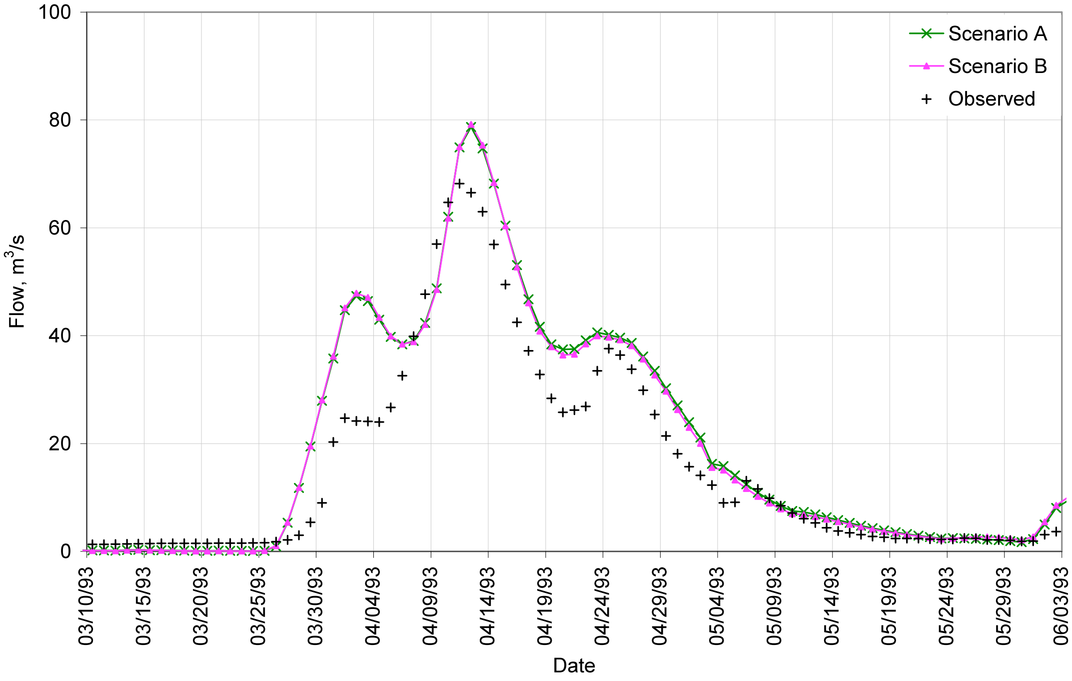

Figure 4c: Flood hydrograph – Kemptville Creek near Kemptville (02LA006)

Figure 5a: Flood Frequency Analysis – Rideau River at Carleton University (02LA004)

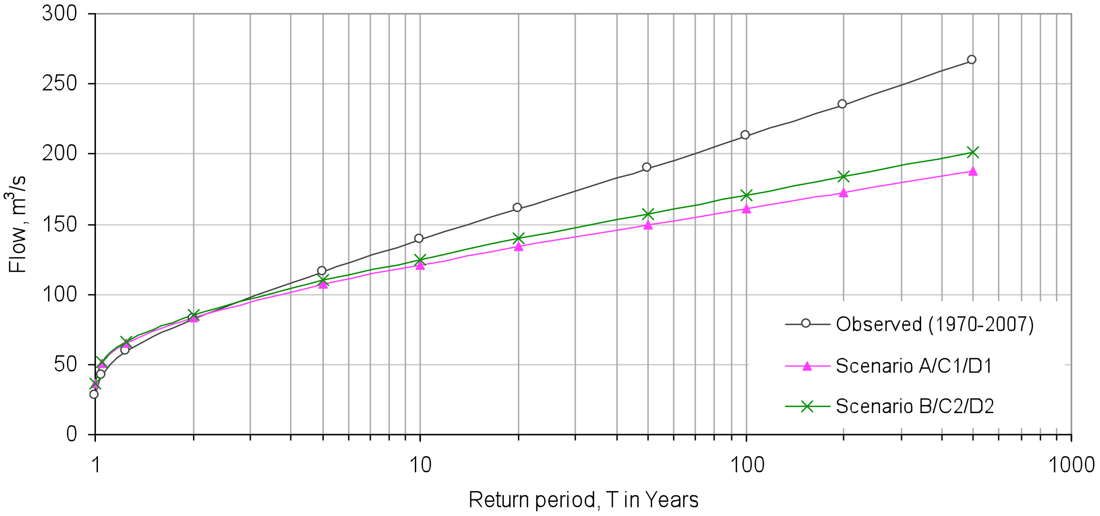

Figure 5b: Flood Frequency Analysis – Jock River at Moodie Drive (02LA007)

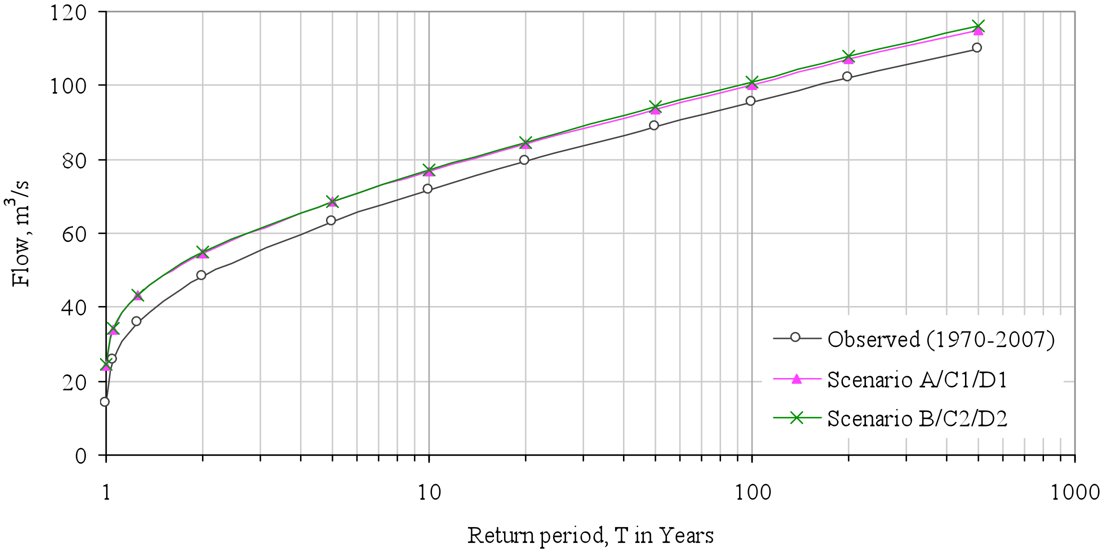

Figure 5c: Flood Frequency Analysis – Kemptville Creek near Kemptville (02LA006)

