Source Water Protection Draft Tier 1 Water Budget Peer Review Record – CLOSPA, January 2009

Comments received from:
1) Shan Mugalingam (c/o Magdi Wadaatalla) – GRCA [SM(GRCA)]
2) Beata Golas – Durham Region, Works [BG(DR)]
3) Scott Bates – MNR [SB(MNR)]
4) Chris Neville – S.S. Papadopulos and Associates [CN(SSPA)]
5) Robert Hester – OPG [RH(OPG)]
6) Bob Goodings – CTC SP Committee
7) Region of Durham (November 2008)
8) Rick Gerber (CTC) (November 2008)

Subject: Central Lake Ontario Conservation Authority
Review of Draft Tier 1 Water Budget Report for CLOSPA
Final Report dated January 2009

Peer Review Comments (External)	**Response to Comments**	**Revisions to Report**
Overview		
From Chris Neville. In our opinion, this is an excellent report that provides a solid framework for those charged with managing water-resources in the CLOCA area. The report provides a comprehensive summary of the current understanding of surface water and groundwater conditions across the entire CLOCA area. We anticipate that the report will serve as an important reference document for hydrologists working in the watershed. The report is a substantial document that contains a relatively large number of tables with important calculations and detailed figures. In our opinion, the analyses have been conducted to a high technical standard. In general, the text is clear and self-contained, and the most of the figures are well presented and include appropriate credits. However, there are areas in the analyses that were not clear to us, and we have highlighted some of our concerns in the following detailed comments. In many cases, we expect that our concerns reflect a lack of understanding on our part, rather than errors in the analyses. Our major objection is related to the interpretation of the Tier1 stress assessment methodology. In our opinion, the analyses are not consistent with the Guidance Documents and are potentially confusing. In our opinion, the conclusions drawn from the analyses are in general inappropriate. There is evidently a need for ongoing data collection; however, long-term water management issues rather than the stress assessments presented in this report should motivate this.	Thanks. We appreciate the positive feedback. We have reviewed the detailed comments and addressed them as best as possible to help clarify discussions of our methodology. These are very strong comments. Without details to indicate what aspects of the analyses were felt to be inconsistent, confusing, and inappropriate, we have attempted to address the specific comments to hopefully clarify. In addition, we have made the key changes requested by the peer review team. In general, we believe that we may have originally interpreted the concept of a "Guidance Module" a little too loosely and felt that we had some freedom to compare alternative methods and advance some new approaches where we felt the suggested methods lacked scientific rigor. In the interest of provincial consistency, however, we have revised our analyses to adhere more strictly to methods outlined. Hopefully, that will	Revisions were made to address the specific comments as well as to address the key issues (e.g. Q_{NET} vs. Q_{IN}, median vs. average flows, and Q_{P90} vs. Tessman). More details provided below. Text corrected or

	clear up any confusion. After careful review of the technical comments below, we have noted that most of the other problems (aside from the key issues identified) resulted from typos, mislabeled graphs, transposed numbers, and some unclear sentences. We have revised these as best as possible.	revised as needed.
General Comments:		
BG(DR) *Guidance Module* We believe that that Central Lake Ontario Conservation Authority (CLOCA) and their consultant, Earthfx should follow the Guidance Module recommendation that Total Groundwater Supply **(Q_{SUPPLY})** equals the sum of groundwater recharge (**$Q_{RECHARGE}$**) and lateral groundwater inflow **(Q_{IN})** Using Total Groundwater represented as **Q_{NET}** does not take into consideration groundwater storage, which is the main source of groundwater for existing wells during the summer months The **Q_{NET}** approach resulted in exaggerated impacts indicating that almost all watersheds in CLOCA are stressed.	We still feel that Qnet is a more accurate measure of the total lateral inflow into the catchment. That we subdivided the flows into the positive and negative components spatially and summed them up separately to provide an estimate of the actual lateral inflows and outflows (rather than the net lateral inflow) was only possible because we used a more complex model for the area. It is unlikely that the Guidance Module had conceived of separating the two terms and it is even less likely that there was an intention to account for groundwater storage by ignoring lateral outflow. However, in the interest of provincial consistency, we have revised our stress analysis to account for lateral inflows only.	Analyses revised. Text revised.
BG(DR) *Consistency* Durham is included in three Source Water Protection (SWP) Regions and five SWP Areas and we require all SWP Areas within our Region to use a consistent and reasonable approach to estimating stresses on watersheds.	Same as above	Analyses revised. Text revised.
BG(DR) *Stresses* The study identified significant stresses in several watersheds in CLOCA jurisdiction, including Darlington Watershed. We have concerns with this conclusion because, based on our knowledge of this watershed, there are no large groundwater takers (no Permit To Take Water) and this area remains essentially undeveloped. By showing significant stresses in the Darlington Watershed, we are lead to question the stresses calculated in other watersheds, including Lynde. We offer that reduced flow in creeks may be related to other variables in the water budget equation including changes in temperature over the last 30 years (i.e. OSHAWA WPCP Meteorological Station). Part of the problem may be with linking the <u>transient</u> hydrologic PRMS model with the <u>steady-state</u> hydrogeologic model?	Analyses now show that Lynde and Darlington are only moderately stressed on an annual average GW demand basis and no watersheds are stressed on a monthly GW demand basis. In the revised surface water analysis, Bowmanville dropped from high to low while Lynde went from low to high. It should noted, nonetheless, that there is a groundwater taking in the Darlington watershed as listed in the PTTW table. In a small watershed like Darlington with naturally low levels of recharge, the reported moderate level of stress is reasonable. Lynde watershed, however, has several SW and GW takings and appears to be losing water to watersheds in the west as reflected in lower baseflow than the other watersheds with headwaters on the ORM. Observations regarding summer spot flows in some sub-watersheds like Kinsale seem to confirm the stress assessment. We looked at monthly and annual precipitation and flow data and found some conflicting trends. Further investigation, well beyond the scope of the current project, would be needed to confirm past trends and analyze future impact of climate change on the water budget.	Analyses revised. Text revised.
BG(DR) *Consumption (PTTW)* We suggest using average water consumption to calculate stresses on the watersheds. Since MOE is collecting average water consumption from all water takers in the Province from January 2007, this data	 Demand was estimated using the guidance module recommended rate of 335 L/d/person. MNR has requested that this be used for a Tier 1	No change needed

should be available to SWP Regions to conduct the analysis based on real information. Based on Durham Water Consumption Data (water billing) the consumption per capita is 750 L/day (or 180 to 230 L/day/person). Typically, residents on wells consume less water than residents serviced by a municipal water supply; therefore, the amount of water used by rural residents i.e. 335 L/person appears to be high. CLOCA used a 55% increase in population for the next 25 years. This number appears to be high. Growth in Durham will occur mostly in serviced areas, not in rural areas. Since Durham is presently working on the *Growth Plan* it is premature to estimate growth at the present time. The area included in the Green Belt and Oak Ridges Moraine (ORM) should be excluded from the rural areas growth estimation because we predict that very little growth will occur in these areas. Please remove Table 25 and Figure 54. All Durham's Water Pollution Control Plants (WPCP) within CLOCA discharge to Lake Ontario; with the exception of Pringle Creek WPCP, which will be decommissioned by 2012. A Table summarizing the total Q_{SUPPLY} *(m^3/day)* and total consumption *(m^3/day)* and percentile per watershed would be very useful for comparison basis.	assessment. According to CLOCA, actual taking (PTTW) data are not yet available from the province to SWP Regions. Additionally, the provincial guidance indicates that Tier1 analyses should use permitted rates to be conservative Note that this rate is reduced by 80% through the consumptive use correction (most rural water pumped is returned through the septic system.) However, an 80% return rate is likely high, because many of the wells are actually moving the water from the deep to shallow aquifer system. Reserves for all plants except Pringle Creek were removed	
BG(DR) <u>*Figures*</u> Figures should be presented on 11x17 sheets within the Report. Ideally, watersheds identified as stressed should be shown on separate maps and the stressors should be identified on the maps.	Specific figures could be redone at 11 x 17, if requested. They would still be bound in at the back per comments received during the peer review of the Conceptual Water Budget report. CLOCA staff have indicated that because of the orientation size and shape of CLOSPA (as well as printing/binding costs and ease of review), it was considered appropriate to print the figures on 8.5x11. All the maps are available digitally in .png format at a high enough resolution so that they can be reproduced at various sizes. Additionally, it may be more appropriate to reproduce the specific maps/figures that are used in the final Assessment Report at the recommended larger size.	None
BG(DR) <u>*Perception*</u> This document should not be available to public. It should be only for the use of qualified professionals.	The report has been subject to extensive internal and external peer review. We have addressed the technical issues raised. We see little reason, from a technical viewpoint, to withhold results this study from the public. According to CLOCA staff, releasing or withholding the report is a provincial decision. At this stage, the province has indicated that draft reports (essentially all reports completed prior to the release of an approved Assessment report) are not for public distribution.	None
BG(DR) <u>*WHPA*</u> Any reference to WHPA should be removed in the report (page 55) because there aren't any within the	There was no mention of WHPA in the entire report.	None

study area.		
From Chris Neville		
1. No municipal water supplies in the CLOCA area are drawn directly from groundwater. Therefore, according to the Source Water Protection Guidance, no subwatersheds in the CLOCA area will proceed to a Tier 2 stress assessment. We support the commitment of CLOCA indicated on Page 12 to support ongoing analyses of groundwater resources. Although there may be no current motivation for further analyses as part of source water protection programs, ongoing work will be invaluable for future water management. In our opinion, the analyses described in the Tier 1 report provide a strong basis for additional analyses. We concur that attention should be directed towards refining estimates of water demands.	We mention the lack of municipal supplies in the text. We agree with the rest of the statement.	None
2. We concur with the interpretation of the objectives of the Tier 1 stress assessment presented on Page 15. Tier 1 assessments are being conducted to identify, at a screening level, those areas that are potentially stressed and that should therefore be the subject of refined evaluations.	We agree with this statement.	None
3. In our opinion, it is essential that stress assessment calculations be presented that are based on the methodology presented in the MOE Guidance Documents. We recommend that the calculations of the stress assessments for average annual conditions according to: $$SA_{AVG}(\%) = \frac{Q_{AVG}}{Q_{IN} + Q_{RCH} - Q_{RESERVE}} \times 100$$ where Q_{AVG} is the rate of the average annual demand. Here Q_{IN}, Q_{RCH}, and $Q_{RESERVE}$ are average annual quantities. In our opinion, the presentation on Table 29 is potentially confusing and a single stress assessment should be reported. Other calculations based on different interpretations are potentially useful; however, we recommend that they be reported in appendices separate from the main report. The water budget analyses developed for this report are important contributions to the understanding of the CLOCA watersheds, and provide information that is important for future water management efforts. However, it is important to note that the stress assessments are intended, in part, to direct attention to those watersheds that should be the focus of immediate follow-up work. Towards this end, the stress assessments should follow a consistent approach for all watersheds in Ontario. The identification in this report of watersheds in which there are no significant municipal or agricultural takings as "potentially significantly stressed" is not consistent with our experience elsewhere in the province. Although there may be "better" ways to assess the potential impacts of existing and future water withdrawals, it is crucial to note that the stress assessment methodology developed for the MOE Guidance Document is intended to support the development of indices of stress following a consistent approach. The Guidance Documents do not define the sustainable yield of a watershed as the sum of Q_{IN} and Q_{RCH}. Rather, the action levels are set deliberately as a relatively small fraction of that amount.	This is another Q_{IN} versus Q_{NET} comment. We agreed, as per MNR recommendations, to revise the report for the sake of consistency with other SP studies. Still, we feel that there needs to be some recognition that not all inflow into a basin is "available supply" and that some should be reserved for downstream users. Analyses now show that Lynde and Darlington are only moderately stressed on an annual average GW demand basis and no watersheds are stressed on a monthly GW demand basis. Agreed	Analyses revised. Text revised.
4. Sufficient information is presented in the report to calculate stress assessments that are consistent with the MOE Guidance Documents. To improve our own understanding, we have developed them here.	This is identical to the revised assessment that we now present. The reason we included the additional information was so that we could easily do the stress assessment in multiple ways and compare results. It was	Analyses revised. Text revised.

