Watershed Pollutant Load Assessments
for the
Canadian side of the western basin of Lake Ontario.

A report prepared for CTC Source Protection Region

Photograph of the Pickering- Ajax waterfront in February 2009 following major snowmelt in western Durham watersheds. (Photo credit Loy Wise)

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Introduction

The shoreline of Lake Ontario is a valued amenity in southern Ontario. It is also an area of contrasting uses, including public green spaces, Provincially Significant Wetlands, recreational boating, shipping, municipal and private sector infrastructure related to the treatment of wastewater and potable water, and the generation of electric power. Emerging water quality issues include beach postings, fouling of the shoreline by algae (Cladophora) and periods of impaired aesthetics and presumably poor water quality (as evident by high turbidity) following storm or snowmelt inputs from watershed tributaries. Lake Ontario also serves as the drinking water source for over 6 million residents of the Province of Ontario.

In order to understand spatial and temporal patterns in the water quality of the nearshore and its influence on lake based drinking water supplies, it is necessary to understand the transport mechanisms of pollutants from local watersheds to Lake Ontario and the mixing/transport processes within the lake.

Accurate loads estimates for Lake Ontario tributaries have not been determined for decades. The last time pollutant loads were estimated lake wide was for the PLUARG (Pollution From Landuse Activities Reference Group) studies in 1970s.

Study Area

In the initial phase of this project we developed pollutant load estimates for tributaries extending from the Niagara River around the Canadian shoreline to Prince Edward County. This work was undertaken in conjunction with Intake Protection Zone studies initiated by the Lake Ontario Collaborative. Our current efforts are focusing on loading estimates for seven tributaries (Twenty Mile Creek, Sixteen Mile Creek, Credit River, Duffins Creek, Carruthers Creek, Ganaraska River and Cobourg Creek) Figure 1. The chosen pilot watersheds reflect a range of land uses, physiographic settings and drainage areas and as well based upon the knowledge that the City of Toronto and TRCA were monitoring an additional six watersheds draining into the Toronto waterfront. The seven study watersheds fall within the four nearshore study areas selected for the Canadian side of Lake Ontario, during the 2008 International year of study (add reference). Six of the seven watersheds have current watershed plans. More detailed information on these watersheds can be found in recent characterization reports prepared by local source protections committees.

Figures 2 and 3 illustrate differences in watershed drainage areas and land use. Watershed drainage areas range in size from 38 to 948 km^2. The land cover summaries were derived from the Ministry of Natural Resources (MNR) Southern Ontario Land Resource Information System (SOLIRIS) and were summarized by local Conservation Authority (CA) GIS staff. Natural cover is the highest in Cobourg and Ganaraska watersheds. Credit River and Carruthers Creek share not only the distinction of being the largest and smallest watersheds surveyed in this study, but also having the highest percentage of urban land use. Twenty Mile Creek has the largest percentage of its watershed in agricultural land use and the least amount of natural cover.

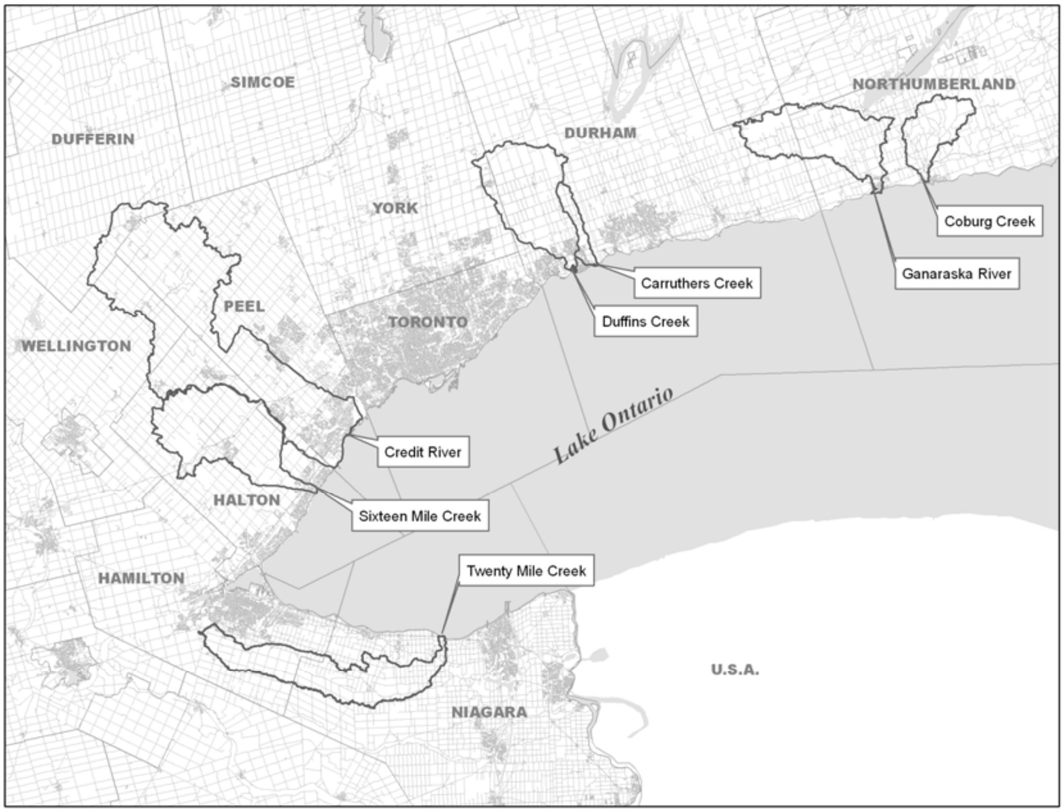

Figure 1 Location of Pilot Study Areas Watersheds

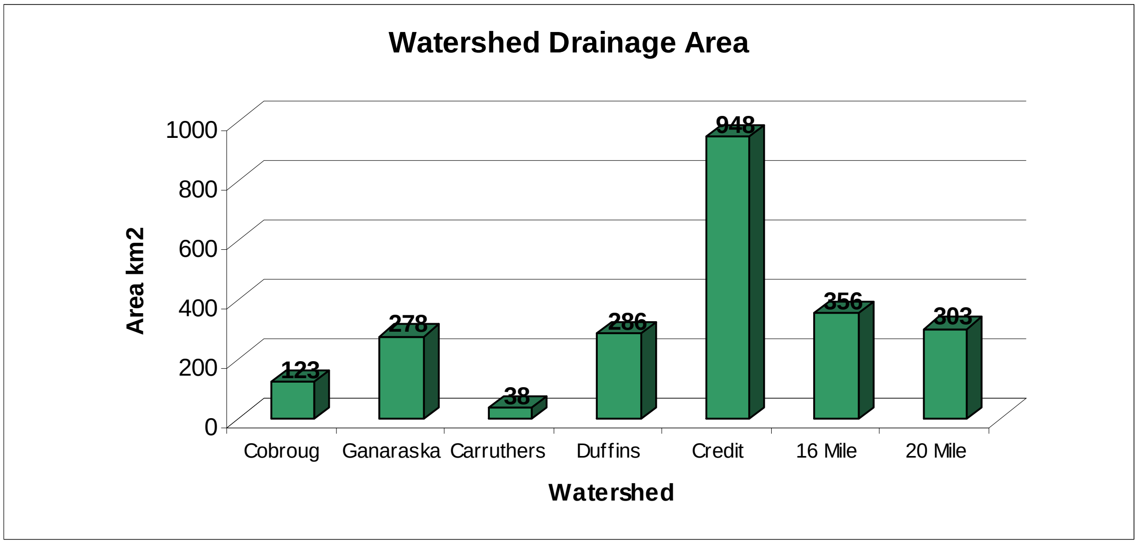

Figure 2 Pilot Watershed Drainage Areas

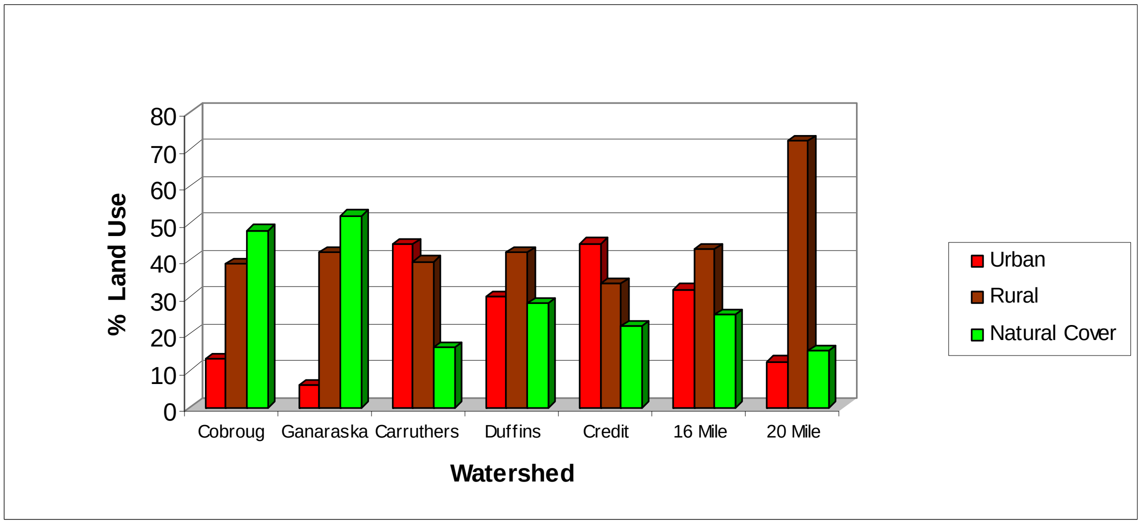

Figure 3 Pilot Watershed Land Use

Method

Tributary Sampling

Automatic water samplers were set up at locations identified by local conservation authority as being as close to Lake Ontario as possible, but upstream of any wind induced back water effects. Where possible the sampling locations were located at stream flow monitoring sites. Stream flow monitoring stations were not available in the lower reaches of Sixteen Mile Creek or the Credit River. For these watersheds we tracked changes in water levels during the sampling period and prorated flows based upon watershed areas and the nearest upstream gauge.