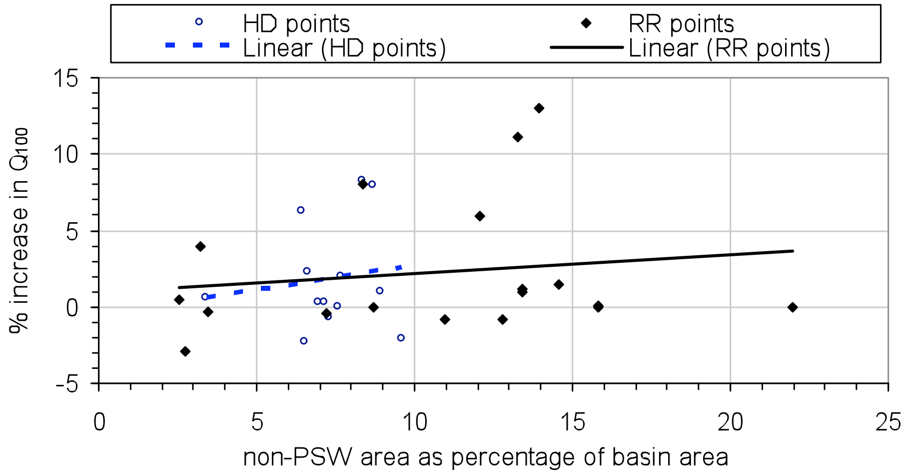

Figure 6a: Variation of Flood Increase with non-PSW area

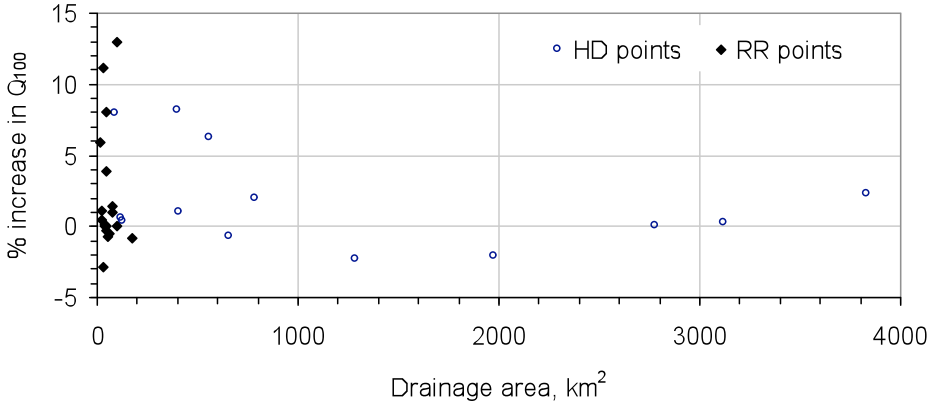

Figure 6b: Variation of Flood Increase with Drainage area

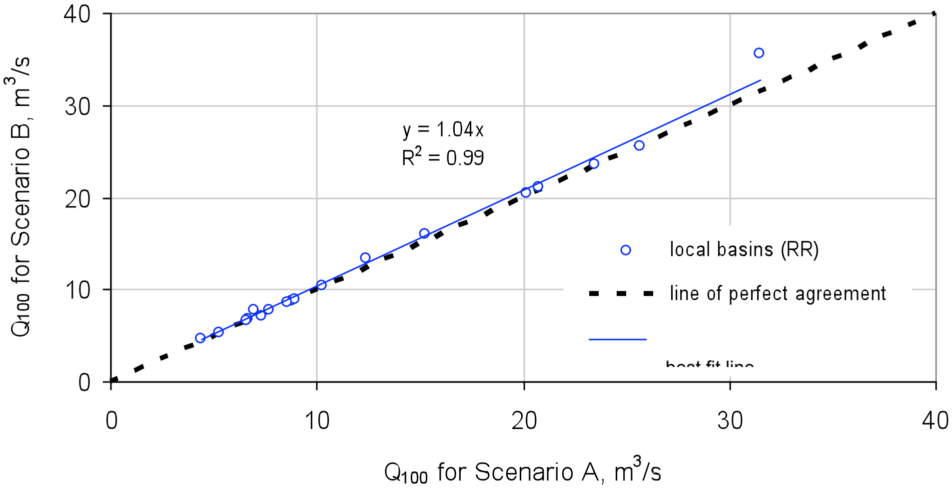

Figure 6c: Flood Flows with and without non-PSW (Scenario A and B)

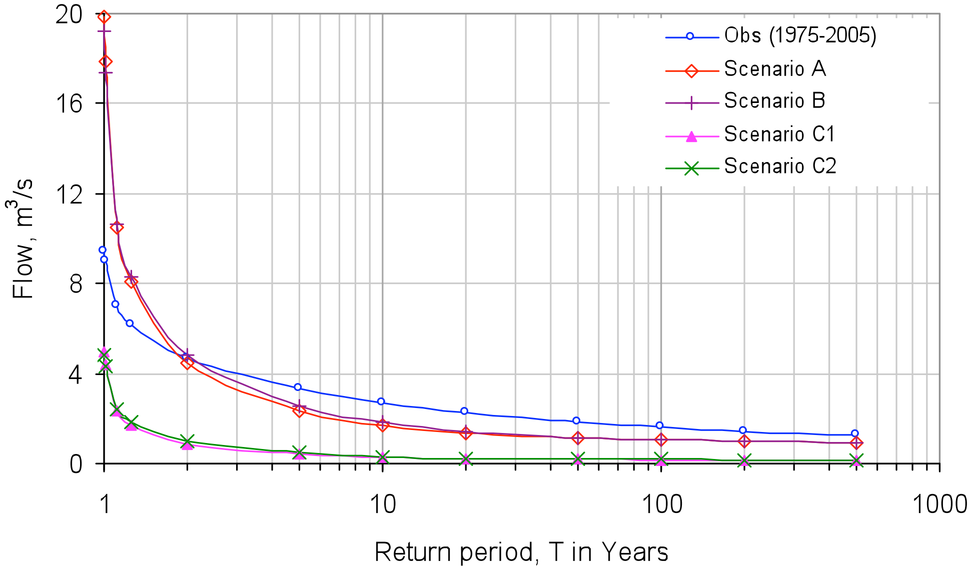

Figure 7: Low Flow Frequency Analysis – Rideau at Carleton University (02LA004)

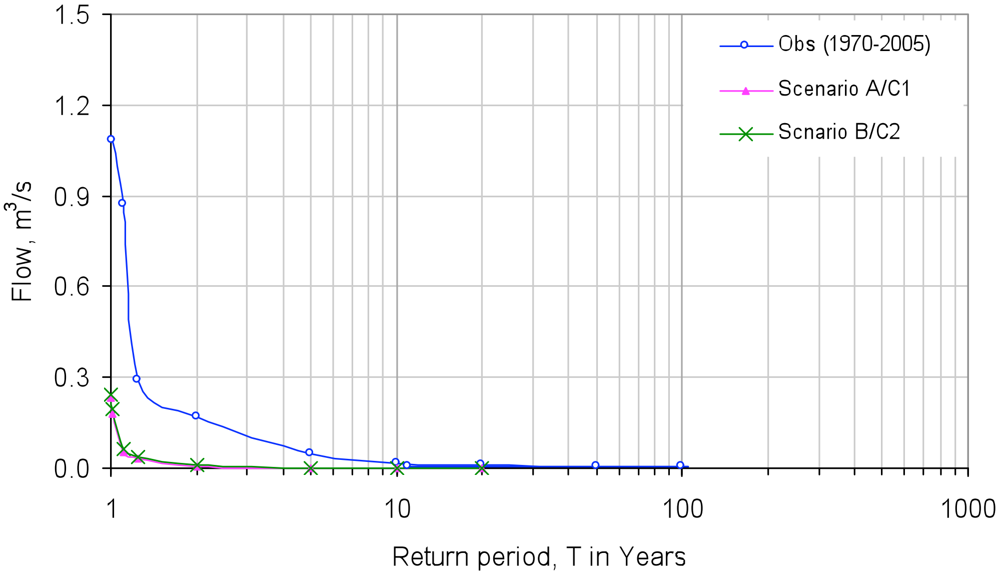

Figure 8: Low Flow Frequency Analysis – Kemptville Creek near Kemptville (02LA006)

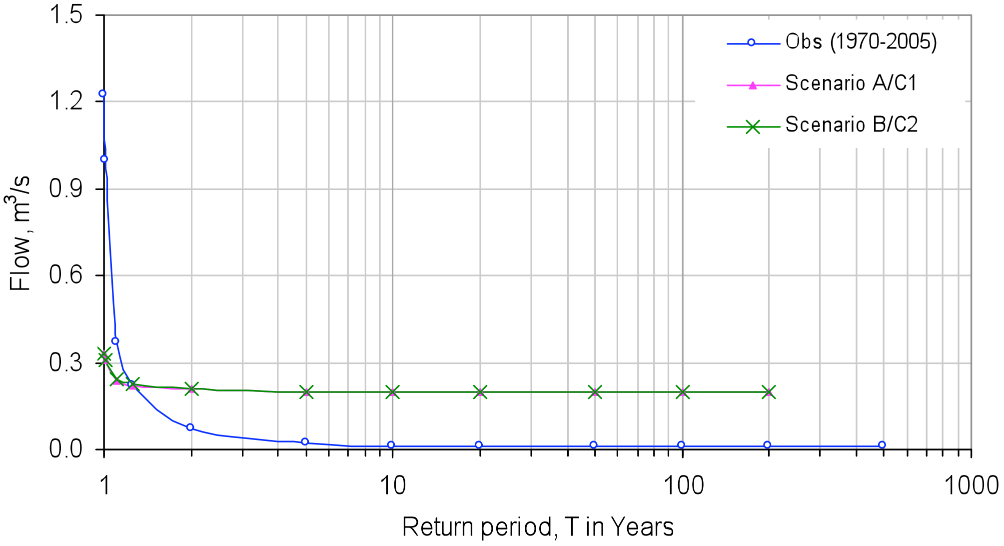

Figure 9: Low Flow Frequency Analysis –Jock River at Moodie Dr (02LA007)