<table>
<tr>
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<table>
<tr><th>Watershed</th><th>Recharge (m^3/s)</th><th>Q_{IN} (m^3/s)</th><th>GW demand (m^3/s)</th><th>Q reserve (m^3/s)</th><th>Stress assessment (%)</th></tr>
<tr><td>Lynde Creek</td><td>0.6765</td><td>0.202</td><td>0.0984</td><td>0.068</td><td>12.1</td></tr>
<tr><td>Pringle Creek</td><td>0.1115</td><td>0.042</td><td>0.0043</td><td>0.011</td><td>3.0</td></tr>
<tr><td>Corbett Creek</td><td>0.0463</td><td>0.017</td><td>0.0001</td><td>0.004</td><td>0.2</td></tr>
<tr><td>Goodman Creek</td><td>0.0462</td><td>0.015</td><td>0.0009</td><td>0.002</td><td>1.5</td></tr>
<tr><td>Oshawa Creek</td><td>0.5892</td><td>0.197</td><td>0.0297</td><td>0.065</td><td>4.1</td></tr>
<tr><td>Harmony Creek</td><td>0.1756</td><td>0.081</td><td>0.0095</td><td>0.018</td><td>4.0</td></tr>
<tr><td>Farewell Creek</td><td>0.1577</td><td>0.110</td><td>0.0100</td><td>0.018</td><td>4.0</td></tr>
<tr><td>Robinson Creek</td><td>0.0193</td><td>0.015</td><td>0.0023</td><td>0.000</td><td>6.8</td></tr>
<tr><td>Tooley Creek</td><td>0.0423</td><td>0.020</td><td>0.0038</td><td>0.003</td><td>6.4</td></tr>
<tr><td>Black Creek</td><td>0.1243</td><td>0.067</td><td>0.0062</td><td>0.011</td><td>3.4</td></tr>
<tr><td>Darlington Creek</td><td>0.0702</td><td>0.022</td><td>0.0149</td><td>0.004</td><td>16.9</td></tr>
<tr><td>Bowmanville Creek</td><td>0.6149</td><td>0.305</td><td>0.0239</td><td>0.082</td><td>2.9</td></tr>
<tr><td>Westside Creek</td><td>0.0180</td><td>0.022</td><td>0.0015</td><td>0.001</td><td>3.8</td></tr>
<tr><td>Soper Creek</td><td>0.4152</td><td>0.200</td><td>0.0170</td><td>0.041</td><td>3.0</td></tr>
<tr><td>Bennet Creek</td><td>0.0272</td><td>0.021</td><td>0.0018</td><td>0.002</td><td>3.9</td></tr>
<tr><td>Lake Catchments</td><td>0.0747</td><td>0.110</td><td>0.0032</td><td>0.009</td><td>1.8</td></tr>
</table>

The values for these calculations are drawn from the following tables in the report:

• Recharge: Table 12;
• Q_{IN}: Table 13;
• GW demand: Table 15; and
• Q reserve: Table 28.

No watershed is identified as being “potentially significantly stressed”. Only Lynde Creek and Darlington Creek are identified as being “potentially moderately stressed”. In the case of Lynde Creek, the demand term is the highest of the watersheds, and is about 5 times larger than the next highest demand. In the case of Darlington Creek, the recharge is relatively low.
</td>
<td>not intended to confuse others.</td>
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<td>5. We do not understand how the monthly groundwater stress assessments listed on Table 30 have been calculated. However, it is evident that the methodology is not consistent with MOE Guidance Documents. Our understanding is that the monthly and annual stress assessments differ only in the treatment of the demand term. We recommend that the calculations of the stress assessments for maximum monthly demand conditions be repeated according to:</td>
<td>As noted, the Guidance Module says that only monthly variation in demand is used in the monthly stress analysis but not monthly variation in recharge. We have revised the calculations accordingly.

It should be pointed out that we do not agree with the assumptions that dividing the annual recharge by 12 will somehow account for storage in the aquifer system. While we agree that the stress analysis is overly conservative when storage is neglected completely, there is no mechanism, short of doing a transient water budget or transient model</td>
<td>Analyses revised. Text revised.</td>
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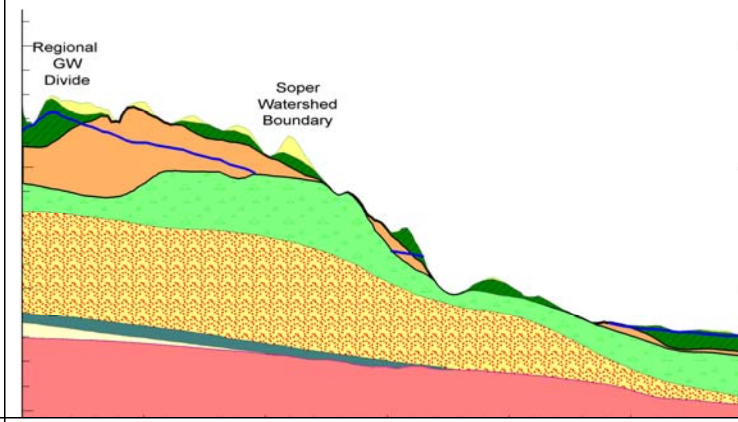
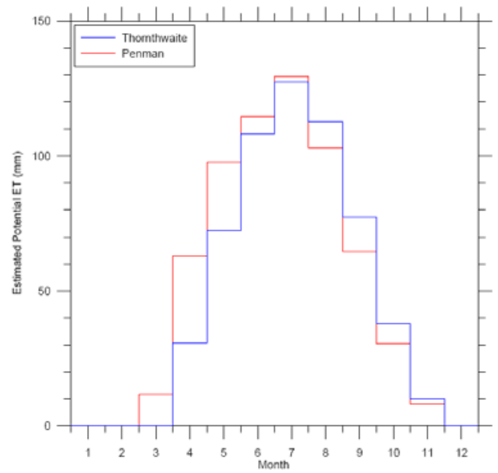
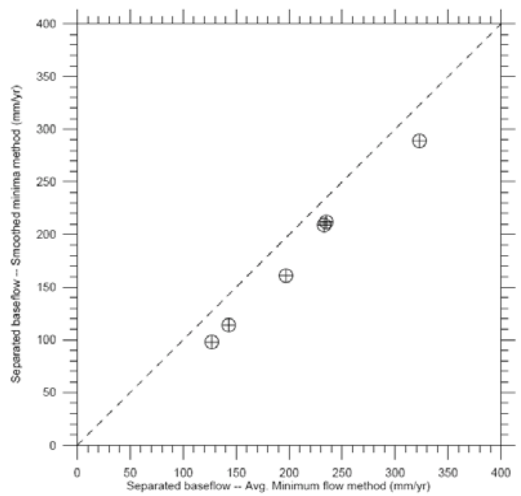
</table>

$$SA_{MM}(\%) = \frac{Q_{MM}}{Q_{IN} + Q_{RCH} - Q_{RESERVE}} \times 100$$ where Q_{MM} is the rate of the maximum monthly demand. The remaining quantities in the stress assessment are the same as those adopted for the stress assessment for average annual conditions. This approach implicitly conceives of the groundwater system as a reservoir that has some storage capacity. To allow checking of the calculations, we recommend that a corresponding version of Table 21 be presented for current conditions.	simulation, to properly account for the addition and depletion of water from storage on a monthly basis. An ad-hoc method with no scientific basis is not always better than a conservative method. What we did in our analysis was to compare monthly recharge against monthly demand. Because we had calculated average monthly recharge, we felt important to use this information in the analysis. The method identified several basins where monthly percent water demand exceeded the threshold and indicated that more in-depth analysis (i.e., a transient water budget) would be useful.	
Main Report:		
SB (MNR) Page 11: In the report it states, "Based on the outcome of this Tier 1 preliminary stress assessment, additional characterization and detailed stress assessment may need to be performed." Although the preliminary stress assessment may have identified subwatersheds that are above the specified stress thresholds we know that CLOCA will not be proceeding further in the WB/WQRA exercise because the SPA does not contain any inland municipal drinking water systems. However the information generated in the Tier 1 exercise will be useful for other programs within the Conservation Authority. It would be appropriate to clarify this statement and others throughout the document, to indicate that no further work will be required under the WB/WQRA exercise.	Agreed	Sentence revised
SM (GRCA) Page 11: The sentence "Total surface water demand by month is also relatively uniform over the year, in part because snow making extraction from surface water bodies occurs in the winter months." (Executive Summary, pg. 11, last paragraph) does not appear to be logical.	Sentence is not incorrect but not necessary. Nonetheless, water is indeed pumped from large ponds in the winter. It may be a case of groundwater being pumped into the ponds and thus takings may be double counted but for the purposes of the Tier 1 work, per the guidance, the permitted rates for both SW and GW takings were used. Further investigation can be conducted outside of the SWP initiative and when the actual taking data become available.	Sentence deleted
SB (MNR) Page 13: In the report it states, "Finally, the demand estimates were adjusted, as per the guidance module, to account for water pumped but locally returned to the watershed." The WB/WQRA guidance module outlines methods to evaluate consumptive demands at three different spatial scales; watershed, subwatershed and unit. Although it appears that the consumptive demand estimates have been computed correctly you may wish to clarify in the text that the consumptive demands have been calculated at the 'unit' scale. For example, water taken from an aquifer and discharged to a local stream would be considered 100% consumptive to the aquifer 'unit' but would not be considered consumptive if evaluated at the subwatershed scale. Please clarify in the text that your consumptive demand calculations have been performed for each water user at the 'unit' scale.	This analysis was done at the watershed scale and not at the "unit" scale. The guidance module states "Unregulated water uses are generally estimated on a per unit basis, as established from the trends found in surveys". No surveys have been completed to allocate water use (either permitted or unpermitted) on a unit basis, so the assessment had to be completed on a per watershed scale.	Text updated
SB (MNR) Page 14: In the report it states, "In our opinion, however, a more realistic estimate of Q_{SUPPLY} might be based on the net lateral inflow into the catchment (Q_{NET}) because the lateral outflow from one catchment forms the lateral inflow to an adjacent catchment and therefore the total inflow is not entirely "available" for water supply use within each catchment. Based on these discussions, the project management and internal peer review team subsequently requested that the Q_{NET} calculation approach be used." As discussed at our peer review meeting on February 28th, 2008 the calculation of Q_{SUPPLY} should be undertaken using only the groundwater recharge ($Q_{RECHARGE}$) and the groundwater flow in (Q_{IN}) to each subwatershed as the supply term. The primary reason for not using the Q_{NET} approach is that the stress	This is another Q_{IN} versus Q_{NET} comment. We agreed to the MNR recommendations and we will revise accordingly. Regarding the appropriateness of the thresholds, it may be that the design and testing took place in large catchments (i.e., the GRCA watershed) where lateral inflows and outflows are a small component of the available supply. In CLOCA, however, lateral inflows and outflows are a significant component of the water budget in many of the catchments and should be	Analyses revised. Text revised.