The automatic samplers were programmed to fill a carousel of bottles over 24 to 48 hours depending upon watershed runoff responses. Equipment problems prevented Halton Region CA staff from deploying an automatic sampler in 2009. Wet weather grab samples were taken, as frequently as possible, in 2009 for 16 Mile Creek.

A spreadsheet program used water level or discharge records to estimate aliquots of sample needed from each collection bottle, to make a volume weight sample. Handling and shipping of the water samples to the MOE lab followed procedures employed for the Provincial Water Quality Monitoring Program. Crews that processed the event samples –also collected grab water samples for the routine monitoring programs. Laboratory analysis followed procedures used at Provincial Ministry of Environment Laboratories.

Load Estimation Procedures

Routine monitoring programs operated by CAs in partnership with the Ministry of Environment (MOE) Provincial Water Quality Monitoring Network (PWQMN) collect up to 8 samples a year between April and October. Some of the CAs collected additional samples to fill in the 4 month gap in the PWQMN. Furthermore, water quality monitoring stations established for routine monitoring programs are not always located near the watershed outlets to Lake Ontario.

Recognizing the limitations of existing routine watershed water quality monitoring programs for estimating pollutant loads to Lake Ontario and for the calibration of watershed models such as SWAT, we initiated a multi year program to sample seven representative Lake Ontario watersheds following major storms. The objective of this study was to estimate pollutant loads for nutrients and suspended solids. These parameters are known to be good surrogates of pathogens and other contaminants that might risk the treatment of raw water supplies. For example, following major runoff events, fine sediments, typically tracked as turbidity, and suspended solids can impact the drinking water treatment process, thereby putting the quality of Lake Ontario water supplies at risk.

Two methods were employed to estimate pollutant loads for 2008 and 2009. These methods are described in detail in a supporting document being prepared for the Journal of Great Lakes Research (Booty et .al 2011). The Beale Ratio method recommended by IJC, involves collecting a large number of samples across a representative range of stream flow conditions. Eddie and Onn, 1981 have shown that to achieve 10% precision for annual loads in Ontario streams, between 44 and 210 samples are required. As a result, the Beale Ratio technique is not well supported by current watershed monitoring programs. For the purposes of our study, the additional samples collected during wet weather, combined with routine monitoring samples provided adequate number of samples for the National Water Research Institute (NWRI) modified ratio technique. This method assumes that flow is completely known and its errors can be ignored and that missing concentrations can be determined based upon the relationship between flow and concentration. The NWRI technique estimates the regression parameters by using the maximum likelihood or least square methods. Both “ratio” loading estimation techniques generate estimates of variance.

Recognizing that the Beale Ratio technique is not well supported by current watershed monitoring programs; and that it is unlikely additional resources are forthcoming for additional water sampling, we elected to develop and compare an alternative loadings estimate- the Event Mean Concentration (EMC) approach developed by the EPA in 1980s. For the EMC method, a number of wet and dry runoff events are sampled to estimate “event mean values” for corresponding wet and dry conditions. Using EMCs approach, pollutant loads can be estimated for any period, providing streamflow records are available. For the EMC load method Water Survey of Canada (WSC) and or CA stream flow records for the watersheds and are multiplied by corresponding EMC (wet/dry) summaries to estimate pollutant loads. Unit correction factors are applied –loads are expressed as kg per day. The EMC loading technique has been previously employed for Halton Region watersheds, the Credit River and Duffins Creek (add references). In the initial phases of this study, we estimated loads for western Lake Ontario tributaries using previously published EMC values and Unit Area Loads reported for PLUARG. Phase two of this work was intended to update Phase 1 EMC values and to revise loads to the Canadian portion of the lake. Load estimates for the 7 pilot watersheds were then pro-rated to nearby watersheds on an area weighted basis. The assumption here is that climate patterns, runoff responses and stream chemistry for unmonitored watersheds are similar to the selected nearby pilot watersheds.

Results

Tributary Sampling

Detailed accounts of the MOE lab results are provided in Appendix 1. Observations for both wet weather and dry weather were used to estimate loads following procedures for the NWRI modified Beale Ratio method. Load estimates using this procedure most closely match procedures preferred by the International Joint Commission (IJC) for Great Lakes Tributary Load estimation. As discussed previously, “ratio load” estimation procedures require frequent sampling of the watersheds, and as a result, routine monitoring by CAs as part of the PWQMN is not adequate for load estimations. The NWRI method provides both annual and monthly estimates of pollutant loads and has the added advantage of statically quantifying variation in the load estimates. Tables 1 and 2 illustrate annual and monthly loads for the seven watersheds, as determined by the ratio method.

It is widely recognized that Suspended Solids, Total Phosphorus, Filtered Reactive Phosphorus and Nitrate and Nitrite Nitrogen (NOx) have utility in understanding watershed water quality responses to precipitation events. While Ontario Drinking Water Standards do not exist for these parameters, they are considered to be reasonable surrogates of water quality constituents that are of direct interest in terms drinking water health consideration. They are the key parameters for understanding watershed influences on water quality and ecology of nearshore water areas of Lake Ontario.

Event Mean Concentrations (EMCS)

Accurate estimation of pollutant loads to the Great lakes usually requires both concentration and discharge data. Typically these data are seldom collected at the same location and or at frequent enough interval to support loading computations using ratio estimators such as the Beale Ratio method. Alternative methods have been developed by the US EPA (NURP 1983), that provide a reliable basis for characterizing annual or seasonal mass based upon Event Mean Concentrations (EMC) determined from flow weighted composite sampling of events and daily flows. The NURP study determined that EMCs and runoff volumes are independent. NURP loadings technique works well for highly variable streamflow and chemistry data, and allows for meaningful comparisons of results from different sites and (climatic) events. While it is possible, with varying degrees of precision to pro-rate flows, it has not been proven practical to estimate concentration data from periodic “grab” sampling of neighbouring watersheds or upstream locations within watersheds.

Typically the determination of “wet” versus “dry” conditions is done by examining the hydrograph from the nearest flow sampling location, and comparing with accompanied daily precipitation and air temperature data. Using these inputs, loads for “wet weather” periods when the watershed is influenced by melting snow or precipitation response can be determined. The remaining periods as classified as being “dry weather” response, at which time overland runoff is less influential on water quality.

Our grab samples collected between the runoff events were deemed to be inadequate to fully characterize dry weather conditions. The last 5 years of data collected by the Provincial Water Quality Monitoring Network were used to determine dry weather EMCs for the watersheds. In the case of the Carruthers Creek, this watershed-was only recently added to the program, so we used a smaller subset of samples to estimate dry weather EMC. It is recognized that water samples collected under the PWQMN monitoring program typically reflect periods when the watersheds are not generally under the influence of rainfall. In our pilot watersheds, dry weather driven stream conditions occur about 70% of the time.

Event Mean Concentrations (EMC) values were prepared for TP, FRP, NOx and TSS for each watershed during wet weather. EMC values are influenced by both the number and size of events sampled each year. In 2009 field crews were able collect samples for a longer period of time. They attempted to sample, when possible spring runoff conditions. Differences in EMCs are reported in figures 4 to 6. Filtered reactive and total phosphorus concentrations are noticeably higher in the Twenty Mile Creek. This is somewhat surprising given the low suspended solids values for that watershed. It is assumed that this may be in response to intensive farming practices in this watershed and presumably higher application rates of fertilizer. In the other watersheds, SS and TP values are more in keeping with relationships associated with nutrients bound to soil particles. Differences in SS concentrations between sampling years are most apparent in Cobourg and Ganaraska watersheds. Higher observed SS in Duffins and Sixteen Mile Creek are of interest and may be influenced by stream channel erosion process during higher runoff periods.

The EMC loadings method was developed by the EPA as part of the Nationwide Urban Runoff Program and as a means of addressing variability in urban loads imparted through differences in rainfall intensity and occurrence and geographic features that impact runoff quantity and quality. EMC is defined as the event total constituent mass discharge divided by the event total runoff volume. The mass discharge may be quantified using a flow-weighted composite sample. It is recognized that considerable variation in wet weather concentrations was observed even within years. In part this may be an artifact of the sampling effort. Field crews were diligent in the collection of as many event samples as possible. However water quality sampling efforts were a function of stream responses, equipment malfunctions and the logistics of arranging program funding. Additional efforts are now underway to quantify confidence levels in EMC load estimates for the pilot watersheds and to ascertain the statistical influence of a few large events on the EMC estimates.