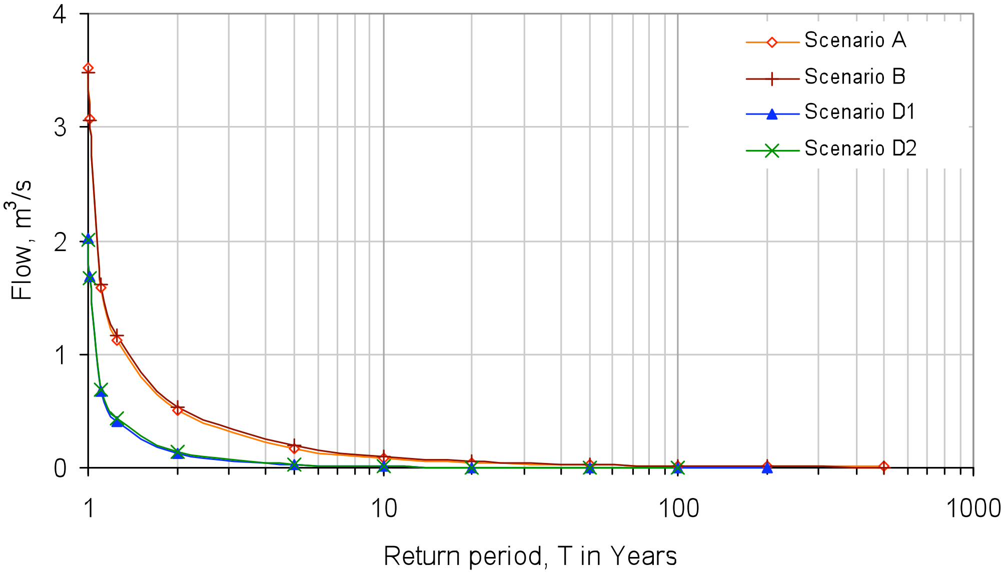

Figure 10: Low Flow Frequency Analysis –Tay River at Perth (02LA024)