thresholds for the stress assessment have been designed and tested to work using the approach outlined in the guidance document. Using the Q_{NET} approach would require redesigning the stress thresholds (likely on a monthly basis) and would contribute to inconsistent results when compared to other stress assessments being undertaken across the province.	considered more carefully in the stress analyses as to whether all the lateral inflow is "available" for water supply use given that a portion of that water is required to supply the lateral inflow to adjacent catchments. Alternative approaches for sensitive, smaller sized catchments could be to either (1) consider the net lateral flow as part of the supply or (2) consider lateral outflow to be part of the groundwater reserve.	
SB (MNR) Page 14: In the report it states, "When the monthly $Q_{RECHARGE}$ is low in the summer months, Q_{SUPPLY} becomes negative in catchments with a negative Q_{NET}." As discussed at our peer review meeting on February 28th, 2008 the calculation of the Q_{SUPPLY} needs to consider groundwater storage to avoid the negative supply values you are calculating in the summer months. Because the Tier 1 exercise will not involve transient groundwater modelling Appendix A of the guidance document outlines a simple surrogate method to account for groundwater storage on a monthly basis by dividing the estimated annual average recharge by twelve. Using this method should eliminate the negative supply values you are encountering and eliminate the need for your newly introduced method (70% of groundwater inflow) for determining groundwater supply which should be removed from the document.	We have revised the calculations accordingly. (See earlier note on same topic)	Sections deleted. Analyses revised. Text revised.
CN (SSPA) Page 19: The report indicates that significant groundwater contributions to first-order streams have been "confirmed" in the CAMC-YPDT modelling. We recommend that this degree of certainty be avoided when referring to groundwater modelling.	Agreed	"confirmed" changed to "indicated based on results of"
CN (SSPA) Page 21: Inverse-squared distance weighting is used to develop a continuous distribution of precipitation from a dispersed network of precipitation stations. Is this the most appropriate approach for precipitation data? For example, Theissen polygons are used to interpolate data from weather stations in the Toronto and Region Conservation Authority (**Conceptual Understanding of the Watersheds**, December 2006).	Nearest neighbor interpolation (Theissen polygons) is a graphical procedure that predates computers and the method is not inherently better than any other for rainfall data. We used Theissen polygons in early model runs which gave abrupt changes in simulated recharge. Use of inverse distance squared gave a smoother interpolation. Interpolation using variogram analysis and kriging would be an even better technique, but there were not enough rain gauge data to justify its application.	No change
CN (SSPA) Page 21: The text indicates that the hydraulic conductivity of frozen soil is assumed to be 1/100th of the hydraulic conductivity of non-frozen soil. However, our review of Table 2 suggests that the ratio is 1/20. What is the correct value assumed in the analysis, and what is the basis for the assumed ratio?	The hydraulic conductivity of frozen soil was initially assumed to be 1/100th of the hydraulic conductivity of non-frozen soil and then adjusted to 1/20 to get a better match to hydrographs. The tables shown in the report are directly from the spreadsheets used in the "lookup" assignment of model parameters.	Text corrected
CN (SSPA) Page 22: The text refers to the "recharge zone". Is this the same as the "unsaturated zone" or the "perched water zone"? Is water in this zone "subsurface water"?	In PRMS, the "soil zone" is subdivided into a "recharge zone" and "lower zone". Both are subject to ET. Water in excess of field capacity (after ET) can (potentially) infiltrate to the water table. This was all explained on the previous page. The subsurface zone, which represents the rest of the unsaturated zone, lies below the "soil zone"	No change
CN (SSPA) Page 22: The text reads, "Storage in the unsaturated zone was determined based on the thickness of the recharge and soil sizes multiplied by the available water." What does this sentence mean?	Typo. Should be "recharge and soil zones". Also, "unsaturated zone" should be "upper soil zone".	Text revised
CN (SSPA) Page 22: Is PRMS capable of routing recharge from one subwatershed to another?	No. That is why we had to use both the PRMS and MODFLOW models, because the PRMS model will over/underestimate flows at the gauge if there is a significant amount of cross-watershed flow. We used MODFLOW to estimate those flows.	No change. (This point is mentioned several times in

		the text)
CN (SSPA) Page 22: What is the “discharge coefficient”? Is this a calibration parameter, or a physical quantity that can be estimated independently of the analysis?	The discharge coefficient is an exponential decay coefficient meant to simulate baseflow recession. This was approximated by visually comparing with the recessions observed in the streamflow hydrographs.	Sentence added to clarify.
CN (SSPA) Page 23: Are we correct in understanding that the highest ground surface elevations are north of the northern limits of the CLOCA area? Are the limits of the CLOCA area delineated as the axis of the Oak Ridges Moraine (that is, the hummocky terrain in Figure 9)?	There are areas of higher topography that contribute groundwater flow to the CLOCA watersheds. This occurs most notably northeast of Soper and northwest of Lynde (as stated in text). Also, the exposed surface of the ORM is not always symmetric about the topographic ridge and the sands to the south are often covered by Halton Till. These factors tend to displace the regional divide north of the axis of the ORM. The hummocky topography covers a somewhat similar area (actually the exposed ORM deposits and thin Halton overlying ORM deposits) but does not include the outwash sands which also have high recharge.  	No change. Discussion of hummocky topography modified to clarify.
CN (SSPA) Page 25: What are the “transmission factors”?	Transmission coefficients for short-wave radiation through the winter vegetation canopy. TRNCF is used in the snowmelt calculation and allows snow to persist beneath pine forests (low TRNCF value) and melt faster under oak forest canopy (high TRNCF)	Text added
CN (SSPA) Pages 25 and 28: Is it possible to estimate the parameters on Table 1 independently of the calibration? The text indicates that “many” of these parameters can be estimated directly from known or measurable basin characteristics. Which of these parameters have been estimated for locations in the CLOCA area?	Some were estimated from airphotos, some from parameters specified in the TRCA work with WABAS and HSPF. Most of these were adjusted in the calibration.	No change.
SM (GRCA) Page 26: It appears that the climate variables (daily rainfall and temperature) were interpolated spatially using IDW technique. TCC, Quinte, Cataraqui, and Mississippi-Rideau regions used a spatial dataset developed by NRCan that employed a spline technique, while the Thames-Sydenham region uses a Kriging technique.	We have not seen the NRCAN data, but believe that the technique was applied to estimating annual mean data from the monthly means and not for interpolating daily data. We have not seen the Thames data. The IDW method seemed reasonable for interpolating daily data and was especially useful for filling in missing daily values.	No change.
CN (SSPA) Page 27: Estimates of potential evapotranspiration are listed on Table 6. The values are plotted below. The annual total potential evapotranspiration obtained with the Thornthwaite and Penman methods are similar; however, the timings appear to differ. Is one approach more reliable than the other?	Generally, variations on the Penman method are thought to be more reliable (ASCE, 1990). Penman, however, needs humidity, wind speed, and temperature at two elevations and it is therefore more difficult to find	No change.

	data. Best check would be long-term lysimeter studies. We are not aware of any lysimeter studies in CLOCA.	
CN (SSPA) Page 28: We are confused by the different baseflow estimates reported on Table 7. In the figure below, separated baseflows estimated with the average minimum flow method are plotted against the estimates obtained with the smoothed minima method. In our opinion, there appears to be a systematic bias between the two approaches. Is one approach considered more reliable that the other? 	Baseflow is a key calibration target but we can only estimate. You are right in that the local minima method is conservative. As we stated "Conservative estimates can be used to determine a minimum value of baseflow while the more aggressive techniques can be applied to estimate baseflow in streams with a good hydraulic connection to the aquifer and where the groundwater response is assumed to be rapid". Only way to know for sure may be by chemical/isotope baseflow separation. Ken Howard has tried this on Rouge and Duffins.	No change.
CN (SSPA) Page 28: It is indicated in the report that simulated flows are expected to arrive earlier and at higher magnitudes than the observed flows. How were the results accumulated to the watershed scale, and what is the basis for this expectation?	In reality, there is a time lag caused by the very slow groundwater movement to the channel. Slow overland flow to the channels and time for flow in the upper reaches to reach the gauge may also extend the hydrograph over one day. A lot of surface water model calibration focuses on matching the time response of peak flows. In daily mode, the model assumes that runoff reaches the gauge in one day. We could have spent	No change.

	additional effort to run the model in continuous storm mode to get better matches to the storm event hydrographs but based on provincial guidance we did not feel this to be appropriate at the Tier 1 level. We did adjust the groundwater discharge parameter to get a better match to baseflow recession, but this was more for esthetics since there is no feed back to the GW model and we were mainly checking against monthly and annual flows.	
CN (SSPA) Page 29 and Page 33: The approach of adjusting baseflow estimates before they are used as targets seems inappropriate. In our opinion, it is more appropriate to leave the target alone, and carefully design the model calculations that are compared against the targets. In this the representative area would be established for the model calculations that correspond to the support scale for the observations.	We could have modeled the extended catchment and added some code to divert the runoff from the external area away from the gauge and then used the GWLOSS term (which is another exponential decay term) to account for the groundwater flow that bypasses the gauge. This would have been a lot of additional coding, but in the end, you still would be explicitly subtracting an estimated volume from the computed GW discharge to streams. The iterative method of adjusting baseflow targets seemed more intuitive. The comment is that it is better to modify the model than correct the observations. This may be correct in a philosophical sense, but the end result is the same and the work to modify the code was not justified. With regards to the support scale, we would have liked to extend the PRMS model beyond the CLOCA boundaries but did not have the necessary land use coverage. We would still have had to modify the code to take recharge from the extended areas and add it to the groundwater reservoir but divert it from the surface water system.	No change.
CN (SSPA) Page 29: The report indicates that in all analyses it is assumed that groundwater is the primary source of discharge in the CLOCA streams. Is this assumption reasonable? Is it testable?	There are a fair number of small wetlands on the flanks of the ORM and associated with the Iroquois Beach. They may be contributing to estimated baseflow. As we indicated, hydrograph separation techniques cannot distinguish between the different sources of flow. You could test using chemical separation techniques, but even these have simplifying assumptions. Also, results may vary during the year due to high/low antecedent stage in the wetlands and other factors.	No change.
CN (SSPA) Page 29: The report indicates that streams with headwaters on the Oak Ridges Moraine had higher baseflow values, *with the exception of Lynde Creek* (italics added). Why is Lynde Creek different?	The west-trending bedrock valley may be diverting some of the flow from the northwest back to Duffins Creek and/or the upper reaches of Duffins Creek are more deeply incised into ORM deposits (while the upper reaches of Lynde are on top of Halton Till) and pulls in some of the flow. Cross watershed flow is seen best in the observed and simulated heads in the area west of Coronation Gardens. Subtle factors like these are usually missed in surface water models but are represented in the GW model which extends beyond the CLOCA boundaries.	Sentence added.
CN (SSPA) Page 31: Are we correct in understanding that the white area in Figure 21 is the East Model,	No, the white area is the entire East Model, the yellow area is CLOCA	Text added.