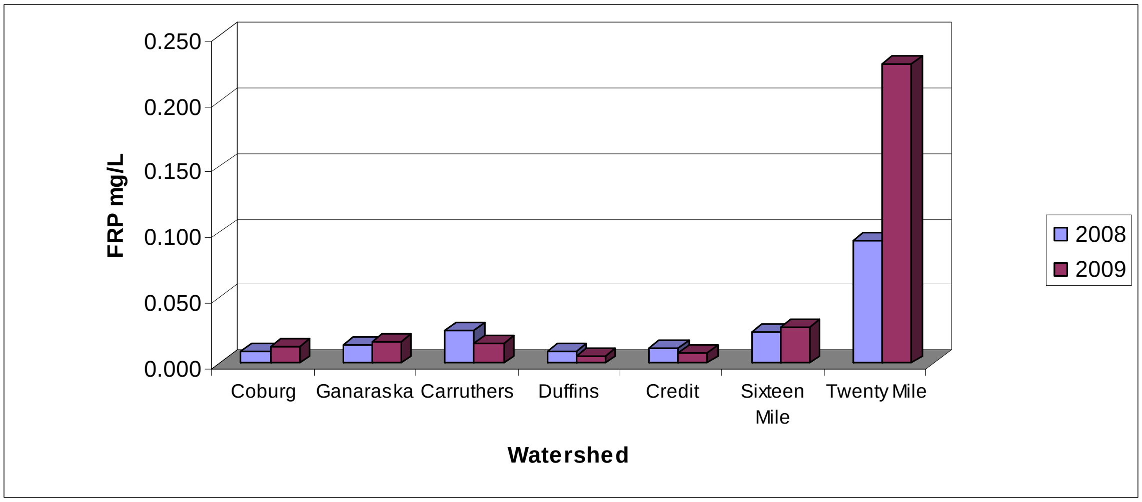

Figure 4 EMC for Filtered Reactive Phosphorus in Volume Weighted Samples

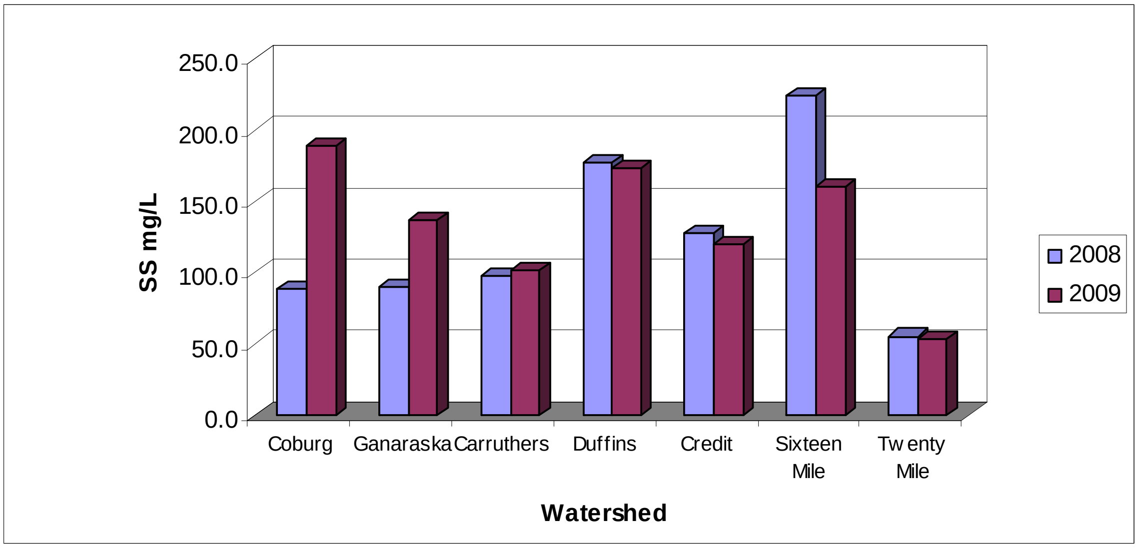

Figure 5 EMC Total Suspended Solids in Volume Weighted Samples

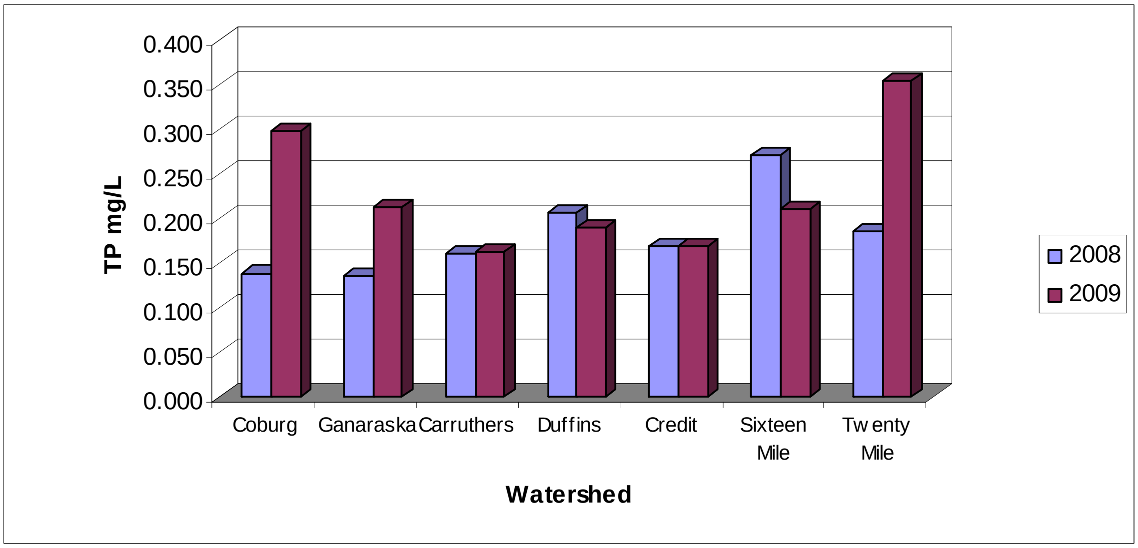

Figure 6 EMC for Total Phosphorus Volume Weighted Samples

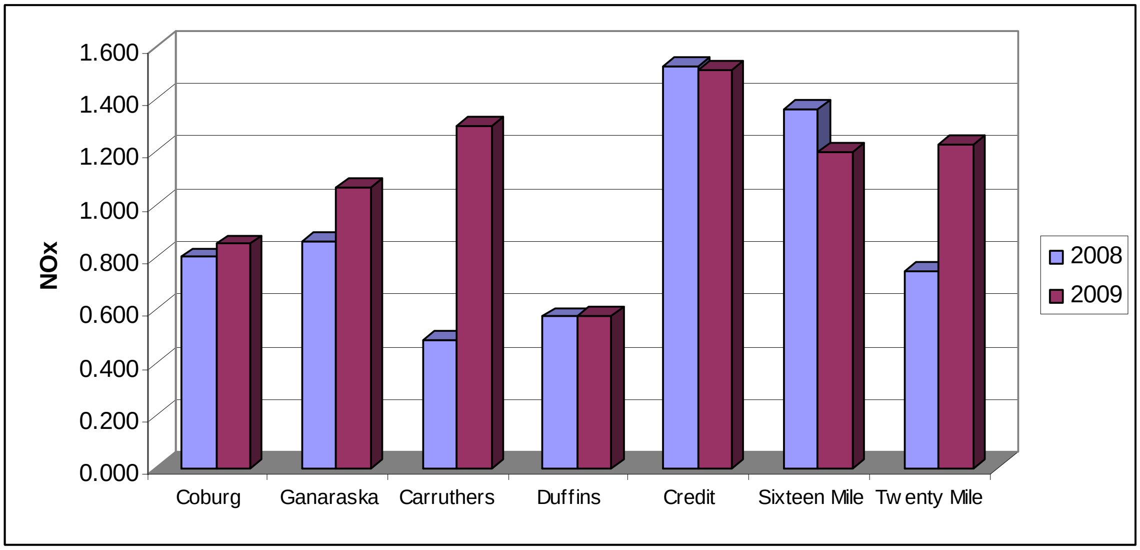

Figure 7 EMC for NOx Volume Weighted Samples

Climatic and Streamflow Patterns

Annual runoff volumes (dam3.yr) in the 7 pilot watersheds are presented in Figure 7. Streamflow measurements taken close to the water quality monitoring stations near the outlet to Lake Ontario were available for 5 of the 7 watersheds. For the Credit River and Sixteen Mile Creek, we prorated flows using data from upstream gauge locations in these watersheds. Observed differences in annual runoff volumes in Figure 4, is a function of watershed area and patterns in precipitation. Runoff volumes are a function of the watershed drainage areas, with the largest volumes being discharged from the Credit River. Nearshore areas of Lake Ontario in proximity of the larger watersheds should exhibit the most tributary "influence".