Table 1: Wetland Areas in RVCA

Sub-Watershed	Basin	Basin Area (km^2)	PSW (km^2)	LSW (km^2)	NEW (km^2)	Total Wetland (km^2)	Total Wetland (as % of basin area)	PSW (as % of basin area)	Non-PSW (as % of basin area)
Jock River	Flowing Creek 1	48.53	1.73	0.20	1.37	3.30	6.80	3.57	3.23
Jock River	Flowing Creek 2	3.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jock River	Leamy Creek	5.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jock River	Hobb's Drain	33.99	4.05		1.39	5.44	16.00	11.90	4.10
Jock River	Jock A1	17.93	1.64		0.72	2.36	13.14	9.14	4.00
Jock River	Jock A2	12.02	0.00		0.02	0.02	0.20	0.00	0.20
Jock River	Jock B1	5.82	5.05		0.01	5.06	86.92	86.83	0.09
Jock River	Jock B2	4.81	0.45		0.01	0.46	9.57	9.29	0.28
Jock River	Jock B3	11.36	2.94		0.25	3.19	28.12	25.90	2.22
Jock River	Jock C1	11.04	0.13		1.04	1.17	10.64	1.21	9.43
Jock River	Jock C2	3.15	2.52		0.00	2.53	80.24	80.18	0.06
Jock River	Jock D1	89.02	8.79	0.01	2.76	11.56	12.99	9.87	3.11
Jock River	Jock D2	17.55	0.00	1.51	0.30	1.81	10.32	0.00	10.32
Jock River	Jock E	82.17	22.06		12.08	34.14	41.55	26.84	14.70
Jock River	King's Creek	94.89	6.45		10.71	17.16	18.08	6.79	11.29
Jock River	Monahan Drain 1	27.48	0.32		0.02	0.35	1.26	1.18	0.08
Jock River	Monahan Drain 2	3.42	0.00		0.01	0.01	0.29	0.00	0.29
Jock River	Monahan Drain 3	11.87	0.00		0.00	0.00	0.00	0.00	0.00
Jock River	Nicholl's Creek	62.83	24.24		3.71	27.95	44.49	38.58	5.91
Jock River	South Nepean	31.10	0.39		0.01	0.40	1.29	1.25	0.05
Kemptville Creek	Barnes Creek	27.74	4.51		0.76	5.27	19.00	16.27	2.74
Kemptville Creek	Kemptville A1	21.67	0.95		0.14	1.09	5.05	4.40	0.65
Kemptville Creek	Kemptville A2	20.54	0.26	2.70	0.06	3.02	14.70	1.26	13.44
Kemptville Creek	Kemptville A3	61.01	11.59		7.31	18.91	30.99	19.00	11.99
Kemptville Creek	North Branch Kemptville A	18.05	0.81		2.18	2.99	16.58	4.51	12.07
Kemptville Creek	North Branch Kemptville B	107.47	36.57	0.77	6.05	43.39	40.38	34.03	6.34
Kemptville Creek	South Branch A	79.52	3.82	4.13	6.52	14.47	18.20	4.80	13.40
Kemptville Creek	South Branch B	124.13	23.98		5.87	29.84	24.04	19.32	4.73
Lower Rideau	Brassil's Creek	76.35	7.22		11.14	18.36	24.05	9.45	14.59
Lower Rideau	Cranberry Creek	52.00	8.94		1.25	10.18	19.58	17.19	2.40
Lower Rideau	Doyle Creek	14.24	0.00		0.16	0.16	1.10	0.00	1.10
Lower Rideau	McDermott Drain	18.09	0.22		0.10	0.32	1.76	1.23	0.53
Lower Rideau	Mosquito Creek	37.61	0.00		0.29	0.29	0.77	0.00	0.77
Lower Rideau	Mud Creek	62.20	0.00		0.07	0.07	0.11	0.00	0.11
Lower Rideau	Murphy Drain	47.01	0.23		0.44	0.67	1.42	0.49	0.93
Lower Rideau	Rideau 1	11.64	0.00		0.00	0.00	0.02	0.00	0.02
Lower Rideau	Rideau 11	8.05	0.00		0.03	0.03	0.39	0.00	0.39
Lower Rideau	Rideau 12	6.40	0.18		0.13	0.31	4.92	2.85	2.07
Lower Rideau	Rideau 13	48.37	4.32		1.53	5.86	12.11	8.94	3.17
Lower Rideau	Rideau 2	21.07	0.00		0.09	0.09	0.44	0.00	0.44
Lower Rideau	Rideau 3	17.10	0.00		0.03	0.03	0.15	0.00	0.15
Lower Rideau	Rideau 6	11.57	1.01		0.47	1.48	12.81	8.75	4.05
Lower Rideau	Rideau 7	24.38	1.41		0.62	2.03	8.32	5.78	2.54
Lower Rideau	Rideau 8	12.91	0.00		0.10	0.10	0.79	0.00	0.79
Lower Rideau	Rideau 9A	19.56	0.00		0.00	0.00	0.00	0.00	0.00
Lower Rideau	Rideau F	13.47	0.31		0.11	0.41	3.08	2.29	0.79
Lower Rideau	Rideau G	7.67	0.00		0.00	0.00	0.03	0.00	0.03
Lower Rideau	Rideau H	27.75	0.91		0.24	1.15	4.16	3.29	0.87
Lower Rideau	Sawmill Creek	22.25	0.00		0.02	0.02	0.11	0.00	0.11
Lower Rideau	Steven Creek 2	28.71	0.00		0.26	0.26	0.90	0.00	0.90
Lower Rideau	Steven Creek 3	42.53	12.81		1.59	14.41	33.87	30.13	3.75
Lower Rideau	Taylor Drain	53.33	11.13		2.40	13.53	25.36	20.86	4.50
Lower Rideau	Steven Creek 1	28.97	0.00		0.00	0.00	0.00	0.00	0.00
Lower Rideau	Barheaven creek	7.05	0.00		0.00	0.00	0.00	0.00	0.00
Lower Rideau	Rideau 4	2.99	0.00		0.00	0.00	0.00	0.00	0.00
Lower Rideau	Black Rapids Cr	15.96	0.00		0.00	0.00	0.00	0.00	0.00
Lower Rideau	Rideau 5	2.70	0.00		0.00	0.00	0.00	0.00	0.00
Lower Rideau	Nepean Cr	10.83	0.00		0.00	0.00	0.00	0.00	0.00
Lower Rideau	Rideau 10	4.04	0.00		0.00	0.00	0.00	0.00	0.00
Lower Rideau	Rideau 9B	1.93	0.00		0.00	0.00	0.00	0.00	0.00
Middle Rideau River	Barbers Creek	76.82	14.91		6.99	21.91	28.52	19.41	9.10
Middle Rideau River	Bellamy Pond	31.29	2.13		2.45	4.59	14.65	6.82	7.84
Middle Rideau River	Black Creek 1	43.32	0.10	3.94	5.58	9.62	22.20	0.23	21.98
Middle Rideau River	Black Creek 2	98.28	21.09		15.55	36.64	37.28	21.46	15.82
Middle Rideau River	Dales Creek	37.49	5.25		3.27	8.52	22.74	14.01	8.73
Middle Rideau River	Hutton Creek A	33.87	3.25	0.09	1.41	4.75	14.01	9.58	4.43
Middle Rideau River	Hutton Creek B	24.56	5.06	0.30	1.30	6.67	27.14	20.61	6.52
Middle Rideau River	Irish Creek A	34.88	4.13		2.38	6.52	18.68	11.85	6.83
Middle Rideau River	Irish Creek B	48.19	4.80	0.60	1.95	7.35	15.24	9.95	5.29
Middle Rideau River	Irish Lake	49.23	5.40		0.90	6.30	12.81	10.97	1.83
Middle Rideau River	Otter Creek	54.89	1.19	1.42	3.46	6.07	11.06	2.18	8.88
Middle Rideau River	Otter Lake	36.35	1.46	3.12	2.63	7.21	19.84	4.01	15.83
Middle Rideau River	Rideau A	36.59	2.23		0.59	2.82	7.71	6.09	1.62
Middle Rideau River	Rideau B	7.89	0.69		0.16	0.85	10.83	8.78	2.05
Middle Rideau River	Rideau C	22.33	0.52	1.67	1.89	4.07	18.25	2.31	15.94
Middle Rideau River	Rideau Creek	62.06	10.45		3.64	14.09	22.70	16.84	5.86
Middle Rideau River	Rideau D	7.21	1.52		0.06	1.58	21.84	21.06	0.77
Middle Rideau River	Rideau E	47.70	6.79		1.92	8.71	18.25	14.24	4.02
Middle Rideau River	Rosedale Creek	74.98	10.34		8.32	18.66	24.89	13.79	11.10
Ottawa River East	Becketts Creek	59.55	0.29		0.06	0.35	0.60	0.49	0.10
Ottawa River East	Borthwick Creek	10.93	3.46		0.34	3.80	34.79	31.67	3.11
Ottawa River East	Cardinal Creek	41.06	0.21	0.13	0.03	0.36	0.88	0.50	0.38
Ottawa River East	Cyrville Drain	7.45	0.00		0.02	0.02	0.28	0.00	0.28
Ottawa River East	East Bilberry Creek	11.93	0.14			0.14	1.16	1.16	0.00
Ottawa River East	McEwan Creek	15.34	0.00		0.02	0.02	0.16	0.00	0.16
Ottawa River East	Mud Creek (GCk)	17.32	1.14		0.02	1.16	6.71	6.58	0.14
Ottawa River East	Ottawa East A	14.13	0.00		0.00	0.00	0.03	0.00	0.03
Ottawa River East	Ramsay Creek	22.91	0.56		0.05	0.60	2.63	2.43	0.20
Ottawa River East	Taylor Creek	11.22	1.57		0.00	1.57	13.98	13.98	0.00
Ottawa River East	Unnamed Drain	8.37	5.02		0.08	5.09	60.87	59.95	0.92
Ottawa River East	West Bilberry Creek	8.70	0.00		0.00	0.00	0.02	0.00	0.02
Ottawa River East	Greens Ck	17.11	0.54	0.00	0.00	0.00	0.00	0.00	0.00
Ottawa River East	Ottawa drain	11.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ottawa River East	Ottawa 1	5.99	0.18	0.00	0.00	0.00	0.00	0.00	0.00
Ottawa River West	Graham Creek	29.34	0.54		0.13	0.67	2.28	1.84	0.44
Ottawa River West	Ottawa 5	1.96	0.00	0.16	0.04	0.20	9.96	0.00	9.96
Ottawa River West	Ottawa 6	3.49	0.18		0.05	0.24	6.75	5.27	1.48
Ottawa River West	Ottawa 7	0.93	0.00		0.04	0.04	3.88	0.00	3.88
Ottawa River West	Ottawa 8	1.86	0.00		0.00	0.00	0.18	0.00	0.18
Ottawa River West	Ottawa West E	45.03	0.00		0.02	0.02	0.05	0.00	0.05
Ottawa River West	Stillwater Creek	24.69	2.44	0.09	0.42	2.95	11.97	9.89	2.08
Ottawa River West	Pinecrest Ck	14.03		0.00	0.00	0.00	0.00	0.00	0.00
Rideau Lakes	Big Rideau A	48.79	1.62	1.24	1.98	4.84	9.93	3.33	6.60
Rideau Lakes	Big Rideau B	108.80	6.39	1.31	2.49	10.18	9.36	5.87	3.49
Rideau Lakes	Black Lake 1	28.29	0.00		3.75	3.75	13.26	0.00	13.26
Rideau Lakes	Black Lake 2	21.19	0.00		2.21	2.21	10.42	0.00	10.42
Rideau Lakes	Black Lake 3	18.08	3.17		0.85	4.03	22.28	17.56	4.72
Rideau Lakes	Black Lake 4	26.02	3.32		1.32	4.64	17.85	12.77	5.08
Rideau Lakes	Lower Rideau	48.47	6.55	2.07	1.99	10.61	21.90	13.52	8.37
Rideau Lakes	Upper Rideau	60.85	0.05		1.60	1.65	2.71	0.09	2.62
Rideau Lakes	Wesport Sand Lake	16.61	0.00		0.36	0.36	2.16	0.00	2.16
Rideau Lakes	Wolfe Lake 1	37.36	2.01	0.07	1.23	3.31	8.85	5.38	3.47
Rideau Lakes	Wolfe Lake 2	35.42	1.00		1.47	2.46	6.95	2.81	4.14
Tay River	Blueberry Creek	44.46	13.27		1.54	14.81	33.31	29.85	3.46
Tay River	Bobs Lake	132.52	1.14	2.06	6.90	10.11	7.63	0.86	6.76
Tay River	Christie Lake	32.18	0.00	0.26	1.40	1.66	5.15	0.00	5.15
Tay River	Crosby Lake	38.76	3.03		1.68	4.72	12.17	7.82	4.35
Tay River	Crow Lake	49.72	0.00		2.41	2.41	4.84	0.00	4.84
Tay River	Eagle Lake	33.70	0.00		1.79	1.79	5.31	0.00	5.31
Tay River	Elbow Lake	26.96	0.00		4.25	4.25	15.78	0.00	15.78
Tay River	Fish Creek	28.92	0.00		3.01	3.01	10.42	0.00	10.42
Tay River	Grants Creek	30.70	3.08		1.14	4.22	13.75	10.05	3.70
Tay River	Long Lake 1	12.08	0.00		0.75	0.75	6.24	0.00	6.24
Tay River	Long Lake 2	9.36	0.00		0.61	0.61	6.54	0.00	6.54
Tay River	Long Lake 3	62.71	0.00	0.00	8.60	8.60	13.71	0.00	13.71
Tay River	Otty Lake/Jebbs Creeek	52.16	0.83		6.68	7.51	14.40	1.60	12.80
Tay River	Pike Lake	24.01	0.00		2.09	2.09	8.72	0.00	8.72
Tay River	Rudsdale Creek	63.26	0.00		3.24	3.24	5.13	0.00	5.13
Tay River	Tay A	12.90	0.94		1.29	2.23	17.30	7.27	10.03
Tay River	Tay B	58.10	8.86		4.19	13.05	22.46	15.24	7.22
Tay River	Tay C	55.13	0.00		4.13	4.13	7.50	0.00	7.50
Tay River	Tay D	29.58	0.00	0.95	1.58	2.53	8.54	0.00	8.54
Total RVCA area (km^2)		**4256.17**							
Wetland areas (km^2)			384.10	28.79	226.71	639.60			
Wetland as % of RVCA area			9.0	0.7	5.3				
Total wetland as % of RVCA area		**15.03**							
Type of wetlands			**PSW**	**LSW**	**NEW**				
Non-PSWs = LSW + NEW									

Table 2: Modeling Scenarios

Model Scenario	Description	Type of Analysis Done	Expected Results
A	- existing or baseline condition - based on RVCA's 2007 watershed model - all wetlands intact	- hydrograph comparison - flood frequency analysis	Comparison of A and B allows one to see the impacts of non-PSW removal on flood flows throughout the entire Rideau watershed
B	- hypothetical condition - all PSWs intact - all non-PSWs lost		
C1	- hypothetical condition - unregulated part of Rideau basin d/s of Smiths Falls is simulated (as in Scenario A) - no inflow from upstream of Smiths Falls - simulates the local contribution to low flows - all wetlands intact	- hydrograph comparison - low flow frequency analysis	Comparison of C1 and C2 allows one to see the impacts of non-PSW removal on the local contribution (downstream of Smiths Falls) to low flows in the Lower Rideau river reach
C2	- same as C1 - all PSWs intact - all non-PSWs lost - simulates local contribution to low flow under modified condition		
D1	- hypothetical condition - unregulated part of Tay basin d/s of Bolingbroke is simulated (as in Scenario A) - no inflow from upstream of Bolingbroke - simulates the local contribution to low flows - all wetlands intact	- hydrograph comparison - low flow frequency analysis	Comparison of D1 and D2 allows one to see the impacts of non-PSW removal on the local contribution (downstream of Bolingbroke) to low flows in the Tay basin
D2	- same as D1 - all PSWs intact - all non-PSWs lost - simulates local contribution to low flow under modified condition		