and that the yellow area is the area that is referred to as "scaled down".	where PRMS was applied for this study. The subset of the East Model (now shown) was truncated west of Duffins Creek and north of the center of Lake Scugog.	
CN (SSPA) Page 31: How are the eastern and western boundaries of the model defined?	Watershed divides east and west of the CLOCA area were treated as no-flow boundaries.	Text added.
CN (SSPA) Page 32: We recommend that a map be prepared to indicate the locations of high-quality pumping tests that were used to constrain the groundwater modelling calibration.	Nearly all of these are outside CLOCA in north Durham Region. The table will be prepared as part of the Durham Model (East Model) documentation.	No change required
CN (SSPA) Page 32: How were hydraulic conductivities assigned to lithologic log descriptions? Were the units identified in the logs assigned generalized values based on literature values?	As noted in the text, the method is described in Kassenaar and Wexler (2006) in the Methodology section and is somewhat similar to Martin and Frind. Method starts by assigning K's to each lithologic unit in the logs. Then average T's are calculated based on thickness of litho-zones within each aquifer. K's of the aquitards were assigned uniform values unless mapped as being thin or very thick.	No change required
CN (SSPA) Page 32: Are the recharge rates listed on Table 8 the final calibration values, or values used to constrain the initial simulations?	As indicated, Table 8 values were the initial estimates used in the East Model before PRMS. Estimates for recharge in the CLOCA watersheds were then updated in an iterative manner using the PRMS code. These estimates did help influence but not constrain the calibration. You have to also understand that each cell has a unique recharge value but surficial geology, rather than land use, had the most influence on model results.	No change required
CN (SSPA) Page 32: Our experience suggests that it is generally not possible to estimate the hydraulic conductivity of the upper aquifer and the recharge rate independently. How is this issue of nonuniqueness addressed in the analyses?	That is really the point of the whole exercise. We need a somewhat independent method for computing recharge so that we can better calibrate K's.	No change required
CN (SSPA) Page 32: The report indicates that model results were compared against "observed flow patterns". How are flow patterns observed? Are they not inferred from water level data? Are sufficient high-quality water level data available to constrain these inferences?	Maybe it's a poor term, but what we are referring to as flow patterns are the shape of the contour lines and the gradients (separation between lines). These are determined by interpolation of the data. The data have inherent error, but, surprisingly, they do produce reasonable looking maps (ignoring local noise and data gaps) There are insufficient high-quality data to do any inferences about spatial patterns in the flow. There are 14 PGMN sites across CLOCA, monitoring different aquifers. With five or ten times the number, you could begin to get some interesting spatial inferences.	No change required
CN (SSPA) Page 32: There are a relatively large number of recharge values that can be adjusted during calibration. Are there in fact 10 different values as suggested on Table 8. How is calibration accomplished effectively with this many adjustable parameters?	There are many more than 10 parameters. Table 8 just lists some of the surficial geology zones. The key parameters are in Table 1 and 2. These form a matrix of 32x25 or so possible combinations of land use and soil types, each with 9 land use parameters and 11 soil type parameters). This is why using consistent parameters across watersheds was so important otherwise the task would be impossible. There were not enough gauges within each watershed, so we had to look at the baseflow estimates from all gauges across CLOCA. Different gauged catchments have different combinations of geology and land use, so the response of each is unique. We calibrated to Lynde first and then extended these	No change required

	values across CLOCA to check for consistency. We recognize that we will not be able to nail down properties for the minor combinations (for example, there are only a few cells that have the Ski-Hill-Halton Till combination), but we should be able to get close on the major ones (forest on moraine, agriculture on Halton Till) Also, we looked at the previous modelling to provide a starting point so we know that recharge over the ORM must be high to sustain the high water levels observed and that the hydraulic conductivities of Newmarket and Halton Tills limit the amount of recharge that can be applied.	
CN (SSPA) Page 33: The description of the water balance calculations with PRMS suggests that the recharge to the unsaturated and saturated zones are additive. Do these processed not occur in series in the soil column, so that adding them is in some sense double-counting?	The PRMS logic is somewhat convoluted but, ultimately makes sense. Water can either go directly to the GW reservoir or, if daily percolation capacity is exceeded, it goes to the unsaturated zone reservoir. Ultimately, the water in the unsaturated reservoir either goes to interflow or back to the GW reservoir. The water is only counted once, at the split. We deliberately set the interflow partitioning low, so that most of the water re-infiltrates and then discharges as baseflow. USS is significant only in Newmarket and lacustrine clay covered soils	Text revised to clarify.
CN (SSPA) Page 33: We do not understand the results presented in Figure 20. It appears that there are four measures evaluated with two data sets. We cannot understand why the PRMS total flow and corrected total flow are apparently compared against different sets of observed values of total flow. We also cannot understand why the PRMS and MODFLOW estimates of separated baseflow are not compared against the same independent estimates of baseflow.	We will split Figure 20 into two figures for clarity. The observed and simulated values for PRMS were reversed on the graph. That is why it appeared that we compared PRMS and MODFLOW against different observations. Thanks for catching it.	Graph corrected. Split into Figure 20a and 20b.
CN (SSPA) Page 33: Is the same information presented in Figures 14 and 22? It does not appear that the same information is presented. How are they different, and how were they developed?	Figure 14 is for the climate normal 1971-2000. The point of the figure was to show the limited coverage and the apparent spatial trend in the data. Figure 22 is the average for the simulation period WY1981 to WY 1999. Results are similar but not identical.	Text “for WY1981 to WY1999” added to caption.
CN (SSPA) Page 33: It is indicated in the report that “losses to depression storage may offset some of the additional throughfall in the urban areas”. What is “throughfall”?	Throughfall is water making it past the canopy (i.e. after interception is satisfied). The tree coverage is less dense in urban areas so there is less interception but there are more flat roofs and parking lots for puddles. Water from both interception and depression storage is assumed to be lost to evaporation.	Text added at first occurrence of “throughfall” in the report
CN (SSPA) Page 34: The rates of evapotranspiration estimated through calibration of the PRMS analyses are shown in Figure 26, referred to as “annual average actual evapotranspiration”. The report indicates that these average rates are “comparable” with the regional estimates listed on Table 6. The estimates listed on Table 6 are independent land use factors, soil factors, and climate factors. How is that we can expect these estimates to be similar to the results of the PRMS analysis? Is it possible that the dominant parameters are climatic, and that everything else is of second-order significance?	The ET models (e.g. Penman, Jensen Haise, Thornthwaite, Harmon, and Hargreaves) all have factors and coefficients that were derived to fit lysimeter and small scale field studies and, as you indicate, are dominated by factors such as insolation and temperature. It is not surprising that the methods all give reasonable results. As you noted earlier, the shape of the Penman and Thornthwaite curves are fairly close and that is why it is hard to select the “best” model because they all work. <u>The point being made in the report was more that our application produced reasonable results, indicating that we did not introduce significant errors in model formulation or input data sets.</u> As an aside, when we first set up the	Text revised. Additional comment added.

	model, we had some timing errors (I believe we started the solar data in January but the rest of the data in October) and the model produced very poor matches to observed flows, especially snowmelt-generated flows, indicating that the model is sensitive to input errors.	
CN (SSPA) Page 34: How is "net recharge" related to the simulated annual recharge shown in Figures 29?	As explained above, water can either go directly to the GW reservoir or, if daily percolation capacity is exceeded, it is diverted to the unsaturated zone reservoir. Figure 29 shows annual USS which is the net water diverted to the unsaturated zone reservoir. Ultimately, the water in the unsaturated reservoir either goes to interflow or back to the GW reservoir. We deliberately set the interflow partitioning low, so that most of the water (more than 90%) re-infiltrates and then discharges as baseflow. For simplification, we've added USS and UGS to make the composite figure.	We added a GW recharge (without USS) figure and added text to clarify.
CN (SSPA) Page 34: The report refers to streams that are "head up on the till surface". What does "head up" mean?	Better phrase should be "whose headwaters are located on the till"	Text Modified
CN (SSPA) Page 34: We are confused by the reference to the recharge rates estimated through calibration of the PRMS and MODFLOW models. Our understanding is that the analyses are loosely coupled by maintaining consistency between the recharge rates estimated with the PRMS analysis and specified for the MODFLOW simulations. However, in some sections of the report it seems this is only approximately correct. For example, at the bottom of Page 34 it is indicated that the rates "are generally consistent with those estimated in the East Model calibration but in the last sentence it is indicated that these values "were used as input to the East Model." On Page 35 it is indicated that the spatial distribution of recharge determined by PRMS is more accurate. This seems to suggest that the recharge distribution developed from calibration of the PRMS analyses is distinct from the recharge distribution estimated from calibration of the MODFLOW model, and that the distribution from the PRMS analyses is more reliable. We recommend that the relation between the recharge rates estimated in the surface water and groundwater models be indicated clearly throughout the report.	As indicated in the report, we developed (relatively simple) estimates of recharge for the entire East Model. These were shown in Table 8. MODFLOW model results were then analyzed to determine net lateral inflow into each gauged catchment. The corrected baseflow estimates were used as calibration targets for PRMS. The PRMS model gave us refined estimates of recharge for the CLOCA watersheds which were not radically different from our simplified estimates. Although the process could have ended there, we used the PRMS recharge estimates within the CLOCA area and the Table 8 values outside the CLOCA area in the MODFLOW model. The new MODFLOW model results were re-analyzed to determine net lateral inflow into each gauged catchment. The new corrected baseflow estimates were used to fine-tune the calibration of PRMS. The results converged fairly. This process is described several times in the report and shown visually in Figure 33.	No change
CN (SSPA) Page 34: We are puzzled by some of the recharge values listed on Table 8. As a preliminary check we have expressed the recharge rates as a ratio of the water surplus, assuming an average annual precipitation of 870 mm and evapotranspiration of 600 mm (average of the Thornthwaite and Penman estimates). Is there any independent evidence of recharge rates that are as high as 35 and 60% greater than the surplus?	The methods for calculating recharge that you cite (P-ET to get surplus) do not account for soil and vegetation variation. They use monthly average values for some parameters. However, even though they are simple, they do give good watershed-scale estimates of recharge. On the other hand, we know that recharge varies locally, Using a more complex model, we included local variations in factors that affect interception, and depression storage, that control runoff prior to ET (e.g. in urban areas), that allow rapid infiltration of water from the soil zone in coarse sediments, so that less is lost to ET in the ORM and more in the fine grained till soils. The effects can be see by comparing PET (Figure 25) which is relatively uniform with AET (Figure 27) which shows that AET	No change

<table>
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<tr><th>Material</th><th>RCH/(P-ET) (%)</th></tr>
<tr><td>Glacial Lake sands</td><td>67</td></tr>
<tr><td>Glacial Lake silts and clays</td><td>34</td></tr>
<tr><td>Other recent deposits</td><td>60</td></tr>
<tr><td>Halton Till - hummocky</td><td>135</td></tr>
<tr><td>Halton Till – north of ORM</td><td>45</td></tr>
<tr><td>Halton Till – south of ORM</td><td>34</td></tr>
<tr><td>ORM deposits - hummocky</td><td>157</td></tr>
<tr><td>ORM deposits – non-hummocky</td><td>120</td></tr>
<tr><td>Newmarket Till</td><td>11</td></tr>
<tr><td>Lower sediments/weathered bedrock</td><td>11</td></tr>
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</td>
<td>is lower in the ORM and urban areas. Runoff is very low in the ORM (due to hummocky topography and sandy soil) and the combination of low AET and low RO leads to high recharge. These high recharge rates sustain the high heads that occur in the ORM area despite the high K of the sediments. Conversely, low AET in the urban areas does not lead to high recharge in the urban areas because of the high RO. Similar analyses can be done for each of the soils/land use combinations.