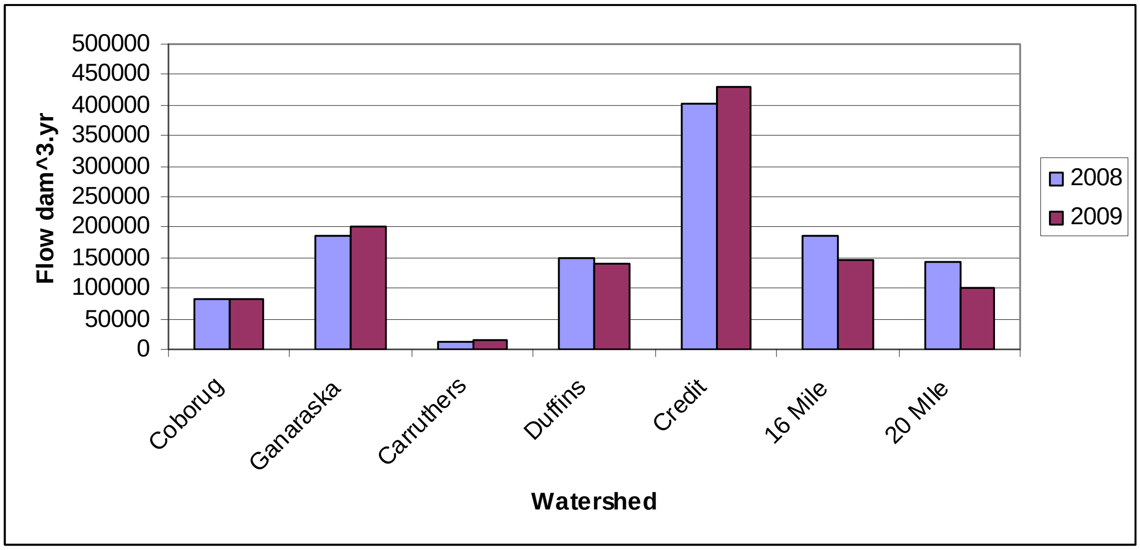

Figure 8 2008 and 2009 Annual Runoff

Monthly and annual trends in total precipitation are depicted in figures 9 and 10. Of note, is the variation observed in local climate patterns across the western basin of Lake Ontario. These differences can be as great, as variations observed between the months. In the Hamilton area in both 2008 and 2009, significantly more rainfall occurred during the summer than in the Toronto and Cobourg areas. Months of the year, with higher precipitation volumes manifest into higher pollutant loads to the lake. Of note, is the 2008 winter precipitation totals which resulted in a sizeable snow pack that melted in the spring. The summer of 2008, saw rainfall amounts that caused localized road flooding and some incidents of basement flooding. Lower amounts of precipitation during the winter of 2009 in Cobourg and Toronto were offset by higher amounts in April. Summer months in 2009 were noticeably wetter in the Hamilton area in 2009. However, annual precipitation volumes were very similar in all three watersheds in the two years. This observation is an important sourcewater consideration, for Lake Ontario. The “water quality” focus for pollutant loads to the nearshore, needs to be on higher precipitation periods– as conditions tend to average out over the course of a year.

Suspended Solid Loads

Taking into consideration reduced evapotranspiration – higher precipitation values over winter and spring will generate proportionally more runoff and most likely higher SS loads.

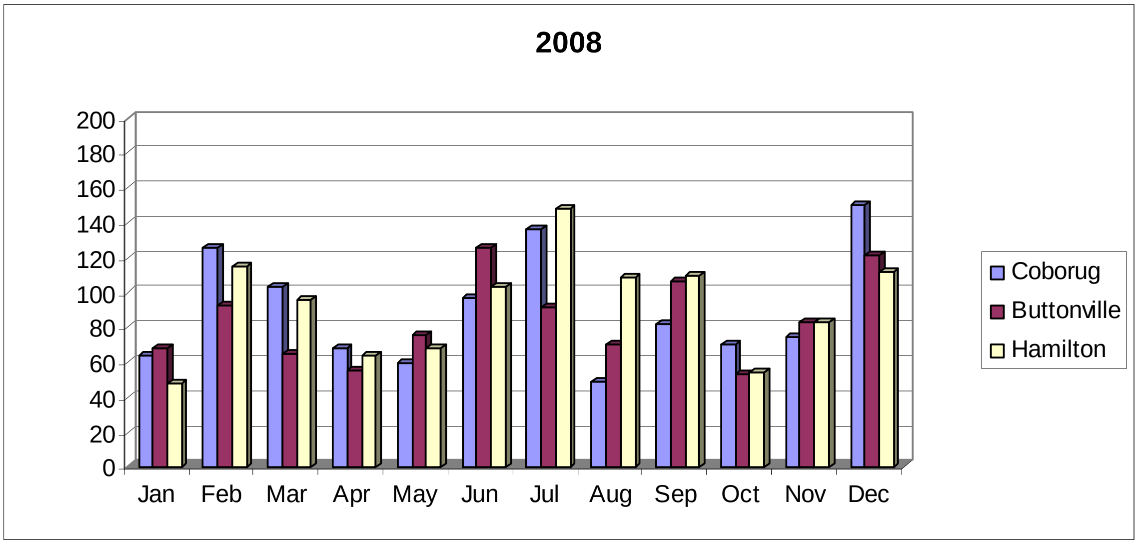

Figure 9 2008 Monthly Precipitation Canadian Shoreline of Lake Ontario

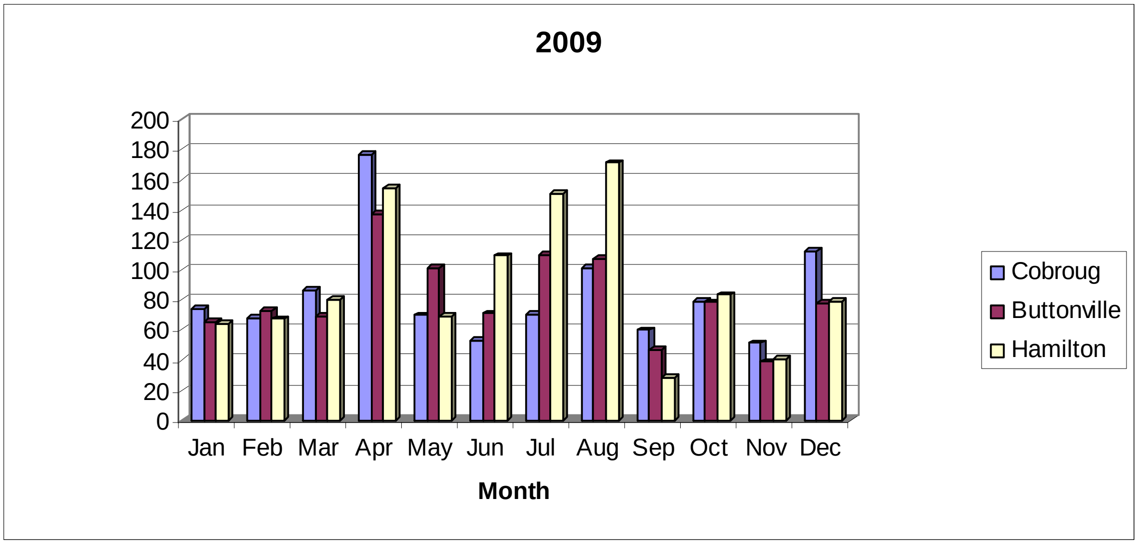

Figure 10 **2009 Monthly Precipitation Canadian Portion of Lake Ontario**

Volumes weighted and grab sampling undertaken in 2008 and 2009, during snowmelt and runoff events allowed the study team to develop fairly reliable estimates of pollutants loads to Lake Ontario. Alternative load estimation methods such as the EMC approach or watershed models will be required to track changes in pollutant loads on a year to year basis. As long as the landuse remains relatively unchanged, our assumption is that reasonable loads estimates can be achieved in the future using EMC values and appropriate streamflow discharge measurements.

Snowmelt is a dominant factor in terms of non point source loadings to the lake. Extreme events play an important function each year. The majority of the Suspended Solids (SS) loads are delivered by a small number of events. This trend was also observed during the Pollution from Land Use Activities Reference Group (PLUARG) study (Final PLUARG Report to IJC, 1978). These periods of higher loads, typically occur in the spring during snowmelt and in the late fall. Consequently, runoff events occurring during these periods of the year must be captured by water quality monitoring programs in order to be able to accurately calculate loads. Figure 11 presents the annual suspended solids loads for 2008 and 2009, for the seven watersheds**.**

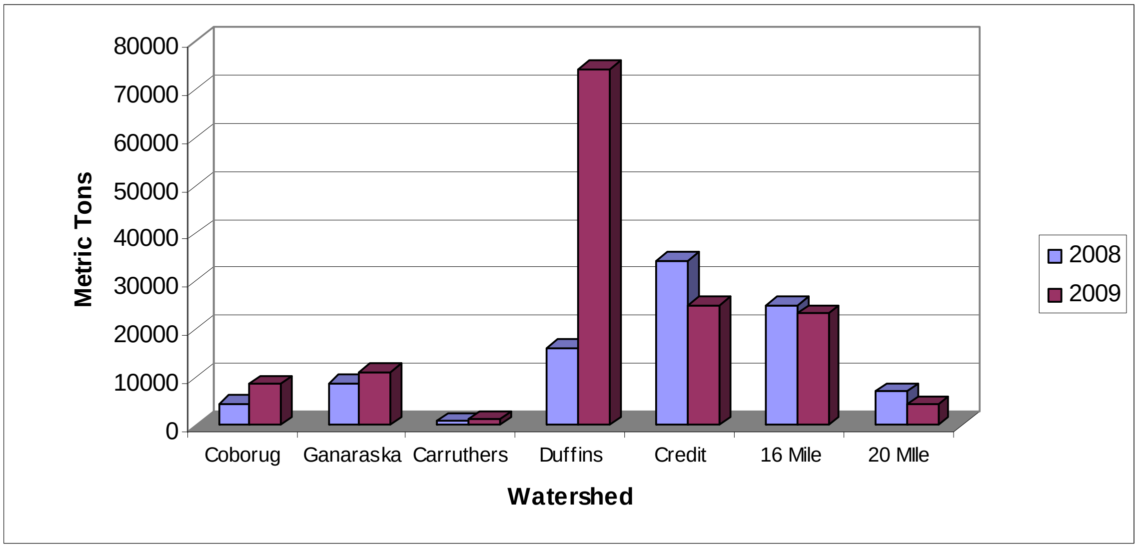

Figure 11 Total Suspended Solids by Watershed

In general the mass of non point source pollutants being transported to the lake, increases with watershed drainage areas. In the case of suspended solids, higher loads appear to be being generated in the urbanizing watersheds. Of interest is the markedly higher load for Duffins Creek in 2009, which is attributed the melt of a substantive snow pack and a few unusually large precipitation events (Figure 10). Figure 12 illustrates suspended solid loads normalized by watershed drainage areas. Further investigations are needed to understand the disparate difference observed in the 2009 for Duffins Creek. Monthly loads for Duffins Creek show large amounts of particulate material being transported in February, March and April 2009 (Figure 13). In 2008, the largest mass was transported during the month of April, but in terms of the total mass of suspended solids transported, it was still appreciably less than mobilized in 2009. As evident in Figure 8, total stream runoff volumes were fairly similar in all watersheds in 2008 and 2009. From a watershed loadings perspective, the key difference is how this streamflow runoff is distributed throughout the year.