Table 3 NAM Parameters

			Base condition							Changed condition		
Sub-watershed	**Basin**	**Basin Area**	**U_{max}**	**L_{max}**	**CQOF**	**non PSW area**	**non PSW**	**ΔU_{max}**	**ΔL_{max}**	**U_{max}**	**L_{max}**	**CQOF**
		km^2	mm	mm	(-)	km^2	(%)	mm	mm	mm	mm	(-)
Lower	BRASSILS CR	76.3498	30.9	219	0.209	11.143	14.59	4.51	31.96	26.4	251	0.270
	RIDEAU 12	6.399	30.5	186	0.215	0.132	2.07	0.63	3.85	29.9	190	0.224
	MURPHY DR	47.0097	30.4	175	0.22	0.437	0.93	0.28	1.63	30.1	177	0.224
	RIDEAU F	13.4664	29.5	180	0.215	0.106	0.79	0.23	1.41	29.3	181	0.218
	RIDEAU 6	11.5703	29.0	147	0.21	0.469	4.05	1.17	5.96	27.8	153	0.227
	RIDEAU H	27.7488	29.1	173	0.215	0.241	0.87	0.25	1.50	28.8	174	0.219
	MCDERMOTT DR	18.0911	28.5	143	0.215	0.096	0.53	0.15	0.76	28.3	144	0.217
	RIDEAU 8	12.9064	29.0	128	0.218	0.102	0.79	0.23	1.01	28.8	129	0.221
	DOYLE CR	14.2394	28.3	152	0.21	0.157	1.10	0.31	1.67	28.0	154	0.215
	RIDEAU 7	24.3841	29.9	178	0.209	0.620	2.54	0.76	4.52	29.1	183	0.220
	RIDEAU 13	48.3714	30.5	180	0.22	1.535	3.17	0.97	5.71	29.5	186	0.234
	CRANBERRY CR	52.0015	30.8	228	0.22	1.246	2.40	0.74	5.46	30.1	233	0.231
	RIDEAU 2	21.068	28.6	177	0.215	0.094	0.44	0.13	0.79	28.5	178	0.217
	MUD CR	62.2045	30.4	253	0.251	0.067	0.11	0.03	0.27	30.4	253	0.252
	RIDEAU 11	8.0524	30.1	176	0.231	0.032	0.39	0.12	0.69	30.0	177	0.233
	RIDEAU 3	17.105	30.1	137	0.225	0.025	0.15	0.04	0.20	30.1	137	0.226
	BARRHAVEN CR	7.0487	30.5	227	0.23	0.000	0.00	0.00	0.00	30.5	227	0.230
	RIDEAU 4	2.9946	30.6	196	0.225	0.000	0.00	0.00	0.00	30.6	196	0.225
	BLACK RAPIDS CR	15.9643	29.7	188	0.25	0.000	0.00	0.00	0.00	29.7	188	0.250
	RIDEAU 5	2.6995	30.9	80	0.25	0.000	0.00	0.00	0.00	30.9	80	0.250
	NEPEAN CR	10.8294	30.8	109	0.2	0.000	0.00	0.00	0.00	30.8	109	0.200
	RIDEAU 10	4.0397	30.6	241	0.235	0.000	0.00	0.00	0.00	30.6	241	0.235
	MOSQUITO CR	37.6102	30.4	211	0.231	0.290	0.77	0.23	1.63	30.2	213	0.235
	RIDEAU 9A	19.5626	30.4	136	0.214	0.001	0.00	0.00	0.01	30.4	136	0.214
	RIDEAU 1	11.6355	30.9	71	0.3	0.002	0.02	0.01	0.01	30.9	71	0.300
	RIDEAU G	7.6702	30.8	83	0.251	0.002	0.03	0.01	0.02	30.8	83	0.251
	RIDEAU 9B	1.9264	30.6	103	0.21	0.000	0.00	0.00	0.00	30.6	103	0.210
	DALES CR	37.4856	29.8	229	0.209	3.272	8.73	2.60	19.99	27.2	249	0.245
	RIDEAU CR	62.0623	29.8	239	0.22	3.636	5.86	1.75	14.00	28.1	253	0.246
	STEVENS 3	42.5262	30.1	220	0.225	1.593	3.75	1.13	8.24	29.0	228	0.242
	TAYLOR	53.3272	30.4	225	0.235	2.400	4.50	1.37	10.13	29.0	235	0.256
	STEVENS 2	28.7112	30.4	233	0.235	0.258	0.90	0.27	2.09	30.1	235	0.239
	STEVENS 1	28.9738	30.5	250	0.241	0.000	0.00	0.00	0.00	30.5	250	0.241
	SAWMILLUP	22.2478	30.7	119	0.24	0.025	0.11	0.03	0.13	30.7	119	0.241
Jock	JOCK ED2	99.7199	38.5	226	0.54	13.891	12.51	4.82	28.27	33.7	254	0.678
	JOCK D1	89.0186	38.5	260	0.54	2.769	3.11	1.20	8.09	37.3	268	0.574
	KINGS CREEK	94.8859	39.3	257	0.56	10.711	11.29	4.44	29.02	34.9	286	0.686
	NICHOLS CREEK	62.8299	39.3	190	0.57	3.712	5.91	2.32	11.23	37.0	201	0.637
	HOBBS DRAIN	33.9922	39.1	295	0.55	1.393	4.10	1.60	12.10	37.5	307	0.595
	JOCK C1	11.0372	39.5	252	0.55	1.041	9.43	3.72	23.76	35.8	276	0.654
	JOCK C2	3.1475	39.5	139	0.55	0.002	0.06	0.02	0.08	39.5	139	0.551
	JOCK B1	5.8187	39.2	95	0.54	0.005	0.09	0.04	0.09	39.2	95	0.543
	JOCK B2	4.8091	39.2	234	0.54	0.013	0.28	0.11	0.66	39.1	235	0.545
	JOCK B3	11.3591	39.5	248	0.55	0.252	2.22	0.88	5.51	38.6	254	0.574
	JOCK A1	17.9317	39.2	239	0.57	0.718	4.00	1.57	9.56	37.6	249	0.616
	FLOWING CREEK1	48.5302	39.2	267	0.56	1.568	3.23	1.27	8.62	37.9	276	0.596
	FLOWING CREEK2	3.0763	39.5	214	0.56	0.000	0.00	0.00	0.00	39.5	214	0.560
	LEAMY CREEK	5.6427	39.4	207	0.55	0.000	0.00	0.00	0.00	39.4	207	0.550
	JOCKA2	12.0222	39.5	201	0.56	0.024	0.20	0.08	0.40	39.4	201	0.562
	MONAHAN DRAIN1	27.4477	39.4	227	0.55	0.022	0.08	0.03	0.18	39.4	227	0.551
	MONAHAN DRAIN2	3.4541	39.3	231	0.54	0.010	0.29	0.11	0.67	39.2	232	0.543
	MONAHAN DRAIN3	11.873	39.5	212	0.54	0.000	0.00	0.00	0.00	39.5	212	0.540
	SOUTH NEPEAN	31.0993	39.5	204	0.55	0.014	0.05	0.02	0.10	39.5	204	0.551
Kemptville	KEMPT SOUTH B	124.129	23.2	232	0.247	5.866	4.73	1.10	10.96	22.1	243	0.270
	KEMPT SOUTH A	79.5168	20.8	195	0.23	10.652	13.40	2.79	26.12	18.0	221	0.292
	KEMPT NORTH B	107.466	20.6	191	0.247	6.817	6.34	1.31	12.12	19.3	203	0.278
	KEMPT NORTH A	18.048	20.7	193	0.237	2.178	12.07	2.50	23.29	18.2	216	0.294
	KEMPT A3	61.0123	19.5	157	0.22	7.312	11.99	2.34	18.82	17.2	176	0.273
	KEMPT A2	20.5381	18.5	147	0.223	2.760	13.44	2.49	19.76	16.0	167	0.283
	KEMPT A1	21.6721	19.9	162	0.223	0.141	0.65	0.13	1.05	19.8	163	0.226
	BARNES	27.7431	20.1	173	0.218	0.759	2.74	0.55	4.74	19.5	178	0.230
Middle	BLACK CR2	98.2805	23.5	235	0.100	15.545	15.82	3.72	37.17	19.8	272	0.132
	BLACK CR1	43.3216	24.8	248	0.101	9.521	21.98	5.45	54.50	19.3	303	0.145
	OTTER LAKE	36.3534	21.1	209	0.106	5.755	15.83	3.34	33.09	17.8	242	0.140
	OTTER CR	54.8879	25.1	251	0.103	4.876	8.88	2.23	22.30	22.9	273	0.121
	BELLAMY POND	31.2947	29.5	295	0.100	2.452	7.84	2.31	23.11	27.2	318	0.116
	HUTTON CR B	24.564	24.7	247	0.102	1.602	6.52	1.61	16.11	23.1	263	0.115
	HUTTON CR A	33.8725	24.9	249	0.104	1.499	4.43	1.10	11.02	23.8	260	0.113
	RIDEAU E	47.6984	20.7	207	0.100	1.916	4.02	0.83	8.31	19.9	215	0.108
	RIDEAU D	7.2144	20.1	192	0.105	0.056	0.77	0.15	1.48	19.9	193	0.107
	RIDEAU C	22.3273	21.6	209	0.106	3.559	15.94	3.44	33.31	18.2	242	0.140
	ROSEDALE CR	74.9765	21.9	216	0.100	8.324	11.10	2.43	23.98	19.5	240	0.122
	IRISH LAKE	49.2292	25.4	254	0.109	0.903	1.83	0.47	4.66	24.9	259	0.113
	IRISH CR B	48.1863	25.7	257	0.101	2.549	5.29	1.36	13.59	24.3	271	0.112
	IRISH CR A	34.876	21.5	211	0.103	2.383	6.83	1.47	14.42	20.0	225	0.117
	RIDEAU CR	62.0623	23.9	239	0.101	3.636	5.86	1.40	14.00	22.5	253	0.113
	RIDEAU B	7.8883	24.4	244	0.103	0.162	2.05	0.50	5.00	23.9	249	0.107
	RIDEAU A	36.5919	23.4	230	0.102	0.593	1.62	0.38	3.73	23.0	234	0.105
	BARBER CR	76.8243	21.3	211	0.104	6.995	9.10	1.94	19.21	19.4	230	0.123
	DALES CR	37.4856	22.9	229	0.101	3.272	8.73	2.00	19.99	20.9	249	0.119
Upper	WOLFE LAKE 1	37.3638	20.0	196	0.605	1.296	3.47	0.69	6.80	19.3	203	0.647
	WOLFE LAKE 2	35.4243	20.0	184	0.621	1.468	4.14	0.83	7.62	19.2	192	0.672
	WESTPORT SAND	16.6089	20.1	143	0.620	0.358	2.16	0.43	3.08	19.7	146	0.647
	UPPER RIDEAU	60.8484	20.0	189	0.650	1.595	2.62	0.52	4.96	19.5	194	0.684
	BLACK LAKE 4	26.0182	20.1	211	0.650	1.323	5.08	1.02	10.73	19.1	222	0.716
	BLACK LAKE 3	18.0794	20.0	201	0.600	0.854	4.72	0.94	9.50	19.1	210	0.657
	BLACK LAKE 2	21.1923	20.1	185	0.600	2.209	10.42	2.10	19.28	18.0	204	0.725
	BLACK LAKE 1	28.2896	20.5	231	0.566	3.750	13.26	2.72	30.62	17.8	262	0.716
	BIG RIDEAU B	108.804	20.0	173	0.578	3.795	3.49	0.70	6.03	19.3	179	0.618
	BIG RIDEAU A	48.7876	20.0	154	0.600	3.219	6.60	1.32	10.16	18.7	164	0.679
	LOWER RIDEAU	48.4665	20.1	173	0.560	4.058	8.37	1.68	14.49	18.4	187	0.654
Tay	OTTY	52.1572	34.5	184	0.172	6.676	12.80	4.42	23.55	30.1	208	0.216
	BLUEBERRY	44.4607	34.4	209	0.203	1.537	3.46	1.19	7.23	33.2	216	0.217
	TAYB	58.0986	34.3	232	0.158	4.195	7.22	2.48	16.75	31.8	249	0.181
	TAYA	12.9046	34.4	237	0.265	1.294	10.03	3.45	23.77	30.9	261	0.318
	RUDSDALE	63.2647	34.4	213	0.439	3.244	5.13	1.76	10.93	32.6	224	0.484
	TAYC	55.1307	33.7	188	0.148	4.135	7.50	2.53	14.10	31.2	202	0.170
	CHRISTIE LAKE	32.177	30.2	191	0.274	1.656	5.15	1.56	9.84	28.6	201	0.302
	PIKE&CROSBY	62.7641	20.2	197	0.293	3.777	6.53	1.32	12.86	18.9	210	0.331
	GRANTSCR	30.6967	34.4	229	0.278	1.136	3.70	1.27	8.47	33.1	237	0.299
	LEFE4SUBS	173.736	25.1	209	0.492	19.022	9.67	2.43	20.21	22.7	229	0.587
	TAYD	29.58	34.4	227	0.227	2.527	8.54	2.94	19.39	31.5	246	0.266
	BOBS LAKE	132.522	22.1	182	0.107	8.965	6.76	1.49	12.30	20.6	194	0.121
	CROW LAKE	49.7206	34.3	208	0.18	2.408	4.84	1.66	10.07	32.6	218	0.197