The fact that the models give reasonable results does not mean that we believe that we are simulating <u>all</u> the physics correctly. There are many simplifying assumptions and limitations in the models. For example, if we used 15-minute precipitation data in storm mode, we could better represent the high runoff from intense storms and low runoff from low intensity storms (that have the same daily precipitation). We could account for rejected recharge and properly route overland flow and simulate re-infiltration of excess water from low permeability areas in downstream areas of high permeability. The net results would be that the final recharge map would probably look similar but with more local variability.
While we cannot claim to have the definitive model, we think that it does produce intuitive results that are much more useful than the simplified methods applied in other Tier 1 studies. The models form a framework for doing additional studies and for improving the representation of soil and groundwater physics that was ignored previously.</td>
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<td>CN (SSPA) Page 35: In our opinion, it is difficult to assess the match between the observed and calculated groundwater levels referring only to Figures 34 and 35. We recommend that the reporting of the goodness-of-fit be supplemented with the following:

• Scatterplots comparing observed and calculated water levels in the Oak Ridges Aquifer Complex and the Thorncliffe Aquifer, with distinct symbols to indicate water level targets corresponding to high-reliability data (dedicated observation wells with survey control and boreholes logged by a professional geoscientist);
• Plots of the cumulative probability distribution of model residuals;
• Tables indicating observed and calculated water levels and model residuals, again with indications of high-reliability targets; and
• A listing of statistical measures of model goodness-of-fit.

This additional information can be included in an electronic supplement to the report.</td>
<td>Scatterplots were done and are now included along with the table of statistics. The point of this report, however, was not to document the “East Model” which is the subject of another report (in progress).</td>
<td>Figure and explanation added</td>
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<td>CN (SSPA) Page 36: In our opinion, it is difficult to check the calculations reported in Figure 38. We recommend that a table be added to indicate the values that are suggested in this figure.</td>
<td>We will add the flow/area to Table 8 and add a reference to the table</td>
<td>Add flow/area to Table 8 and add reference to table</td>
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<td>CN (SSPA) Page 36: The report indicates that median flows were compared with average flows. How are the average flows defined? The Period of Record (POR) median flows for the HYDAT stations listed on</td>
<td>A better word would have been “contrasted”. It was not intended to indicate that a correlation analysis was conducted, but rather that the</td>
<td>Point deleted for clarity</td>
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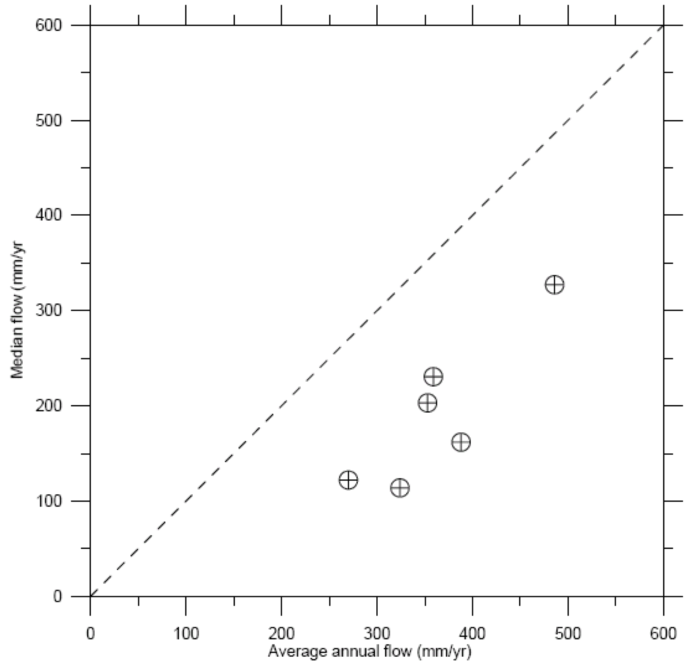
<td>Table 10 are plotted against the average annual flows listed on Table 7 in the figure below. There appears to be relatively little correlation between the two sets of values. Are we misinterpreting the comparison?


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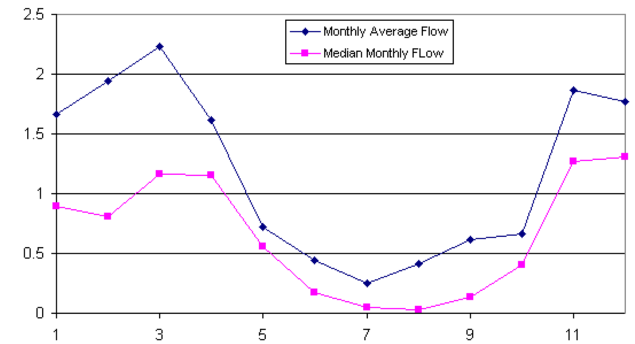
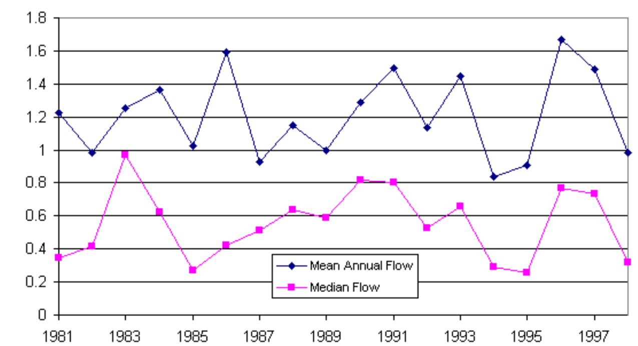
<td>average flows showed a little more variation from month to month than the median flows (results for Oshawa Creek are shown below). Similarly, the mean annual average flows varied a little more from year to year than the median annual flows. It was only a minor point and it has been deleted.




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<td>CN (SSPA) Page 36: We are confused by the references to the comparisons between simulated and observed “mean” and “median” streamflow values for the individual HYDAT gauges. The report indicates an r^2 value of 0.73 for median values for Oshawa Creek. The PRMS calculated average monthly flows (Table 11) are plotted against the observed monthly median flows for Oshawa Creek (Table 10). We must misunderstand something fundament, as we estimate an r^2 value of 0.38, suggesting relatively little correlation.</td>
<td>Table 10 values are median flows for period of record and differ slightly from those for the 19 year simulation period. Table 11 values are the average median flows for the simulation. You can’t compare average versus. median. The figure shows the simulated vs. observed average (blue dots) and the simulated median vs. observed median flows. The r^2 values are 0.81and 0.73, respectively, as stated in the report.</td>
<td>Minor change in text</td>
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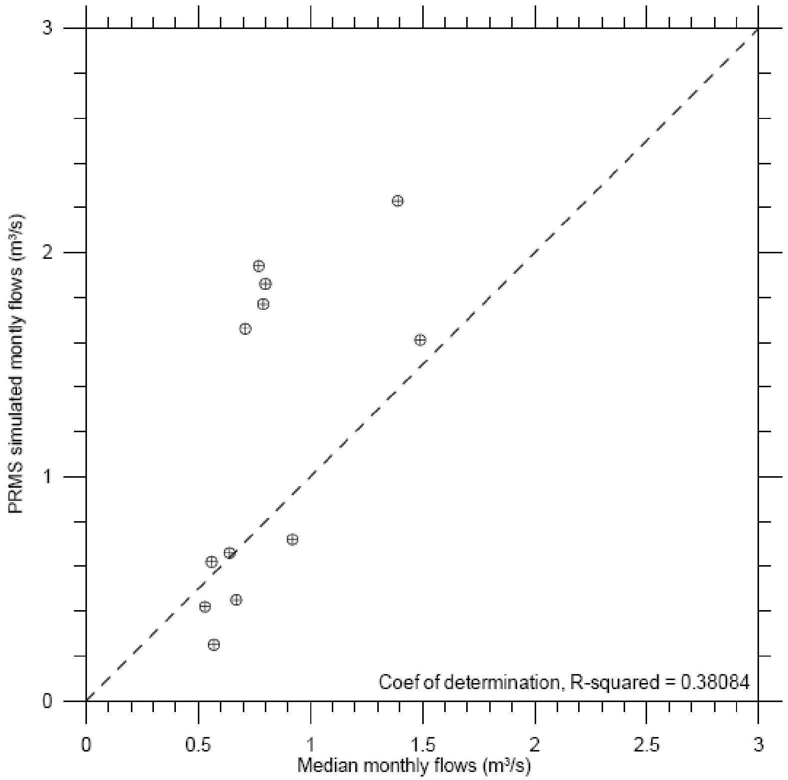	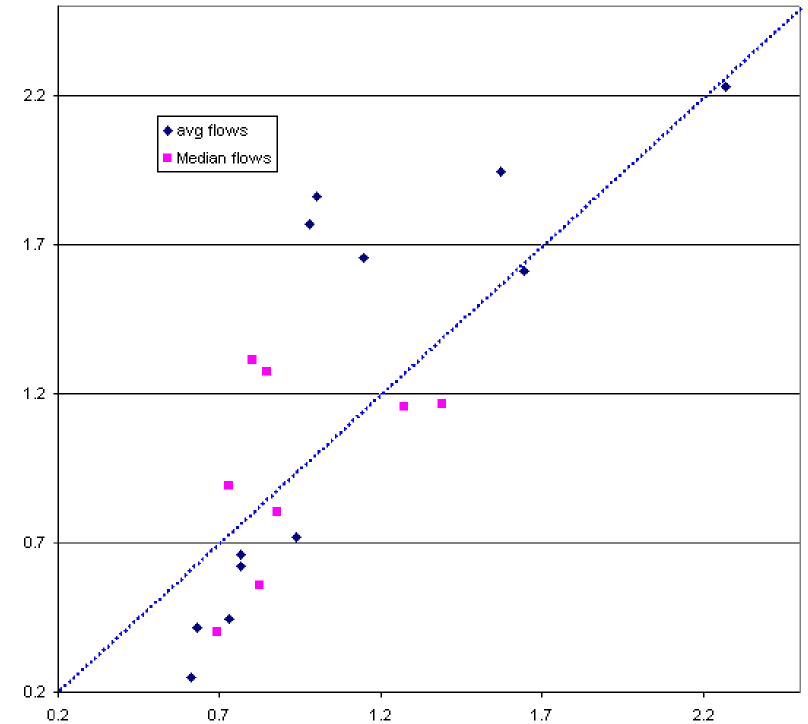 However, as per your later comment, tables will be revised to use Q_{P90},	
CN (SSPA) On a basic level we do not understand some of the basic aspects the water budgets as developed in the report. The components of the water budget are shown in Figure 4 of the report. The components are listed below: 1. Q_P: Precipitation; 2. Q_E: Evapotranspiration; 3. Q_R: Groundwater recharge; 4. Q_{GT}: Groundwater taking; 5. Q_{RO}: Runoff; 6. Q_{ST}: Surface water taking; 7. Q_{GD}: Groundwater discharge to streams (and other surface water bodies); 8. Q_{IN}: Groundwater inflow; and 9. Q_{OUT}: Groundwater outflow. In our experience, we have found that the development of water budgets from these components is	**We appreciate the effort you went through to check our results. We found a small error in your analysis that resolves your question. Details are provided below.**	No change

deceptively subtle. The subtlety arises because there are several different water budgets that can be developed. We indicate four water budgets here: <u>Water budget #1: "Overall"</u> $$Q_P + Q_{IN} = Q_E + Q_{GT} + Q_{ST} + Q_{GD} + Q_{OUT} \quad (1)$$ Here we have not accounted for surface water inflows into the study area. This is consistent with the assumption that the water budget area coincides with the limits of the watershed (that is, the surface watershed). The terms Q_{IN} and Q_{OUT} account for the possibility that the limits of the groundwatershed do not coincide with the limits of the surface watershed. <u>Water budget #2: "Allocation of precipitation"</u> $$Q_P = Q_E + Q_{RO} + Q_R \quad (2)$$ <u>Water budget #3: "Surface water"</u> $$Q_{SW} = Q_{RO} + Q_{GD} \quad (3)$$ Here Q_{SW} represents the surface water flow out of the watershed. On an annual basis, this would correspond to the cumulative discharge measured at a stream gauge at the outlet of the watershed. <u>Water budget #4: "Groundwater"</u> $$Q_R + Q_{IN} = Q_{GT} + Q_{GD} + Q_{OUT} \quad (4)$$ To check the internal consistency of the reported values we consider the reported components for Lynde Creek. Some of these components are indicated in the report and others have been provided in a spreadsheet prepared and transmitted by E.J. Wexler, March 3, 2008.	Eq. 1 is missing the surface water flow term (Q_{RO}). Also SW takings are not explicitly handled in PRMS or MODFLOW and some of the minor GW takings were not represented SW takings – they are not explicitly handled because no direct subtraction was undertaken in PRMS, however, the calibration data (stream flow at gauge) would reflect the influence of surface takings. Eq. 2 checks, this calculates surplus (Qro+Qr) Eq. 3 checks. The equation does not account for interflow, however. Also, Q_{GD} implicitly includes Q_{IN}-Q_{OUT}, the net transfer from other watersheds. , It is also assumed that no surface water transfers from other basins or discharge of pumped groundwater from treatment plants Eq. 4 checks. However, the Q_{GT} used in the model may not be the same Q_{GT} reported in the demand calculation as only municipal and other large takings were used in the model. Also, Q_{GT} is not 'explicitly' reported by the model. Also, the Q_{GT} used by the model was maximum permitted not estimated actual. Agree as long as these are consumptive uses. Simulated discharge to streams is about 162 mm/yr over the whole area and maybe 125 in the gauged area.	