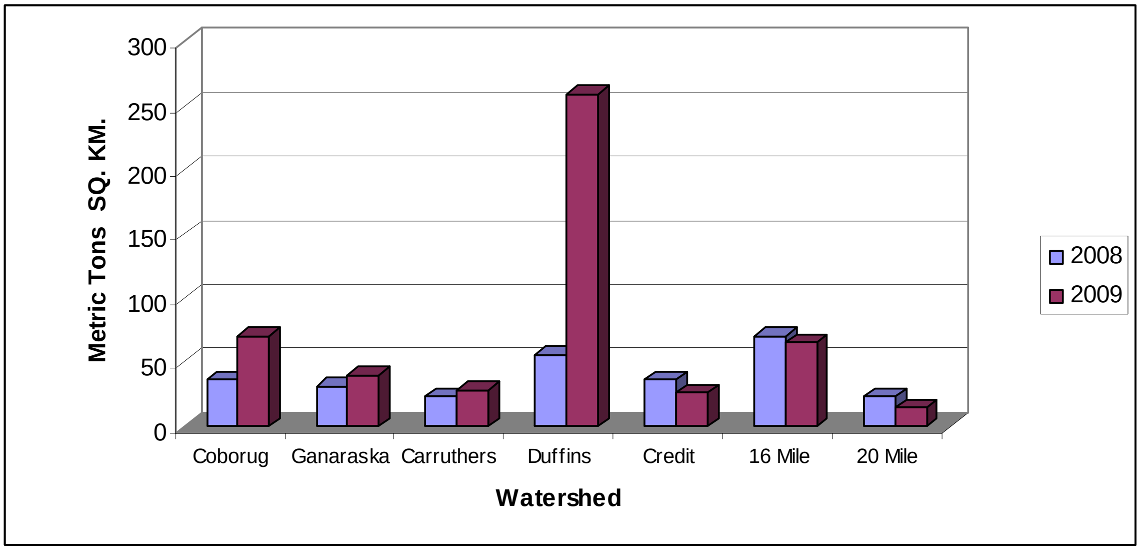

Figure 12 Unit Area Suspended Solid Loads

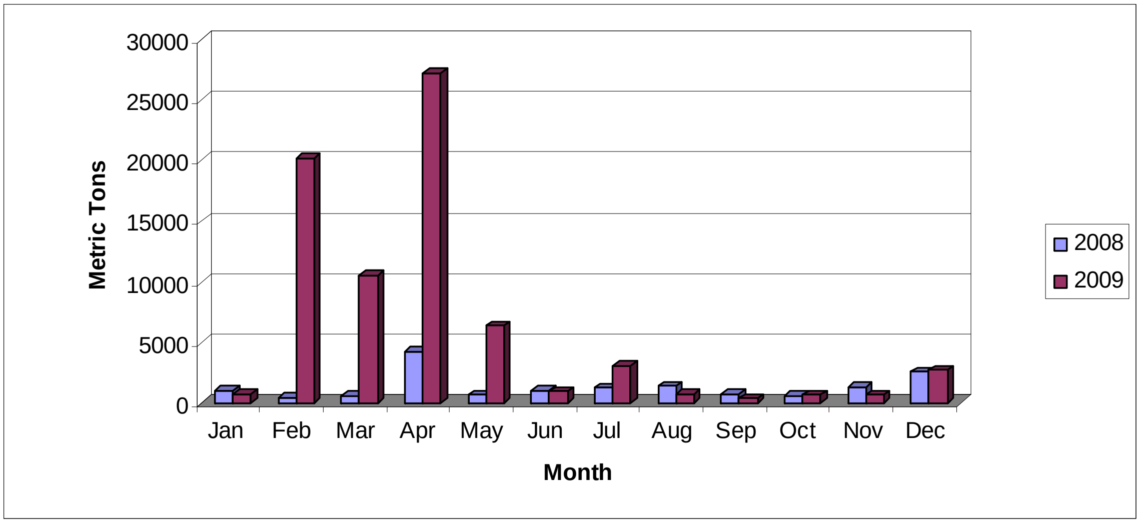

Figure 13 Duffins Creek Suspended Solids by Month

Figure 14 depicts suspended solids transport in Duffins Creek on a daily basis for 2008 and 2009. It should be noted that this figure is plotted on a log scale. To illustrate the streamflow component of the load estimates, daily stream flows for the two years of study in Duffins Creek are presented in Figure 15. In terms of maximum loads to the lake, three to four runoff events a year stand out. These events are frequently associated with snowmelt of or runoff over frozen ground. However, large loading events can occur at anytime throughout the year!

During these runoff major events, significant amounts of sediment are transported from table lands. Extreme flood conditions erode stream banks and transport stream sediments which were deposited in the watercourse, during lower streamflow periods. Figure 16 summarizes differences in SS loads estimates attributed to the method employed to develop the estimates. The EMC method appears more sensitive to daily fluctuations in transport - likely because the monthly totals are summed from daily estimates.