Table 4: Data Extraction Points

Watershed	ID	Location	Type	Drainage Area (km^2)	CFA	LFA
Lower	L1	Rideau at Carleton University (02LA004)	HD	3830.00	✓	✓
	L2	Rideau at Long Island (02LA012)	HD	3120.00	✓	✓
	L3	Rideau at u/s of Kars Bridge	HD	2780.00	✓	✓
	L4	Confluence of Taylor and Steven Creek	HD	124.56	✓	✓
	L5	Outlet of Brassils Creek	RR	76.37	✓	
	L6	Outlet of Rideau 7	RR	24.38	✓	
Jock	J1	Jock at Moodie Dr. (02LA007)	HD	559.00	✓	✓
	J2	Outlet of Richmond Fen	HD	400.45	✓	
	J3	Outlet of ED2	RR	99.72	✓	
	J4	Outlet of Flowing Creek 1	RR	48.53	✓	
Kemptville	K1	Kemptville Creek near Kemptville (02LA006)	HD	409.00	✓	✓
	K2	Outlet of North Branch Kemptville A	HD	125.51	✓	
	K3	Outlet of North Branch Kemptville A	RR	18.05	✓	
	K4	Outlet of South Branch A	RR	79.52	✓	
	K5	Outlet of Kemptville A2	RR	20.54	✓	
	K6	Outlet of Barnes Creek	RR	27.74	✓	
Middle	M1	Rideau at Andrewsville (02LA011)	HD	1975.00	✓	✓
	M2	Outlet of Black Creek 1	RR	43.32	✓	
	M3	Outlet of Black Creek 2	RR	98.28	✓	
	M4	Outlet of Otter Lake	RR	36.35	✓	
	M5	Outlet of Dales Creek	RR	37.49	✓	
Upper	U1	Rideau at Poonamalie (02LA005)	HD	1290.00	✓	
	U2	Outlet of Black lake 1	HD	93.58	✓	
	U3	Outlet of Black lake 1	RR	28.29	✓	
	U4	Outlet of Lower Rideau Lake	RR	48.47	✓	
Tay	T1	Tay at Perth (02LA024)	HD	661.00	✓	✓
	T2	Tay at Port Elmsley (02LA016)	HD	786.00	✓	✓
	T3	Outlet of Otty Lake/Jebbs Creek	RR	52.16	✓	✓
	T4	Outlet of Tay B	RR	58.10	✓	✓
	T5	Outlet of Blueberry Creek	RR	44.46	✓	✓
	T6	Outlet of 4 subs: Fish, Eagle, Long and Elbow	RR	173.74	✓	

Table 5: Flood Frequency Statistics for Scenario A and B (all values in cms)