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Precipitation (Q_P)	888.4	mm/yr
Total Actual ET (Q_E)	558.0	mm/yr
Lateral Inflow (Q_{IN})	48.3	mm/yr
Lateral Outflow (Q_{OUT})	49.9	mm/yr
GW Demand (current) (Q_{GT})	23.5	mm/yr
SW Demand (current) (Q_{ST})	11.5	mm/yr
Net Overland Runoff (Q_{RO})	168.5	mm/yr
Net GW Recharge (Q_R)	161.0	mm/yr

<u>Water budget #1: "Overall"</u>

From Equation (1):

$$Q_P + Q_{IN} = Q_E + Q_{GT} + Q_{ST} + Q_{GD} + Q_{OUT}$$

The value of the calculated groundwater discharge to streams is not indicated. We will try to estimate it by subtraction.

Substituting from the table above yields:

$$(888.4) + (48.3) = (558.0) + (23.5) + (11.5) + Q_{GD} + (49.9)$$
$$936.7 = 642.9 + Q_{GD}$$
$$Q_{GD} = 293.8 \text{ mm/yr}$$

<u>Water budget #2: "Allocation of precipitation"</u>

From Equation (2):

$$Q_P = Q_E + Q_{RO} + Q_R$$

Substituting from the table above yields:

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Actually if you add QST and GWT back in and subtract QRO you get mass balance because Eq 1 is missing Qro, therefore 888.4+48.3=558.0+168.5+Qgd+49.9; Qgd=160.3….this approximates the 162 mm/yr noted above.

The table had QRO in it so there was no need to back it out. My combined QR and QRO gives 329.5 mm/a , Qsw=168.5+162=330.5 (EJ used Qr of 161)

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$(888.4)=(558.0)+(168.5)+(161.0)$ $888.4=887.5$ √ <u>Water budget #3: "Surface water"</u> From Equation (3): $Q_{SW}=Q_{RO}+Q_{GD}$ Substituting the reported value of Q_{RO} and the back-calculated value of Q_{GD} yields: $Q_{SW}=(168.5)+(293.8)$ $=462.3$ mm/yr The area of the Lynde Creek watershed is reported as 132.1 km^2. Therefore, the average annual streamflow for Lynde Creek is estimated as: $Q_{SW}=(462.3\text{ mm/yr})(132.1\text{ km}^2)\left\|\frac{\text{m}}{1000\text{ mm}}\right\|\left\|\frac{10^6\text{ m}^2}{\text{km}^2}\right\|\left\|\frac{\text{yr}}{365\text{ d}}\right\|\left\|\frac{\text{d}}{86400\text{ s}}\right\|$ $=1.94\text{ m}^3/\text{s}$ A stream gauge is located at Whitby, relatively close to the outlet of Lynde Creek (Figures 17 and 18). It is a bit difficult to estimate the average daily flow for this gauge, but a value of 1.94 m^3/s is definitely within the range of observations. √ <u>Water budget #4: "Groundwater"</u> From Equation (4): $Q_R+Q_{IN}=Q_{GT}+Q_{GD}+Q_{OUT}$ Substituting from the table above and the back-calculated value of Q_{GD} yields: $(161.0)+(48.3)=(23.5)+(293.8)+(49.9)$ $209.3=367.2$ **X**	I get 1.38 m^3/s , use the 330.5 above rather than the 462.3; 330.5(131)(1/1000)(1000)1000)(1/365)(1/86400)=1.37 Gauge areas are different. Contributing area at Whitby is 106 km^2 (see Table 7). Of course, all the flows in the gauge areas differ from those you used. I I had 270 mm/yr or 0.9 m^3/s (also in Table 7). This is close to 264 (from 329*106/132) I get 209.3 = 235 which is off by the Qgd which isn't all in the model. 161+48.3=160.3+49.9 209.3=210.2	

There seems to be something wrong in this formulation.		
CN (SSPA) Page 38: We are impressed with the alternative approaches adopted to infer the locations of significant recharge areas. However, we do not understand some fundamental aspects of the analyses. What does "a factor of 1.15 times the groundwater recharge" mean? Does this mean that areas for which the estimated recharge is 15% larger than the area-weighted average recharge over the entire model area are significant recharge areas? What does "0.55 times the surplus" represent? Are we correct in interpreting this as meaning that areas with estimated recharge rates in excess of 0.55(P-ET) are considered significant?	These approaches and values came out of Guidance Module 7 – Appendix B. Is there significance to 0.55 or 1.15? GM7 offers no technical support. That is why we used both methods and compared results to see if they provided similar and intuitively-correct results. GM7 says the methods are to be applied on a watershed basis, thus 1.15 times the recharge in Harmony identifies the Iroquois Beach deposits as HVRA while only the ORM deposits are HVRA in Bowmanville. It appears that the SPA surrounding the CLOCA area (TRCA,GRCA, KRCA and LSCA) are using the 1.15 times approach and for consistency purposes would be appropriate in the CLOCA area	No change.
SB (MNR) Page 38: In the report it states, "In the second method, the calibrated surface water model was used and was configured to output daily streamflow at the outlet of each subwatershed. Land use-based parameters in the model were assigned to correspond to current conditions. Monthly water supply values were calculated as the average monthly (Q_{AVG}) streamflow rate for that month over the simulation period. The simulated mean values were used in this analysis because they tended to correlate better (r2=0.81 for Oshawa Creek for example) with the observed mean values (as compared with the simulated median monthly flows (r2=0.73 for Oshawa Creek) and observed median flows)." This second method for determining the water supply for each subwatershed using the calibrated surface water model seems appropriate however the use of the mean monthly streamflow rate (Q_{AVG}) instead of the median monthly streamflow rate (Q_{P50}) does not correspond to the methods outlined in Appendix A of the WB/WQRA guidance module. For the purpose of consistently comparing the stress assessment results across the province can you please use the median monthly streamflow rate (Q_{P50}) in the calculation of monthly percent water demand for surface water.	Tables will be revised to use Q_{P90}	Table revised
SM (GRCA) Page 38: Significant Recharge Areas (SRAs) are defined in this report as the recharge areas contributing to potential seepage areas and springs as well as stream reaches exhibiting more that 1 l/s discharge. Appendix B/Guidance Module #7 defines SRAs as recharge areas contributing to municipal wells and sensitive ecosystem features dependent on discharge for its sustenance. A SRA methodology document prepared jointly by TCC, CTC, and Lake Simcoe/South Georgian Bay source protection regions with input from CAMC, defines sensitive ecosystem features dependent on discharge for its sustenance to be Wetlands and Coldwater Fisheries. Furthermore, the consultants have identified the end points from the Backward Particle Tracking exercise (Figures 46-48), but have not actually delineated the SRA polygons. It appears the end points tracked backwards from a particular feature, have to be interpolated to arrive at a SRA polygon.	The SRA YPDT-led document was not completed, reviewed or approved at the time of this work. Nor has it been approved by the province to date. As well, it is our understanding that techniques described in this report were provided and included in the cited document. Finally, these approaches have been revised in the Director's rules. HVRA's are now considered the SRA. At the time of this report, we tried two approaches: one based on actual data (e.g., groundwater discharge as observed by the temperature probe overflight and brook trout data) and one on model results. Wetlands would need to be separated into those receiving groundwater discharge and those contributing to groundwater recharge. I don't know that this has been done and doing it ourselves would have been beyond the scope of the Tier 1 and is appropriate for a Tier 2 or 3. We did not delineate SRA polygons precisely for the reasons you identified in the next comment. Also, GM7 makes no mention of polygons. It just says to map SRA's, which we did.	Added discussion and figures related to brook trout occurrence (even though data were received well after writing of draft report)
CN (SSPA) Page 39: The particle tracking results suggest some clustering of recharge contributions to streamflow originating on the Oak Ridges Moraine. However, in our opinion, the results generally suggest a dispersed distribution of sources of recharge. These results suggest that it would be impossible to	We agree.	Text added

mandate land-use on the basis of these results.		
CN (SSPA) Page 40: In our opinion, the estimation of water demand is excellent. In our opinion, a key aspect of long-term water management will be developing reliable methods to predict how the demand and recharge terms may change. The analyses developed for the Tier 1 water budget and stress assessment have the potential to be important components of the evaluation.	Thanks for the positive feedback. It is appreciated.	No change
SB (MNR) Page 42: A minor correction to the reference of O.Reg. 384/04 is required, which should actually be O.Reg. 387/04.	Noted	Text corrected
SB (MNR) Page 42: A reference in the text to Table 34 indicates that there are a total of 79 permits within the study area, however when examining Table 34 there are duplications in the ID field of this table. A manual count of the individual records in this table indicates that there are only 78 records. Please clarify these discrepancies in both the text and the table.	The comment is correct – there are only 78 "records" in the data provided by CLOCA. Some permits and record IDs are duplicated because there are multiple sources covered by one permit number.	Text corrected
SB (MNR) Page 43: A minor correction to clarify that under O.Reg. 387/04 livestock watering does not require a permit even if the taking is larger than 50,000 L/d.	Noted	Text corrected
SB (MNR) Page 44: Does it seem realistic to assume that all 380 wells with a usage code of 'livestock' would actually use 50,000 L/d? As noted above, livestock watering does not require a permit to take water under O.Reg. 387/04 and therefore some livestock operations could use more than 50,000 L/d. It may also be likely that many of these 380 wells use less than 50,000 L/d. It may in fact be a reasonable estimate but it should be discussed further in the text of the report.	A number of attempts to estimate livestock consumption were made. Most of the consumption information that was found focused on water and calorie requirements for newborns and young livestock; however some general estimates were found (and now referenced in the text). A 50,000 l/d estimate was selected based on historical MOE limits. Estimates from general farm consumption data suggests that 10,000 l/day might be typical for the livestock portion of the consumption on an average dairy farm. We made some conservative assumptions about other farm water use. With return flow corrections, our estimate of total consumptive demand per farm is 25,000 l/day. Even if we used half that amount, Darlington and Lynde would still be in the moderately stressed category. De Loe (2001also) estimates that non-permitted agricultural use is high in Lynde watershed and moderate in Darlington watershed.	Text expanded and updated
SB (MNR) Page 44: Is there any basis for using the consumptive factor of 0.5 to determine the consumptive demand of livestock watering? A consumptive factor for this specific water use is not provided in the guidance document; therefore it would be good to provide some rationale for using this value (e.g. best estimate, field experience, etc.). It may in fact be a reasonable estimate but it should be discussed further in the text of the report.	This is simply an estimated value based on a general assumption that 50% is lost to ET. Specific farm operations and different livestock types may have much different consumptive values, for example, milking operations may consume more than pig farms, because the farm product, milk, is primarily water and is removed off site. Our research suggests there is considerable controversy about actual water use, particularly as it relates to manure production at hog operations.	Text updated
SM (GRCA) Page 44: Population growth is estimated to be 3% over the next 25 years. According to Ontario Ministry of Finance estimates, the Durham region is expected to grow by approx. 45% within the next 25 years.	Growth rates used in the text are correct and have been confirmed with Durham Region. As indicated in the text it is the change in groundwater demand (non municipal private consumption) that is estimated at 3% not population growth.	
SB (MNR) Page 45: In the report it states, "The detailed permit calculations, including the consumption correction factors and monthly demand allocations for each permit, are included in digital format on the enclosed CRDROM in the file *PTTW Water Demand Details.xls*." This file was not included with the other peer review documents and would likely be useful to assist in evaluating the report.	The tables were provided to CLOCA but were not distributed in the peer review process. They will be included in the final version.	Table added
SB (MNR) Page 47: In the report it states, "The Region of Durham operates four water pollution control plants (WPCP). They are all located in the lower reaches of the streams in close proximity to Lake Ontario	Figure changed to Pringle Creek STP. Figure reference corrected. Numbers were used in calculating reserve	Text and figure revised