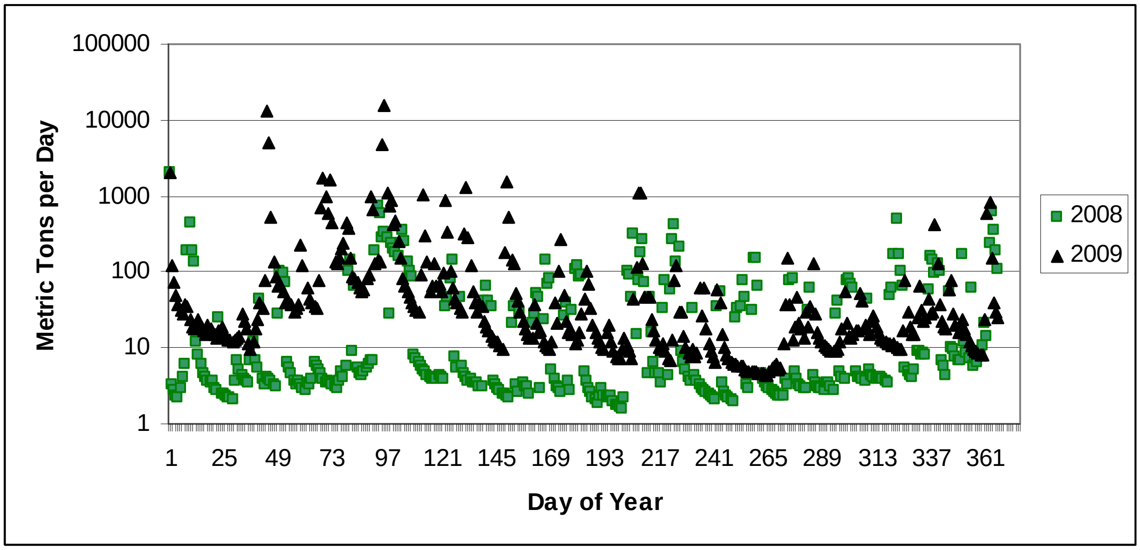

Figure 14 Daily Suspended Solids Duffins Creek

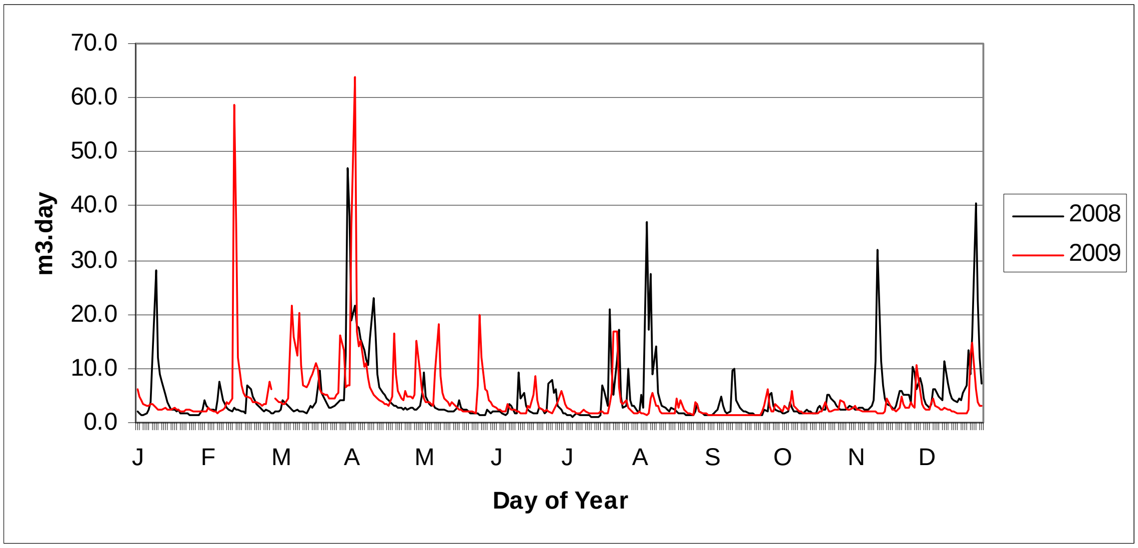

Figure 15 Daily Stream Flow Duffins Creek

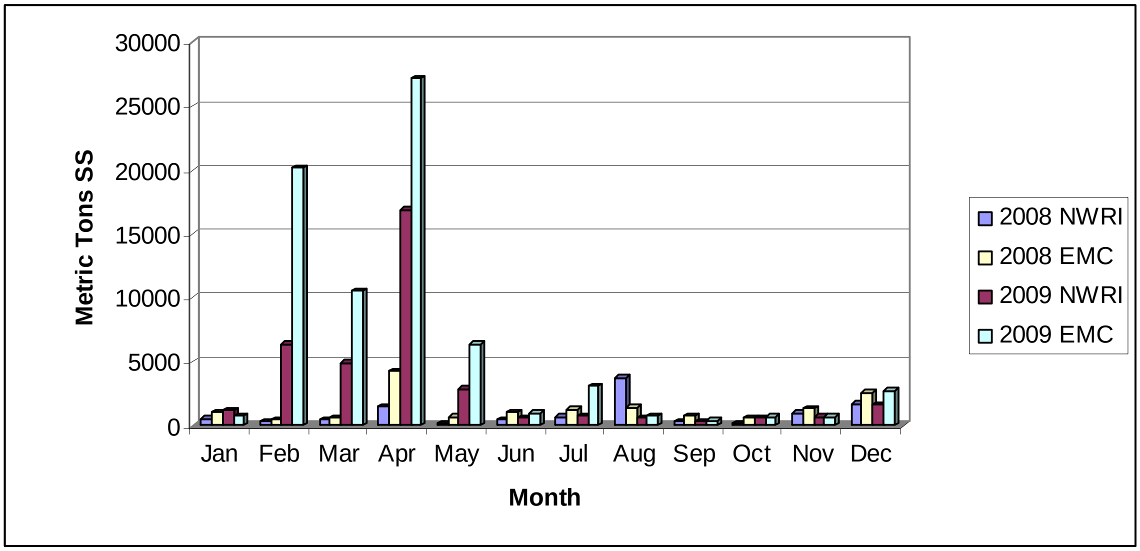

Figure 16 Loading Method Comparisons for Suspended Solids

Appendix 2 provides additional plots illustrating temporal patterns in SS loads to Lake Ontario from the seven pilot watersheds. From a Lake Ontario nearshore drinking water source perspective, the key aspects to focus on, when looking at these plots are the critical periods (days) when the higher loads to the lake take place and "seasonal" year to year differences, as evident by monthly loads. Significant loads to the lake would only be detected at intakes when "in lake" mixing and circulation processes draw the tributary waters towards and downwards to the intakes. This is best understood through the use of hydrodynamic lake models, employed in IPZ studies and interviews with plant operators.

Nutrient Loads

Since the 1970s, levels of total phosphorus in Lake Ontario have generally been declining in response to actions taken to reduce point source and non-point sources of nutrients (Williams et al., 1998; Dove, 2009). Despite reported improvements in total phosphorus levels, in the open lake, there have been increasing reports of problems with poor water quality conditions in the nearshore areas of Lake Ontario (Auer et al., 2010; Higgins et al., 2005, 2008) including algal blooms and *Cladophora*. From a drinking water "treatment perspective", excess algal growth in the Great Lakes have been linked to increased turbidity, filter-clogging, and to taste and odor problems. Around the Great Lakes researchers are attempting to determine, the extent, to which these issues can be attributed to increase in nutrient levels. The nearshore shunt (Hecky et al., 2004) has been postulated as a mechanism for the nearshore water quality problems.

In 2008, a binational study (Makarewicz and Howell, 2011) was undertaken to examine the nearshore zone of Lake Ontario. Comparable studies were designed the Canadian and United States portions of the lake to understand what changes are taking place both physically and biologically. A key question was whether the "nearshore issues" were due to problems with levels of nutrients in the whole lake or if these were due to direct sources from tributaries and waste water plants along the shoreline. Additional insights into nearshore responses to nutrient additions are anticipated, as the findings from the 2008 binational study of Lake Ontario are published and debated.

As expected, spatial and temporal patterns of total phosphorus loads for the seven watersheds followed closely the trends discussed previously for SS. In general, annual and monthly loads of TP are a function of watershed drainage areas (Figures 17 and 18). However, in 2009 significantly higher levels of TP were reported for 20 Mile Creek. Daily loads for TP, NOX and FRP are provided in Appendix 3 and are of considerable interest to researchers modelling the nearshore areas and the growth of *Cladophora* along the waterfront (add references). Dissolved nutrients (FRP and NOx) follow similar seasonal patterns to TP loads- in part due to the "flow" component of the load estimate (Figures 19 to 22). However, differences in EMCs for FRP values are observed in certain watersheds, presumably due to land use differences or agricultural practices such as the application of fertilizers. Monthly, filtered reactive phosphorus (FRP) loads presented in figures 19 and 20- show some remarkably high values for Twenty Mile Creek, this was unexpected given the low reported SS EMC values and it's much smaller watershed drainage area (Figure 2). Substantially higher NOx loads are reported for the Credit River (Figures 21 and 22) and may attributed to urbanization of this watershed.