ID	Location	Return Period (year)	1.003	1.05	1.25	2	5	10	20	50	100	200	500
L1	02LA004	Observed (1970-2007)	4.54	147.00	250.00	348.00	442.00	488.00	526.00	567.00	594.00	619.00	647.00
		A	175.00	221.00	268.00	331.00	412.00	464.00	513.00	575.00	621.00	667.00	728.00
		B	174.00	221.00	270.00	334.00	418.00	472.00	523.00	587.00	635.00	682.00	745.00
L2	02LA012	A	109.00	152.00	192.00	242.00	301.00	336.00	368.00	407.00	435.00	462.00	496.00
		B	109.00	152.00	192.00	242.00	301.00	337.00	369.00	408.00	436.00	463.00	498.00
L3	u/s of Kars Br	A	103.00	142.00	180.00	226.00	281.00	315.00	345.00	382.00	409.00	434.00	468.00
		B	103.00	142.00	180.00	226.00	282.00	315.00	345.00	382.00	409.00	435.00	468.00
L4	Taylor&Steven conf.	A	8.23	11.80	15.00	18.90	23.40	26.00	28.30	31.10	33.10	35.00	37.50
		B	8.25	11.80	15.10	19.00	23.50	26.20	28.50	31.30	33.30	35.30	37.70
L5	Outlet Brassils	A	5.03	7.06	8.99	11.40	14.20	15.90	17.50	19.40	20.80	22.10	23.90
		B	4.96	7.12	9.13	11.60	14.50	16.20	17.80	19.70	21.10	22.40	24.10
L6	Outlet Rideau 7	A	1.64	2.33	2.97	3.74	4.65	5.20	5.69	6.28	6.70	7.11	7.64
		B	1.64	2.33	2.98	3.75	4.67	5.22	5.71	6.30	6.73	7.14	7.66
J1	02LA007	Observed (1970-2007)	27.70	42.40	59.00	82.70	116.00	139.00	161.00	190.00	213.00	235.00	266.00
		A	36.00	50.80	65.40	83.70	107.00	121.00	134.00	150.00	161.00	173.00	188.00
		B	36.50	51.30	66.20	85.50	110.00	125.00	140.00	157.00	171.00	184.00	201.00
J2	Outlet RFen	A	26.90	37.50	48.10	61.90	79.30	90.20	100.00	113.00	122.00	131.00	144.00
		B	26.30	36.80	47.90	62.60	81.90	94.40	106.00	121.00	132.00	143.00	158.00
J3	Outlet ED2	A	6.91	9.63	12.40	15.90	20.40	23.20	25.80	29.10	31.50	33.90	37.00
		B	6.79	9.57	12.50	16.50	21.70	25.10	28.40	32.50	35.60	38.70	42.80
J4	Outlet Flowing Cr1	A	3.62	4.65	5.85	7.60	10.10	11.90	13.60	15.90	17.70	19.50	22.00
		B	3.36	4.65	5.98	7.74	10.00	11.50	12.80	14.60	15.90	17.10	18.80
K1	02LA006	Observed (1970-2007)	14.20	25.60	36.00	48.50	63.10	71.70	79.40	88.70	95.30	102.00	110.00
		A	24.00	33.80	43.10	54.60	68.40	76.70	84.30	93.50	100.00	107.00	115.00
		B	24.60	34.20	43.40	54.80	68.60	77.10	84.70	94.10	101.00	108.00	116.00
K2	Outlet North A (HD)	A	7.76	10.80	13.80	17.30	21.60	24.10	26.50	29.30	31.30	33.30	35.80
		B	7.64	10.80	13.80	17.40	21.70	24.30	26.60	29.40	31.40	33.40	35.90
K3	Outlet North A (RR)	A	0.92	1.47	1.95	2.49	3.11	3.46	3.76	4.12	4.38	4.62	4.92
		B	1.11	1.56	1.99	2.52	3.16	3.55	3.90	4.33	4.64	4.94	5.33
K4	Outlet South A	A	4.90	*6.89*	8.77	11.10	13.80	15.50	17.00	18.90	20.20	21.50	23.20
		B	4.88	6.91	8.81	11.10	14.00	15.70	17.20	19.00	20.40	21.70	23.40
K5	Outlet Kempt A2	A	1.30	1.83	2.33	2.94	3.66	4.09	4.47	4.94	5.28	5.60	6.02
		B	1.29	1.84	2.35	2.96	3.69	4.13	4.52	5.00	5.34	5.67	6.09
K6	Outlet Barnes Cr	A	1.76	2.46	3.13	3.96	4.98	5.59	6.15	6.84	7.33	7.81	8.44
		B	1.75	2.44	3.10	3.91	4.89	5.48	6.01	6.66	7.12	7.58	8.16
M1	02LA011	A	57.80	74.50	92.50	117.00	150.00	172.00	193.00	220.00	240.00	260.00	287.00
		B	57.40	74.40	92.30	117.00	149.00	170.00	190.00	216.00	235.00	255.00	281.00
M2	Outlet Black Cr1	A	2.47	3.39	4.29	5.43	6.86	7.74	8.55	9.56	10.30	11.00	12.00
		B	2.47	3.37	4.25	5.38	6.81	7.69	8.51	9.53	10.30	11.00	12.00
M3	Outlet Black Cr2	A	5.65	7.75	9.82	12.40	15.70	17.70	19.50	21.80	23.50	25.10	27.30
		B	5.66	7.72	9.76	12.40	15.60	17.60	19.50	21.80	23.50	25.10	27.30
M4	Outlet Otter	A	2.13	2.92	3.70	4.68	5.89	6.64	7.32	8.16	8.78	9.38	10.20
		B	2.13	2.91	3.68	4.66	5.87	6.62	7.31	8.16	8.79	9.40	10.20
M5	Outlet Dales	A	2.17	2.96	3.74	4.74	5.97	6.74	7.44	8.31	8.95	9.57	10.40
		B	2.17	2.95	3.73	4.72	5.95	6.72	7.43	8.31	8.95	9.58	10.40
U1	02LA005	A	28.40	33.90	41.70	55.30	78.90	97.40	117.00	146.00	170.00	196.00	233.00
		B	28.30	33.70	41.40	54.70	77.70	95.70	115.00	143.00	166.00	191.00	227.00
U2	Outlet Black Lake1hd	A	5.91	7.81	9.75	12.30	15.60	17.60	19.60	22.00	23.80	25.60	28.00
		B	6.10	7.96	9.93	12.60	16.20	18.50	20.70	23.60	25.70	27.80	30.70
U3	Outlet Black Lake1rr	A	1.70	2.32	2.93	3.70	4.67	5.27	5.81	6.50	6.99	7.48	8.12
		B	1.79	2.39	3.01	3.84	4.94	5.64	6.30	7.14	7.77	8.40	9.22
U4	Outlet Lower Rideau	A	3.00	4.10	5.19	6.57	8.29	9.35	10.30	11.50	12.40	13.30	14.40
		B	3.11	4.19	5.30	6.75	8.64	9.84	11.00	12.40	13.40	14.50	15.80
T1	02LA024	A	17.10	24.80	32.40	42.00	54.20	61.70	68.70	77.30	83.70	89.90	98.00
		B	16.80	24.50	32.10	41.80	53.80	61.30	68.20	76.80	83.10	89.30	97.30
T2	02LA016	A	26.50	33.90	41.60	51.90	65.50	74.20	82.40	92.90	101.00	109.00	119.00
		B	26.90	33.70	41.10	51.30	65.10	74.30	83.00	94.30	103.00	111.00	123.00
T3	Outlet Otty Lake	A	2.03	2.74	3.42	4.27	5.31	5.94	6.52	7.22	7.74	8.24	8.88
		B	2.02	2.72	3.39	4.23	5.26	5.88	6.46	7.17	7.68	8.18	8.83
T4	Outlet TayB	A	2.21	2.94	3.67	4.59	5.75	6.47	7.13	7.95	8.56	9.15	9.92
		B	2.20	2.93	3.65	4.56	5.72	6.43	7.09	7.92	8.52	9.11	9.88
T5	Outlet Blueberry	A	1.71	2.30	2.87	3.58	4.47	5.02	5.51	6.13	6.58	7.02	7.59
		B	1.71	2.29	2.86	3.58	4.46	5.00	5.50	6.11	6.56	7.00	7.57
T6	Outlet 4subs	A	6.80	9.14	11.40	14.20	17.60	19.70	21.60	24.00	25.70	27.30	29.50
		B	6.75	9.05	11.30	14.00	17.50	19.50	21.40	23.80	25.50	27.20	29.30