(Figure 51). Monthly discharge was provided by CLOCA based on data submitted to the MOE and are shown in Table 23. Required dilution factors depend on flow in the stream and on the concentration of the specific contaminant in the effluent. For discharge to Lake Ontario, the MOE requires a minimum dilution factor of 20 to 1 (MOE, 1994). As a conservative assumption, a 40 to 1 dilution factor was assumed for discharge to the streams. Minimum flow requirements based on these discharge rates and dilution factors are also provided in the table." First, please correct the reference to Figure 51 in the text of the report, it appears to be incorrect. Second, the use of these water reserve calculations is not shown in any of the subsequent tables making it difficult to understand how the numbers are being used. Please clarify in the text how these calculations of water reserve (for waste assimilation purposes) are used in the report.		
SB (MNR) Page 47: As discussed at our peer review meeting on February 28th, 2008 the use of the Tessmann method to estimate the surface water reserve should only be used if both stream gauge information and numerical models are unavailable within a SPA. Given that CLOCA has developed a numerical surface water model it is recommended that the Q_{P90} statistic be derived from the modelled stream flow for each of your subwatersheds for use in the stress assessment calculations. Additionally, the calculation of the Tessmann statistic in the report has not been performed correctly, in part due conflicting methods available in published reports.	We will use the Q_{P90} statistic As stated in the report, there are several conflicting definitions of the Tessman method to be found in literature. Were the province wishes to endorse a particular documented method as 'correct', it would be helpful to the scientific community if such a reference could be included in the guidance document. We believe we used the most defensible method. Nonetheless, per direction, we have now revised the document and used the Q_{90} statistic from the model.	Analyses and tables revised
SB (MNR) Page 48: In the report it states, "The Guidance Module 7 is somewhat vague on the methods for calculating groundwater reserve. There is no theoretical basis for this value and it may be low considering that baseflow represents 40% to 60% of streamflow." Please consider rewording these sentences because it appears that there is a mis-understanding of what the groundwater reserve represents at the Tier 1 level of assessment. As indicated on Page 131 of the WB/WQRA guidance module, "The important point to take away from this reserve discussion is that the reserve is applied on top of already conservative % water demand thresholds, so that at the Tier 1 and Tier 2 levels the reserve is designed as an additional buffer that directs watersheds to additional water budgeting work and a better understanding of the intricate link between the groundwater and surface water systems. The reserve is not designed to necessarily reflect the actual in-stream flow requirements, which are only expected to be fully explored at a Tier 3 level." At the Tier 1 level of assessment the actual instream flow requirements are not being evaluated on an individual stream segment basis.	The term vague was a poor choice. The point being made is that there appears to be no background documentation for the selected 10% in the GM except that there is a "rule of thumb" that 10% is a good value. It was our feeling, however, that if the intent of a reserve is to correct the supply term (i.e., the true available supply is $Q_{SUPPLY} - Q_{RESERVE}$), then $Q_{RESERVE}$ should be a value that truly reflects the dependence of the ecosystem on groundwater discharge. Currently, a stream is given a reserve of 0.1QSUPPLY which is about the same as 0.1QGD for most catchments (see response to comment on p. 50 for proof). This implies that the stream could tolerate a 90% decrease in baseflow (since we only reserve 10%). If the 'rule of thumb' truly suggests that water demands less than 10% of Q_{SUPPLY} will not result in observable changes to the hydrologic system, then, by definition, you should reserve 90% of Q_{SUPPLY} for the reserve to ensure that ecosystems that thrive in this type of environment are not threatened. Using the correct value for $Q_{RESERVE}$ would lead to a much more conservative assessment and, if any watersheds fail the stress assessment, then true in-stream flow requirements should be determined. Given all the other uncertainties, it would be better to risk a false positive (i.e. incorrectly identifying a catchment as stressed) than a false negative. For the sake of consistency, however, we used 10% reserve in our analysis.	Text modified slightly.

SB (MNR) Page 48: The methods provided for estimating the groundwater reserve in the WB/WQRA guidance module were outlined in the preferred order of use. Given that CLOCA has developed a numerical groundwater model it would be most appropriate to derive the groundwater reserve value (e.g. 10% of the estimated average annual groundwater discharge) consistently across the SPA from the simulated model outputs. It appears the report currently uses a combination of techniques including baseflow separation for gauged catchments and simulated discharge for ungauged catchments. Additionally the report calculates three variations of the groundwater reserve based on different baseflow separation techniques (e.g. average minimum flow, smoothed minima, median flow) which are not discussed in the report. Based on the variation of methods used and the information provided in Tables 27 and Table 28 it is difficult to determine exactly how the groundwater reserve values have been produced for each individual subwatershed.	As stated in the report, we first estimated groundwater reserve based on real data, i.e., long-term gauge data. However, it is difficult to extrapolate the results to the ungauged catchments. As an alternative, we used model results, which compared well at the gauges, for estimating the reserve for the whole CLOCA area. The results are provided in Table 28 and in the stress analysis tables. The different baseflow methods are described and compared earlier on in the report	Text added to clarify
SB (MNR) Page 50: The table in Section 6.2.1 of the report that is reproduced from the WB/WQRA guidance module contains a known error in the text for the 'Calculation' column of groundwater reserve. The table mistakenly indicates that, "Component of baseflow discharge: suggest 10% of the total groundwater supply should be maintained as a reserve". The preferred method of calculating the groundwater reserve is to use 10% of the estimated average annual groundwater discharge if it can be calculated using a numerical groundwater model. The second preference is to calculate the groundwater reserve using baseflow separation technique. The use of 10% of the total groundwater supply as the groundwater reserve value should only be used if the first two techniques are not able to be calculated.	We used 10% of $Q_{DISCHARGE}$ as indicated in the report. Really, it makes no difference in most catchment. If we do a groundwater balance for the basin (as per Chris Neville), we have: $P + Q_{IN} = ET + RO + Q_{GD} + Q_{OUT} + Q_{ST}+Q_{GT}$ Rearranging: $(P - ET – RO) + Q_{IN} = Q_{GD} + Q_{OUT} + Q_{ST} + G_{GT}$ Or: $Q_{RECHARGE} + Q_{IN} = Q_{GD} + Q_{ST} + G_{GT}$ If we assume that that takings are relatively small and that QNET (i.e., Q_{IN}-Q_{OUT}) is small, as in most of the CLOCA watersheds, we simply have that: $Q_{SUPPLY} = Q_{GD}$	Text in Table Section 6.2.1 corrected clarify
SB (MNR) Page 53: In the report it states, "Q_{SUPPLY} was calculated using the average monthly flows as determined in the PRMS model as discussed in Section 3.6 while $Q_{RESERVE}$ was estimated using the simulated mean monthly and mean annual streamflows in accordance with the Tessman method (See Section 5.1). In some instances, the surface water reserve exceeded the available flows. Guidance Module 7 indicates that in these cases, the water reserve should be set to a realistic proportion of the water supply. Accordingly, in those cases, $Q_{RESERVE}$ was calculated as 30% of Q_{SUPPLY}". As indicated in the WB/WQRA guidance module the median monthly flows, not the average monthly flows, should be used to calculate the Q_{SUPPLY} term. As indicated above the Q_{P90} statistic should be used to calculate the $Q_{RESERVE}$ term. The observation in the report where the surface water reserve exceeds the available flow is likely due to the incorrect calculation of the Tessmann statistic, in part due conflicting methods available in published reports. As discussed at our at our peer review meeting on February 28th, 2008 these calculations will have to be revised.	As per previous comments, we will use the Q_{P90} statistic and remove the Tessman discussion.	Change in approach has been made. Tables and text revised
SB (MNR) Page 57: Section 7 of the report discusses uncertainty primarily in terms of the surface water and groundwater models used for the Tier 1 assessment. While there is undoubtedly uncertainty with all models, this section of the report should primarily deal with the uncertainty associated with the stress level assignment to each of the subwatersheds. In comparison to many other SPRs across the province the	While we did put in a considerable effort into using the best available techniques for assessing water supply, we would be remiss if we did not offer a critical assessment of the uncertainties involved in even the best modelling efforts. From our experience and peer review comments for the	No change needed

level of modelling effort used in this report is very high and it produces some of the more certain assessments possible using current techniques. In this sense it is likely that both the Q_{SUPPLY} and $Q_{RESERVE}$ components of the assessment, when calculated correctly, will have relatively low uncertainties. As is briefly mentioned in the report the largest amount of uncertainty is likely associated with the values used for the Q_{DEMAND} component of the assessment. Focussing the discussion of uncertainty around the stress assessment calculations and the assigned stress levels would add value to the report.	Conceptual water budget as well as MOE Operations staff cautions as part of this peer review, the documentation of uncertainties associated with models is critical to its use in other projects. We did note that uncertainty related to demand is most significant. From the last paragraph of Section 7, Uncertainty, Data and Knowledge Gaps : *"CLOCA, however, is committed to watershed protection and improving of their understanding of the watersheds, and as such has developed a list of data and knowledge gaps for their watersheds (CLOCA, 2007).* ***Most significant of these, from a water budget perspective, is a more comprehensive understanding of the*** Q_{DEMAND} ***components of the water budget, including assessing the permits and actual water use.****"* This comment about demand uncertainty is also repeated in the Executive Summary.	
Tables:		
SB (MNR) Table 11: Although the information in this table is discussed on Page 38 in the surface water supply section it would be useful if the table was referenced in the report. As discussed in the comments above it would be more appropriate if this table contained median monthly stream flow values rather than average monthly stream flow values.	Table is now referenced and has median values	Revised
SB (MNR) Table 15: This summary table of water demand does not show the breakdown between permitted and un-permitted (e.g. irrigation and livestock watering) uses which would be useful to assist in evaluating the demand calculations. While a back-calculation can be performed to determine the permitted value as the residual from the reported un-permitted water taking estimates it would be easier if this information was displayed in the summary table.	Comparisons of the different components of the water demand were included in the text. For example, on page 45 the following is presented: *"…golf course irrigation and snowmaking are the two most significant permitted groundwater uses in the CLOCA watersheds. For comparison, however, the total estimated un-permitted agricultural demand, at 10,627m3/d (0.123 m3/s in Table 18), exceeds both total permitted golf course irrigation (3937 m3/d) and total permitted snowmaking (3000 m3/d)."* Other comparison are also include in the text, for example: *"Based on these assumptions, livestock consumptive demand, as calculated above, is approximately 10 times greater than unserviced human consumption"*	
SB (MNR) Tables 19 & 21: It would be useful if these tables displayed both permitted and un-permitted monthly values separately for each month. The tables currently lump these two water demand components together which makes it difficult to assess the relative contribution of each component to the monthly demand.	As noted above, the text discussion provided the summaries and comparisons of the components of the water budget. The noted tables are already quite large (15 columns) and are already presented in landscape format, so doubling the number of columns to show monthly breakdown of permitted versus non-permitted would make the text very	