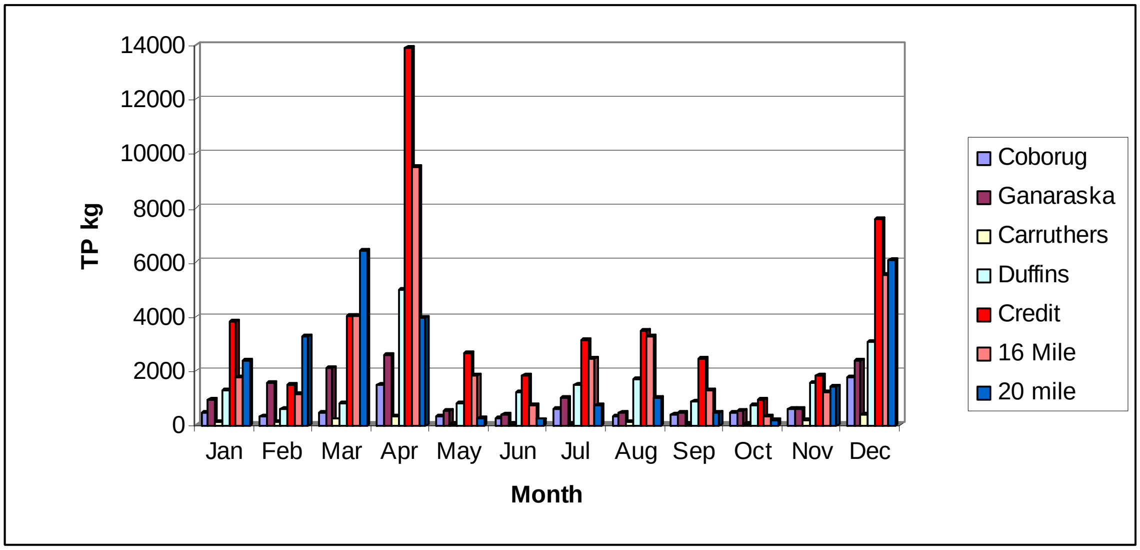

Figure 17 2008 Monthly TP Load by Watershed

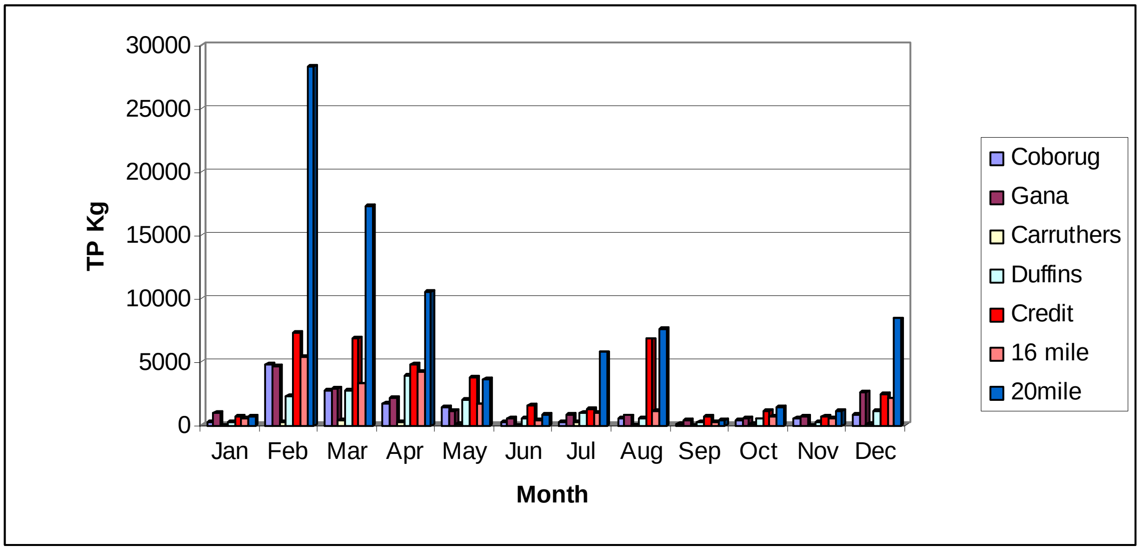

Figure 18 2009 Monthly TP Load by Watershed

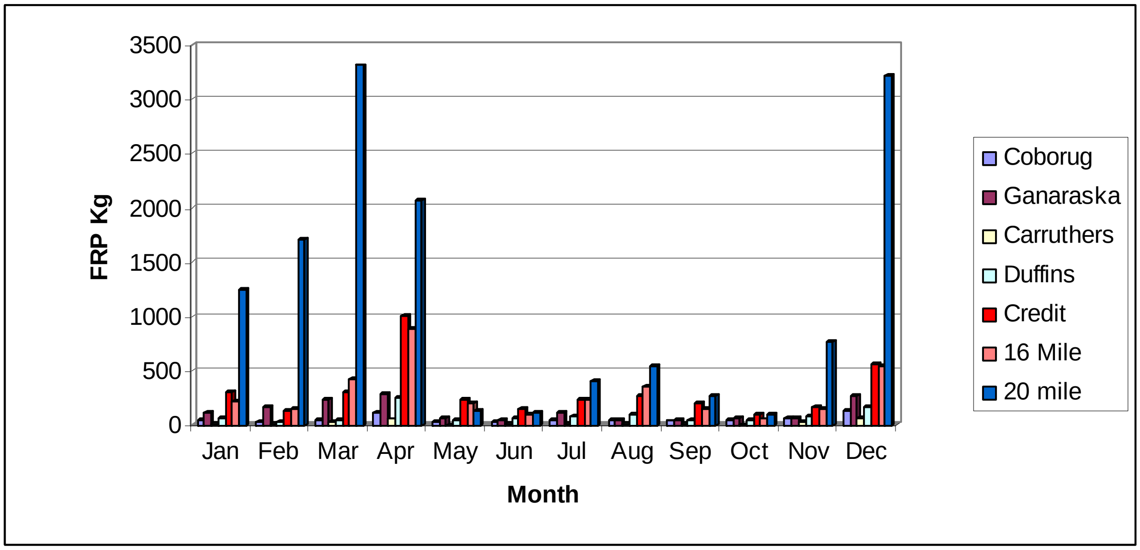

Figure 19 2008 Monthly FRP Loads by Watershed.

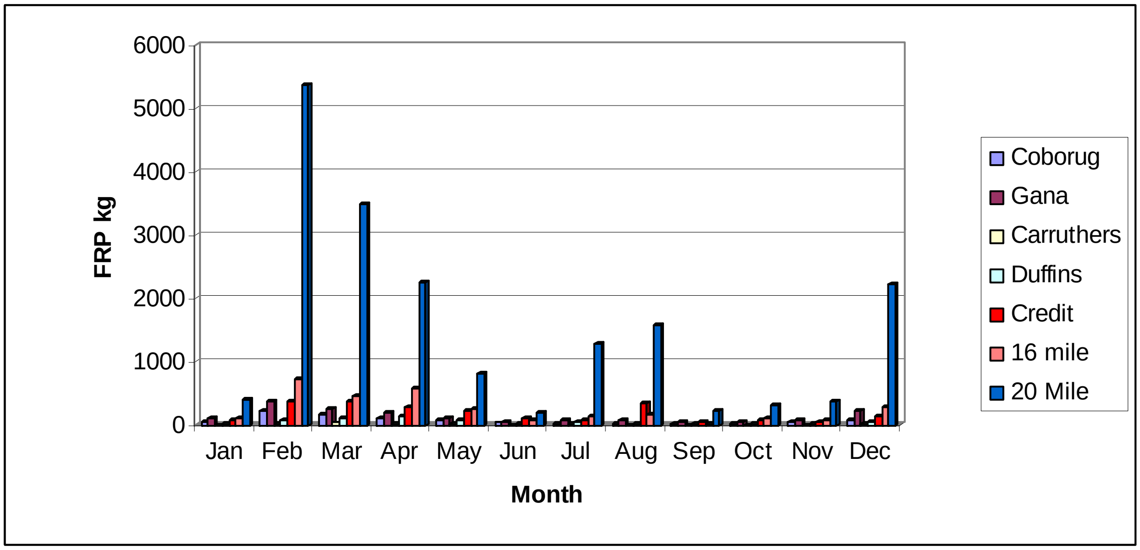

Figure 20 2009 Monthly FRP Load by watershed

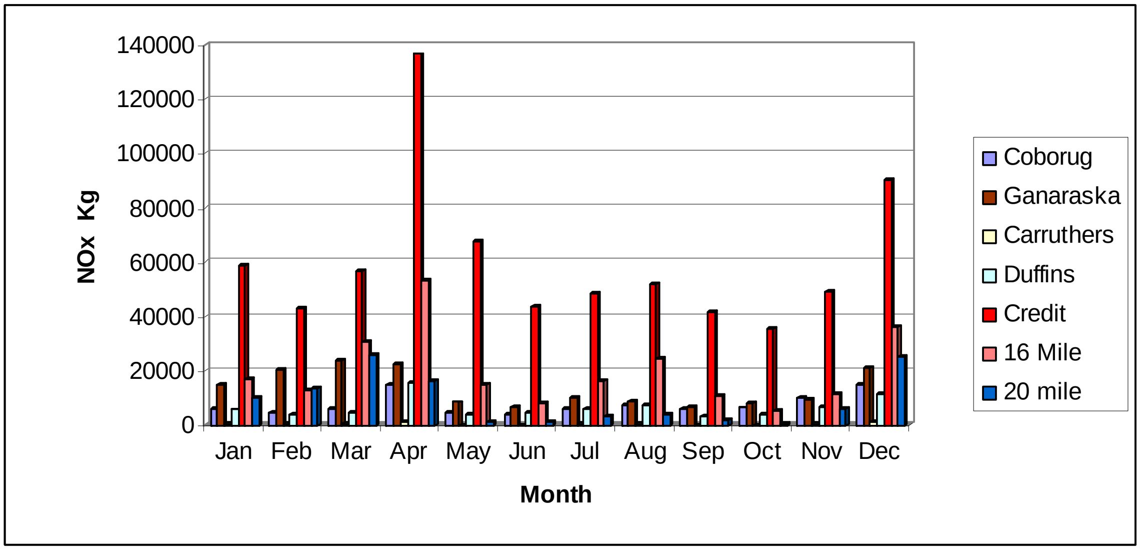

Figure 21 2008 NOx Loads by Watershed

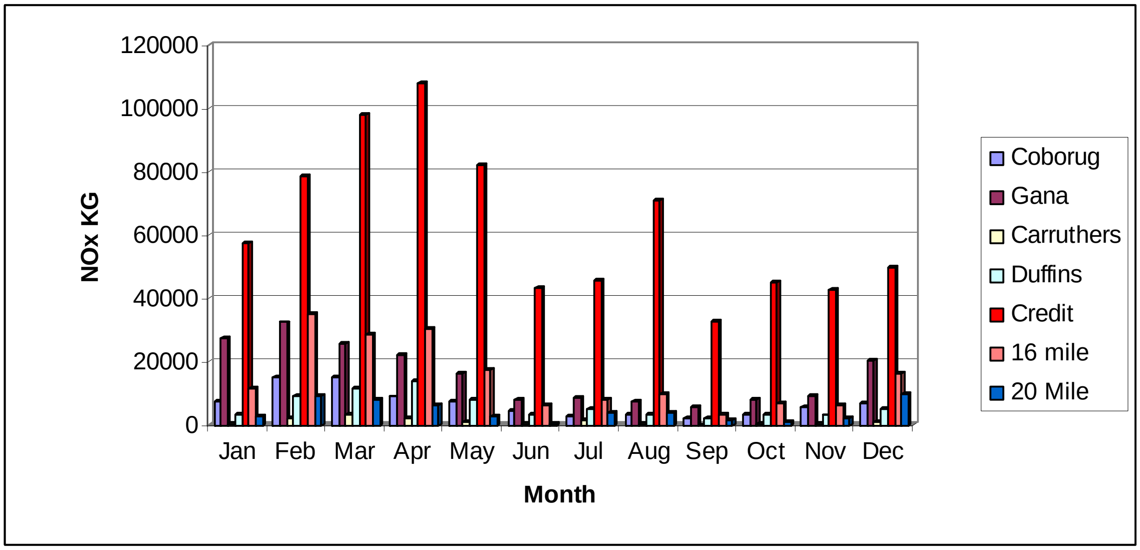

Figure 22 2009 NOx Load by watershed

Prorated Loading of Pilot Watersheds Estimates for Western Lake Ontario

One of the main objectives of this project was to develop load estimate procedures which could be extended to develop estimates of tributary loads for the Canadian portion of lake. Results for the seven pilot watersheds were prorated on an area basis for suspended solids and nutrients. Figure 23 provides an example of this work- which suggests under normal conditions, that the bulk of the tributary load originates from about five watersheds on the Canadian side. With exception of the Welland Canal, these tributaries are all located in the Greater Toronto Area (GTA). This observation is attributed not only to land use (urban intensification) in the GTA, but also to the relatively small size of these remaining watersheds around the lake.