Table 6: Impact of non-PSW removal on 1:100 Year Flood

ID	Data Type	Location	Drainage area (sq-km)	non-PSWs (sq-km)	non-PSW as % of Drainage area	Q100 Scenario A (cms)	Q100 Scenario B (cms)	Change in Flood over base flood (%)
L1	HD	Rideau at Carleton University (02LA004)	3830.00	253.72	6.62	621.00	635.00	2.25
L2	HD	Rideau at Long Island (02LA012)	3120.00	217.29	6.96	435.00	436.00	0.23
L3	HD	Rideau at u/s of Kars Bridge	2780.00	210.75	7.58	409.00	409.00	0.00
L4	HD	Confluence of Taylor and Steven Creek	124.56	4.25	3.41	33.10	33.30	0.60
L5	RR	Outlet of Brassils Creek	76.37	11.14	14.59	20.80	21.10	1.44
L6	RR	Outlet of Rideau 7	24.38	0.62	2.54	6.70	6.73	0.45
J1	HD	Jock at Moodie Dr. (02LA007)	559.00	36.10	6.46	161.00	171.00	6.21
J2	HD	Outlet of Richmond Fen	400.45	33.48	8.36	122.00	132.00	8.20
J3	RR	Outlet of ED2	99.72	13.89	13.93	31.50	35.60	13.02
J4	RR	Outlet of Flowing Creek 1	48.53	1.57	3.23	15.30	15.90	3.92
K1	HD	Kemptville Creek near Kemptville (02LA006)	409.00	36.49	8.92	100.00	101.00	1.00
K2	HD	Outlet of North Branch Kemptville A	125.51	9.00	7.17	31.30	31.40	0.32
K3	RR	Outlet of North Branch Kemptville A	18.05	2.18	12.08	4.38	4.64	5.94
K4	RR	Outlet of South Branch A	79.52	10.65	13.39	20.20	20.40	0.99
K5	RR	Outlet of Kemptville A2	20.54	2.76	13.44	5.28	5.34	1.14
K6	RR	Outlet of Barnes Creek	27.74	0.76	2.74	7.33	7.12	-2.86
M1	HD	Rideau at Andrewsville (02LA011)	1975.00	189.69	9.60	240.00	235.00	-2.08
M2	RR	Outlet of Black Creek 1	43.32	9.52	21.98	10.30	10.30	0.00
M3	RR	Outlet of Black Creek 2	98.28	15.55	15.82	23.50	23.50	0.00
M4	RR	Outlet of Otter Lake	36.35	5.75	15.82	8.78	8.79	0.11
M5	RR	Outlet of Dales Creek	37.49	3.27	8.72	8.95	8.95	0.00
U1	HD	Rideau at Poonamalie (02LA005)	1290.00	84.50	6.55	170.00	166.00	-2.35
U2	HD	Outlet of Black lake 1	93.58	8.13	8.69	23.80	25.70	7.98
U3	RR	Outlet of Black lake 1	28.29	3.75	13.26	6.99	7.77	11.16
U4	RR	Outlet of Lower Rideau Lake	48.47	4.06	8.38	12.40	13.40	8.06
T1	HD	Tay at Perth (02LA024)	661.00	48.44	7.33	83.70	83.10	-0.72
T2	HD	Tay at Port Elmsley (02LA016)	786.00	60.60	7.71	101.00	103.00	1.98
T3	RR	Outlet of Otty Lake/Jebbs Creek	52.16	6.68	12.81	7.74	7.68	-0.78
T4	RR	Outlet of Tay B	58.10	4.19	7.21	8.56	8.52	-0.47
T5	RR	Outlet of Blueberry Creek	44.46	1.54	3.46	6.58	6.56	-0.30
T6	RR	Outlet of 4 subs: Fish, Eagle, Long and Elbow	173.74	19.02	10.95	25.70	25.50	-0.78

Table 7a: Impact of non-PSW removal on 1:20 Year Low Flow (Scenario C1 and C2)

ID	Location	Data Type	Q_{20} for Scenario C1 (cms)	Q_{20} for Scenario C2 (cms)	Change in Q_{20} (%)
L1	Rideau at Carleton University (02LA004)	HD	0.2200	0.2480	12.73
L2	Rideau at Long Island (02LA012)	HD	0.0713	0.0953	33.66
L3	Rideau at u/s of Kars Bridge	HD	0.1050	0.1220	16.19
L4	Confluence of Taylor and Steven Creek	HD	0.1880	0.1880	0.00
M1	Rideau at Andrewsville (02LA011)	HD	0.0152	0.0221	45.39
J1	Jock at Moodie Dr. (02LA007)	HD	0.2000	0.2000	0.00
K1	Kemptville Creek near Kemptville (02LA006)	HD	0.0001	0.0001	0.00

Table 7b: Impact of non-PSW removal on 1:20 Year Low Flow (Scenario D1 and D2)

ID	Location	Data Type	Q_{20} for Scenario D1 (cms)	Q_{20} for Scenario D2 (cms)	Change in Q_{20} (%)
T1	Tay at Perth (02LA024)	HD	0.0040	0.0046	15.00
T2	Tay at Port Elmsley (02LA016)	HD	0.0119	0.0157	31.93
T3	Outlet of Otty Lake/Jebbs Creek	RR	0.0004	0.0006	50.00
T4	Outlet of Tay B	RR	0.0003	0.0004	33.33
T5	Outlet of Blueberry Creek	RR	0.0003	0.0003	0.00

Table 8: Low Flow Statistics

ID	Return period, Year	1.005	1.01	1.11	1.25	2	5	10	20	50	100	200	500
L1	Obs (1948-2005)	9.4410	8.9800	7.0280	6.2020	4.6870	3.3100	2.6880	2.2430	1.8290	1.6060	1.4380	1.2770
	A	19.8900	17.8500	10.5200	8.0570	4.4970	2.3320	1.6830	1.3430	1.1170	1.0320	0.9830	0.9500
	B	19.2000	17.3700	10.6500	8.3080	4.8060	2.5460	1.8250	1.4300	1.1530	1.0430	0.9780	0.9310
	C1	4.9900	4.3890	2.3460	1.7080	0.8540	0.3980	0.2780	0.2200	0.1880	0.1770	0.1710	0.1670
	C2	4.8450	4.3110	2.4360	1.8220	0.9610	0.4620	0.3190	0.2480	0.2020	0.1850	0.1760	0.1700
L2	C1	4.4100	3.8670	2.0140	1.4330	0.6540	0.2340	0.1240	0.0713	0.0040	0.0290	0.0235	0.0201
	C2	4.6840	4.1140	2.1630	1.5490	0.7210	0.2720	0.1520	0.0953	0.0608	0.0490	0.0429	0.0391
L3	C1	4.2330	3.7170	1.9540	1.4010	0.6590	0.2600	0.1550	0.1050	0.0746	0.0644	0.0591	0.0558
	C2	4.1050	3.6500	2.0400	1.5090	0.7570	0.3150	0.1880	0.1220	0.0804	0.0649	0.0563	0.0507
L4	C1	0.2420	0.2330	0.2060	0.1990	0.1920	0.1890	0.1880	0.1880	0.1880	0.1880	0.1880	0.1880
	C2	0.2410	0.2330	0.2060	0.2000	0.1920	0.1890	0.1880	0.1880	0.1880	0.1880	0.1880	0.1880
M1	C1	2.9030	2.5080	1.2090	0.8250	0.3360	0.0973	0.0404	0.0152	0.0013			
	C2	2.8340	2.4790	1.2740	0.8970	0.3940	0.1260	0.0554	0.0221	0.0023			
T1	A	3.5160	3.0770	1.5870	1.1230	0.5040	0.1740	0.0876	0.0470	0.0228	0.0147	0.0105	0.0079
	B	3.4760	3.0590	1.6210	1.1630	0.5380	0.1920	0.0976	0.0517	0.0236	0.0138	0.0087	0.0054
	D1	2.0250	1.6820	0.6670	0.4110	0.1330	0.0292	0.0106	0.0040	0.0011	0.0003	0.0001	
	D2	2.0070	1.6770	0.6860	0.4300	0.1440	0.0331	0.0123	0.0046	0.0011	0.0002		
T2	D1	2.4400	2.1030	1.0040	0.6810	0.2740	0.0782	0.0321	0.0119	0.0009			
	D2	2.4540	2.1250	1.0370	0.7110	0.2950	0.0881	0.0381	0.0157	0.0032			
T3	D1	0.1190	0.1670	0.0680	0.0425	0.0142	0.0032	0.0011	0.0004	0.0000			
	D2	0.1840	0.1560	0.0701	0.0460	0.0172	0.0044	0.0017	0.0006	0.0000			
T4	D1	0.2080	0.1730	0.0682	0.0419	0.0134	0.0028	0.0010	0.0003	0.0000			
	D2	0.1980	0.1660	0.0701	0.0446	0.0155	0.0036	0.0013	0.0004	0.0000			
T5	D1	0.1680	0.1400	0.0562	0.0348	0.1140	0.0025	0.0090	0.0003	0.0000			
	D2	0.1630	0.1360	0.0566	0.0357	0.0122	0.0028	0.0010	0.0003	0.0000			
K1	Obs (1970-2005)	1.0840	0.8700	0.2930	0.1670	0.0485	0.0135	0.0087	0.0073	0.0068	0.0067	0.0067	0.0066
	A/C1	0.2300	0.1810	0.0552	0.0296	0.0069	0.0010	0.0003	0.0001				
	B/C2	0.2450	0.1960	0.0653	0.0367	0.0096	0.0015	0.0004	0.0001				
J1	Obs (1970-2005)	1.2220	0.9980	0.3670	0.2190	0.0700	0.0207	0.0131	0.0106	0.0096	0.0094	0.0093	0.0093
	A/C1	0.3320	0.3080	0.2390	0.2230	0.2070	0.2010	0.2000	0.2000	0.2000	0.2000	0.2000	
	B/C2	0.3330	0.3100	0.2420	0.2260	0.2080	0.2010	0.2000	0.2000	0.2000	0.2000	0.2000	