	small and the table overly complicated. The text also discusses how winter snowmaking nearly balances with summer golf course irrigation, so the permitted takings do not show significant seasonal variation.	
SB (MNR) Table 28: As discussed in the comments above the information provided in this table is derived from a combination of techniques (e.g. 10% of the estimated average annual groundwater discharge and baseflow separation techniques). It is not possible to determine which of these techniques has been used to calculate the groundwater reserve value for each of the individual subwatersheds due to the lumped way in which they have been reported. The preferred method to calculate the groundwater reserve consistently across all subwatersheds is to use 10% of the estimated average annual groundwater discharge as derived from the simulated groundwater model outputs.	Not so. All stress assessment and Table 28 values are from model	Text added to clarify
SB (MNR) Table 29: As discussed in the comments above the Q_{SUPPLY} term will have to be re-calculated to represent $Q_{RECHARGE}$ + Q_{IN} rather than $Q_{RECHARGE}$ + Q_{NET}. The $Q_{RESERVE}$ value should also be re-calculated using 10% of the estimated average annual groundwater discharge rather than the average minimum flow baseflow separation technique.	Tables revised for Q_{IN}. Reserve was correct in the original report so no change is needed there.	Tables revised for Q_{IN}
SB (MNR) Table 30: This table should show the individual components (Q_{DEMAND}, Q_{SUPPLY}, and $Q_{RESERVE}$) of the monthly stress assessment calculation for each of the subwatersheds. It is unclear from the equation provided in the header of the table whether the $Q_{RESERVE}$ component has been included in the calculation.	Tables headings revised	Revised
SB (MNR) Table 31: Similar to Table 29, the Q_{SUPPLY} term will have to be re-calculated to represent $Q_{RECHARGE}$ + Q_{IN} rather than $Q_{RECHARGE}$ + Q_{NET}. The $Q_{RESERVE}$ value should be re-calculated using 10% of the estimated average annual groundwater discharge rather than the average minimum flow baseflow separation technique.	Tables revised for Q_{IN}. Reserve was correct in the original report so no change is needed there.	Tables revised for Q_{IN}
SB (MNR) Table 32: Similar to Table 30, this table should show the individual components (Q_{DEMAND}, Q_{SUPPLY}, and $Q_{RESERVE}$) of the monthly stress assessment calculation for each of the subwatersheds. It is unclear from the equation provided in the header of the table whether the $Q_{RESERVE}$ component has been included in the calculation.	The detailed calculations are included in the CD-ROM spreadsheets. These are very large tables (more than 100 rows), and a single table would span multiple pages, so it is better that the user refer to the digital versions for the details.	
SB (MNR) Table 33: Similar to Tables 30 and 32, this table should show the individual components (Q_{DEMAND}, Q_{SUPPLY}, and $Q_{RESERVE}$) of the monthly stress assessment calculation for each of the subwatersheds.	Same	
Figures		
Response to Comments Received from Durham Region November 4, 2008		
Dagmar PTTWs incorrectly Included in the Lynde Creek Watershed:	The Dagmar permits are within a few hundred metres of the watershed boundary, and therefore were captured in the buffer. These permits are actually outside of the watershed and have been removed from analysis.	Permits removed from Lynde watershed (No longer included in CLOCA WB). All related tables and figures updated
One of the three Columbus Golf Course Permits was included in Lynde Watershed, while it should be in	Incorrect UTM locations were provided, causing the location error.	Permit moved to

the Oshawa Creek Watershed.	Updated UTM location was estimated from other two Columbus permits. Permit correctly assigned to Oshawa watershed.	correct watershed. All related tables and figures updated
Two unknown permits at “3160 Hwy. #7, Pickering” should be removed from analysis.	As requested, these permits have been removed from the analysis.	Permit removed from analysis. All related tables and figures updated
Darlington Watershed No. 11: The St. Mary’s Cement (SMC) pumps for quarry dewatering and industrial cooling are located very close to the shore of Ontario Lake (OL). As per the coordinates provided in Table 33, the pumps are located 60m to 250 m from OL. The SMC PTTW is for the removal of a large amount of water, driving the stresses to moderate and significant for groundwater and surface water, respectively, for the Darlington Watershed. We believe that majority of the Darlington Watershed cannot be moderately/significantly stressed by these takings because they are located so close the shore of OL.	The pumps are located within the watershed. It is possible that much of the water comes from the higher water levels in the overburden aquifers north of the quarry. Alternatively, a portion of the water may come from the south (Lake Ontario). We removed the Dagmar permits (as noted above) because they were just outside the watershed. For consistency, we have left the quarry permit in the watershed.	No change needed
Seasonal Consumption Factor As shown in Table 2, below, it appears that golf course irrigation wells and snow making supply wells are not consistently considered as a seasonal use (a factor of 1 was used). Golf course operators do not irrigate before May 15 or after October 15, even though the golf courses are open much longer. There is potential for breaking irrigation lines when the shallow irrigation lines freeze and golf course operators do not risk expensive repairs. Therefore, a seasonal factor of 0.42 is appropriate. Similarly, snowmaking operations will start to fill reservoirs in November and snowmaking ends around the beginning of March when the temperature becomes too high so a seasonal factor of 0.33 is appropriate.	The factors identified in the review comments are, the **monthly allocation factors,** which vary between 0 and 1 for each month. For example, the Stonehenge GC has a permit for 150 days, or 4.9 months. Therefore, the monthly allocation factor for April was 0.9, and May through Aug was set to 1.0, for a total of 4.9 months of consumption. All other months had a monthly allocation factor of 0.0. These factors (as outlined in provincial Water budget guidance of April 2006) are used to more realistically represent the months of use where actual pumping data are not available and for use in determining the monthly groundwater stress. Study teams were additionally encouraged to fine tune individual permitted takings where it is expected that only part of a month would have takings. In this report, the study team reviewed each permit (and type of operation) to estimate the months of use especially when the permit was granted for a 365 day period. Without local permit specific information (not required for Tier 1), the monthly allocation for each permit was based on general pumping time expectations and best conservative estimates (spring – fall for golf course). Note that the maximum consumption (daily and annual) are correct as provided in the PTTW database. Future revisions will incorporate actual data as it becomes available.	No change needed.
Holding Ponds Holding and dugout ponds are used to store groundwater pumped from wells to supply water for peak	Not enough is known to assess the operational issues associated with each permit. Similarly, we have been quite conservative in the application	No Change need.

demands. Therefore, using water pumped from these ponds to calculate surface or groundwater water stress assessments is a duplication of the groundwater or surface taking. An example is shown in the Table 2, where Dagmar Ski Resort has two of five wells pumping into a pond. PW5 is pumping 2,046L/min and PW10 is pumping 2,500 L/min and their sum equals to 4,546 L/min which is the same amount of water pumped from the irrigation pond for snow making. Takings from holding ponds and dugout ponds should be reviewed in detail before including all, or a portion, of them in surface water or groundwater stress assessment calculations.	of the consumptive return factors, for we assumed that consumption was relative to the watershed, and not the aquifer. For example, we assumed that Golf Course pumping was 70% consumptive (as per Guidance), however we could have assumed that they were most likely drawing water from the deeper aquifers and were therefore 100% consumptive. Individual assessment of the consumption is beyond the data available to a Tier 1 assessment.	
Response to Comments Received from R. Gerber dated November 13, 2008		
Overall, I think that this is a very good report. I agree with the general conclusions of this screening stress assessment that Lynde and Darlington subwatersheds are experiencing moderate groundwater stress. Since this stress is not municipal supply related or induced then any future analysis of this issue should be explored under other programs, not as a Source Water Protection program Tier 2 water quantity analysis	Agreed. Thanks!	General comment. No change needed.
This analysis has determined through model simulations that recharge received outside the CLOCA watersheds discharges to streams within the CLOCA jurisdiction. This estimation will have implications to CLOCA and neighbour (e.g. TCC SWP Area) water quantity issues within and outside of the Source Water Protection program that should be further tested and reconciled. Note that even with inflow along the moraine crest that some watersheds have simulated discharge lower than estimated observed (e.g. BowmanvilleCreek). This could suggest other physical processes and/or limitations in estimation (e.g. baseflow separation) and simulation methodology;	Agreed. Further analysis is beyond the scope of a Tier 1 assessment.	No change needed.
I agree with the statements in the text that many reported (and non-reported) water takings, particularly within the MOE PTTW database, require further and on-going verification effort	Agreed. PTTW Review and validation is ongoing by CLOCA.	No change needed.
The sensitivity of the many parameters utilized within PRMS may be better understood as more applications test the model in other areas of south-central Ontario. This knowledge should be incorporated into any future model refinements;	Agreed. (Recommendation for future refinement and analysis.)	No change needed. (Future recommendation)
The GSC mapped (1997) outcroppings of “Lower Sediments” in the Bowmanville Creek headwaters (northwest of Enniskillen) are, I believe, mainly MIS/ORAC sediments. Through discussions with Dave Sharpe over the years, he once believed that the ORM sediments did not occur very far to the south of the moraine under the Halton Till, if at all. Since this surficial mapping has been released, I believe he has changed that belief somewhat. Looking at boreholes in the Enniskillen area, it appears that the Halton Till is present at or near surface underlain by another till, presumably the Lower Newmarket till that appears to occur beneath the streambed elevation. Intervening silt/sand, etc would then be interpreted to occur within the Oak Ridges Moraine sediment package. I will note that there does exist one small area beneath the stream bed where the Lower Newmarket till may be absent; however, this may reflect limitations in the water well record database. The report states that v5 geologic surfaces are used in the model. I don’t know what the v5 geologic surfaces are, but if they have Lower Sediments at surface in this area then this is different than the geologic interpretation (Dec 2007) that is currently being utilized in the Durham Region model being constructed for the YPDT-CAMC Oak Ridges Moraine hydrogeology program. I haven’t done this nor do I know if enough data exist, but perhaps a detailed hydraulic head analysis may shed some light on the subject. Figure 37 shows that Layer 3 sediments are absent in this area. Figure 39 does show some simulated contour patterns at Enniskillen suggesting possible discharge from Layer 5 (Thorncliffe Aquifer Complex), although the observed heads are hard to read on this figure.	Agreed. This is an important and geologically complex area. A visit to the Enniskillen area was arranged on November 25, 2008 with R. Gerber and M.J.Ford to attempt to evaluate the sediments in this noted area. Soil samples and outcrops were reviewed and analysis is ongoing as to the stratigraphic conditions in this area. Additional analysis is recommended for future model updates.	No change needed. (Future recommendation.)