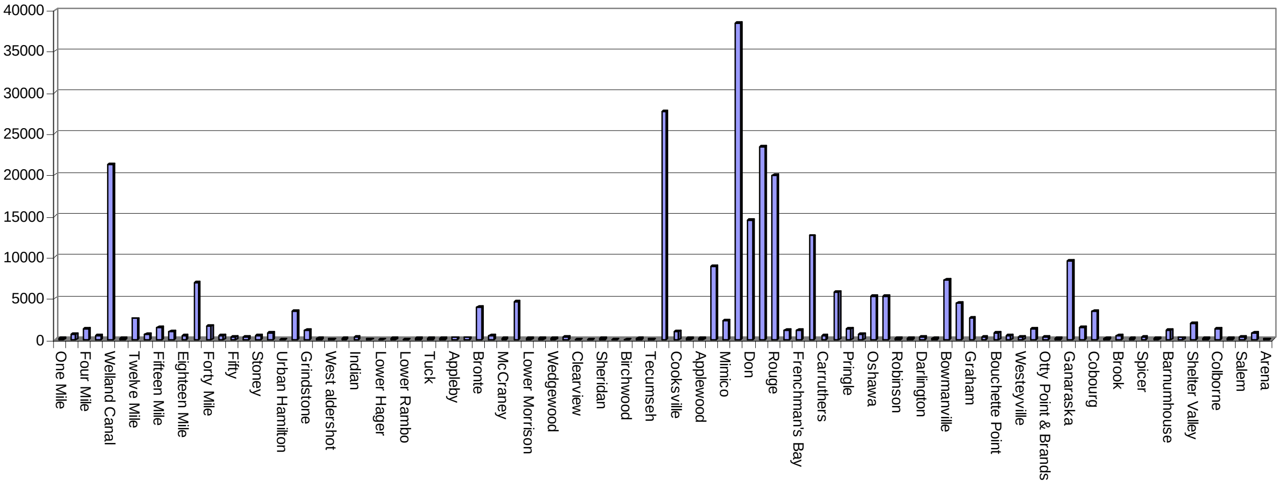

Figure 23 Suspended solid estimates for Canadian Portion of Western Lake Ontario

Method Comparison for Load Estimates to Canadian Lake Ontario Tributaries

Booty et. al. 2011 discussed the implications of loadings calculation methods on estimates of nutrient and sediment loads for Canadian Lake Ontario Tributaries. Several techniques were evaluated for measuring and estimating loading from tributaries with a paucity of data. In on-going monitoring programs conducted by CAs in partnership with the MOE's PWQMN and even within our own "event" surveys in 2008 and 2009, there were often prolonged spring and winter periods without any water quality observations. This gap is adding a higher uncertainty to the total load estimate. In addition to EMC method discussed in this report, a hybrid approach to the NWRI and Beale loading estimate methods was developed for situations with a limited number of event and dry weather water quality samples. In general, Booty et. al. 2009 indicated that the coefficient export method in the Phase 1 load study (unit area) generated higher loads for TP, TSS and NOx than those generated by the EMC method presented here. The hybrid NWRI loading estimate method would provide better results when chemistry data was missing for a period of time. Missing just one or two large flow events such as those during spring melt can seriously underestimate annual loads. For example, TP loads for Duffins Creek for 2009 would be underestimated by 18.1 MT or 55.2 percent if just one spring melt event was missed.

Given the tributary monitoring programs that are currently in place, the use of EMC methods for tracking trends in pollutant loads to Lake Ontario has considerable merit going forward. To provide a sense of the variability in load estimates by the different methods; annual SS and TP loads for 2009 are shown in Figures 23 and 24, for the seven monitored watersheds. Spatial and temporal trends in the loads are similar in all methods, due to the overwhelming influence of the streamflow component on the load estimate. The key difference is the influence of the method on the magnitude of the load estimate. Comparable results were achieved with the Hybrid NWRI and EMC methods. The Beale Ratio and NWRI Method load provide noticeably higher loads but this might be an artifact of the wet weather monitoring data. Both of the "ratio" methods require samples collected across a representative range of runoff events. Since our monitoring programs was designed to characterize wet weather chemistry (for purpose of estimating EMCs) – the employment of our data in either of the two ratio methods, would result in biases the load estimate, given the under representation of dry samples.

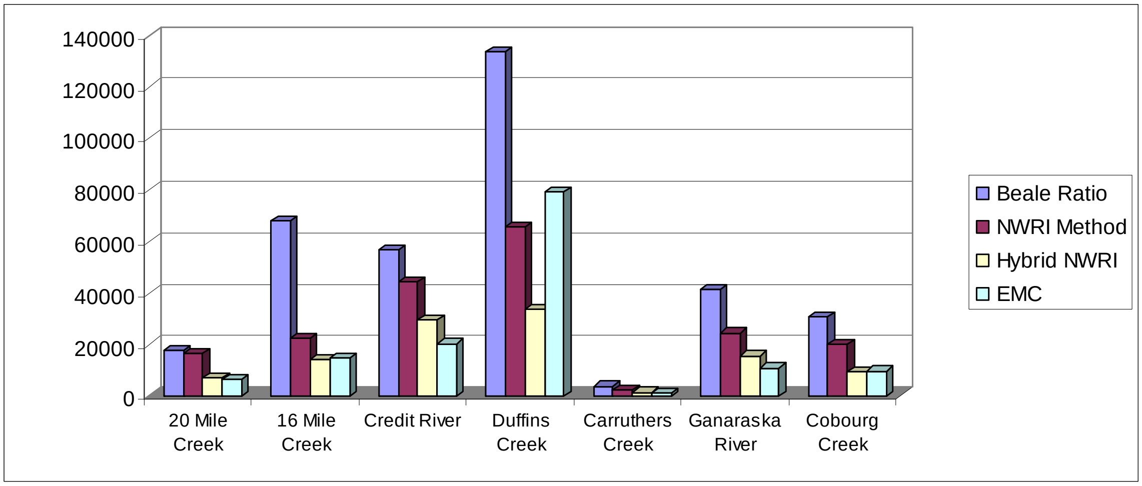

Figure 24 2009 Suspend Load by Estaimation Method

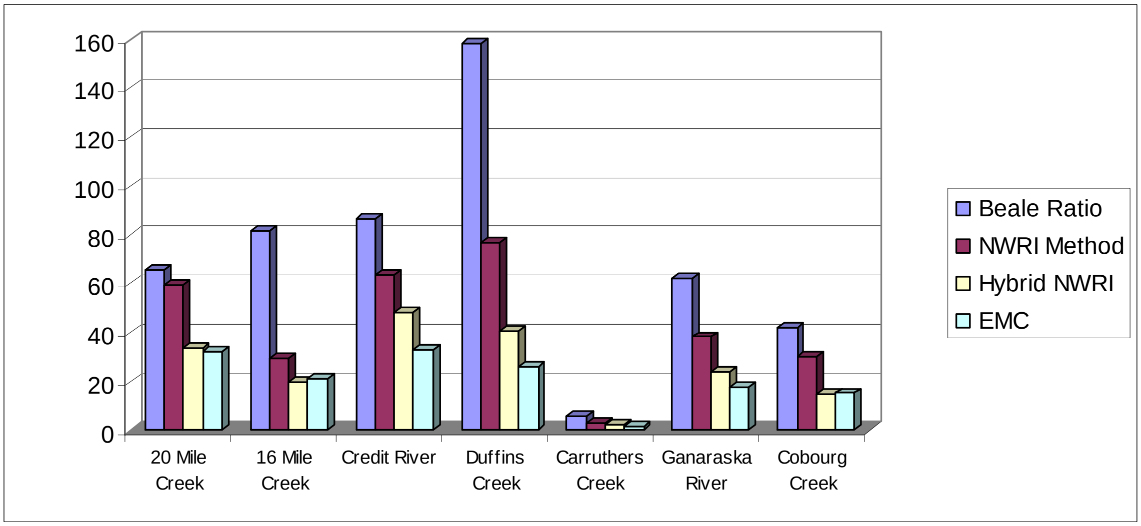

Figure 25 2009 TP Load by Estimation Method

Discussion and Conclusions

This study provides insights into potential delivery mechanism of nutrients and suspended solids from southern Ontario watersheds to the nearshore areas of Lake Ontario. Watershed runoff events that could pose the most concern from a nearshore "contaminant" perspective, are rather infrequent in occurrence, but of considerable magnitude, in terms of the amount of material being transported. Of note, is the observation that significant pollutant loads are typically outside of the range of (design storm) effectiveness of watershed, water quality BMPs. Most BMPs are designed to perform for small frequent storms 25mm over an hour period.

The key question is how the nearshore of Lake Ontario will assimilate watershed inputs and whether drinking intakes are in fact impacted by these report periods of elevated loads. In order for watershed contaminants to interfere with drinking water plant intakes, nearshore mixing would have to quickly transport these materials towards the intake, which have been purposefully located to avoid these occurrences, as much as possible. This question of when and how contaminants are transported to drinking water intakes place is being addressed by intake protection zone, water quality modelling studies undertaken by the CTC Source Protection Committee, Drinking Plant Operators and MOE scientists who were investigating the nearshore areas during the International Year of Study for Lake Ontario. In conclusion, interference with drinking water intakes- may require a series of perfect storms- meaning that runoff from large snowmelt and/or rainfall events, would in turn have to be followed by unique in lake process which that transport the pollutants to the intake with minimal dilution. Findings for the seven pilot watersheds are being extrapolated for the remaining watersheds around the Canadian portion of Lake Ontario. Next steps for this study, involve the preparation of more in-depth technical reports and articles for a special issue of the Journal of Great Lakes Research focusing on the outcomes of the 2008 International Year of Study for Lake Ontario.

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