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Memorandum

To: Sue Miller
From: Neil Hutchinson

Date: January 05, 2011

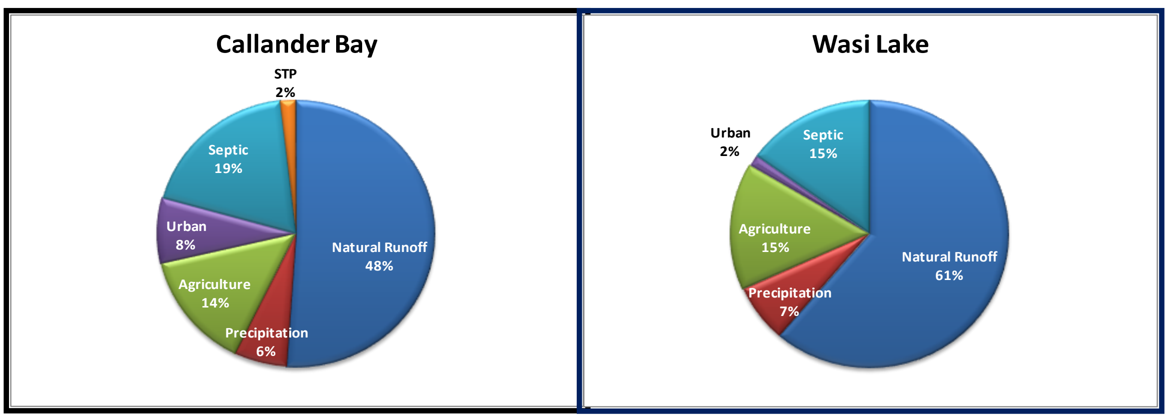
Project No.: **HESL J100024**

Re: Distribution Material for January 13 Callander Bay Meetings

The following material has been excerpted directly from our report on the Callander Bay Subwatershed Phosphorus Budget to inform discussions at our meeting of January 13, 2011. We have incorporated the review comments received on our November 2 draft report and the final report is in the final stages of revision to incorporate refined estimates of land use in the watershed. Our initial assessment, however, is that, while these may reflect fine-tuning of the phosphorus budget they do not substantially change the conclusions of the draft report.

Overall Phosphorus Budget

Figure 1. Relative contribution of phosphorus sources to the total phosphorus loading to Callander Bay and Wasi Lake assuming no attenuation of septic phosphorus by soils.



Phosphorus Budget Validation

Measured Versus Modelled Loading from the Wasi River provides confidence in method.

Measured Annual Load 4,105 kg/yr, 0. 184 kg/ha/yr/ 55% occurs during spring runoff
Modelled Annual Load 4,924 kg/yr (16% difference)
3,465 kg/yr (4% difference) if Wasi Lake retention is considered.
Septic phosphorus assumed mobile.

Phosphorus Concentration Modelling – Wasi Lake

Measured Versus modelled concentration provides confidence in method.

Measured Concentration	37.1 ug/L (2007-2009), 33.3 (2007/2009)
Modelled Concentration	32.4 μg/L assuming septic phosphorus is mobile 28.8 ug/L assuming 26% mobility

Phosphorus Concentration Modelling – Callander Bay

Measured << Modelled concentration

Measured Concentration	21.7 ug/L (2007-2009)
Modelled Concentration	25.4 μg/L assuming septic phosphorus is mobile 22.8 ug/L assuming 26% mobility

Model provides reasonable estimate of response of Bay to loading reductions.
Most likely reason is dilution via mixing with Lake Nipissing.

Information Gaps and Future Monitoring Requirements

Information gaps lead to uncertainty in the relative contribution of different sources of phosphorus to Callander Bay, as well as the response of Callander Bay, particularly for agricultural activities.

Recommendation 1. Refinement of Agricultural and Urban estimates.

Runoff from agriculture and urban areas made up ~22% of the total load to Callander Bay and ~ 50% of the anthropogenic load. These areas represent sources that could potentially be reduced. Further detail is needed; however, in order to a) confirm the estimates and b) identify those areas for mitigation.

The agricultural land cover class does not differentiate between agricultural activities or identify livestock operations that would supply significantly different amounts of phosphorus.

> 1.1 - We therefore recommend that agricultural land use classifications be refined to include areas of devoted to pasture, field crops and row crops and to separate out golf courses and manicured lawns from agricultural practices. This could be done by targeted aerial photography or more detailed analysis of satellite data.
>
> 1.2 - We recommend that information regarding the number and type of animals on watershed farms, the location and sizes of feed lots and manure piles be collected to a) aid in the determination of phosphorus loading from livestock operations and b) identify the best options for BMP implementation. This could be most accurately done by a direct watershed inventory of each agricultural operation.

Recommendation 2. Continue and Expand Tributary Monitoring.

The availability of measured phosphorus concentration data was very useful and showed that the loading estimates for the Wasi River were valid. Our review of hydrologic data showed, however, that flow was variable between years and so loading would also be expected to be. Callander Bay has a hydrologic flushing rate of ~1.9 years (independent of wind derived mixing of water from Lake Nipissing) and so would be expected to reflect the influence of the previous two years of watershed loading in any one year.

2.1 - We therefore recommend that the Wasi River monitoring conducted by the NBMCA continue for at least two more years in order to assess interannual variability in loading to Callander Bay. Sampling should continue year round with particular focus on the spring freshet period (late March to end of May) future years. Although more detailed data review may allow some of the existing sites to be dropped for further surveys, we note that the costs of sampling are largely associated with labour, and that additional phosphorus analyses are relatively inexpensive.

2.2- At the time of report production, phosphorus concentration data were only available for June to September, 2009 for Chiswick and Graham Creeks. Additional data are required to estimate concentrations for the remainder of the year particularly in spring (April, May), and to establish mean annual concentrations and to refine loading estimates. These data could then be used to validate the export coefficient loading estimates at discrete points along the tributaries as was done for Wasi River.

2.3 - Additional monitoring sites should be established in agricultural streams to collect phosphorus concentration and flow data. This information would allow calculation of landuse–specific phosphorus export from agricultural lands and be used to inform management opportunities. The number and locations of additional sites and types of agricultural streams should be determined based on the results of the watershed inventory of different agricultural practices.

2.4 – Loading estimates require accurate assessment of flow as well as concentration. Although the WSC gauge near Astorville provided useful estimates of flow for the other sites on the Wasi River, the accuracy of prorating varies and decreases with smaller streams. We therefore recommend that flow measurements be taken at the same time as water quality samples at a) water quality sites on Chisholm and Graham Creeks and b) any agricultural streams identified for sampling in Recommendation 2.3.

Recommendation 3. Callander Bay Phosphorus Load

Internal loading of phosphorus from anoxic sediments in Callander Bay is a potential source that could be neither confirmed nor excluded in the present study. Internal phosphorus can represent a significant source to some cyanobacteria species that can alter their buoyancy to take advantage of it.

3.2 – We recommend that 4-6 profiles of phosphorus, temperature and dissolved oxygen be taken at 1m intervals from two deep locations in Callander Bay in August and September. Half the profiles should be taken after and during periods of calm conditions and half when wind has altered stratification.

The phosphorus budget and preliminary model substantially overestimated phosphorus concentrations in Callander Bay but provided good agreement for Wasi Lake. The export coefficient model agreed well with measured loads in the Wasi River. The phosphorus budget therefore appears to be reliable but the model for the response of Callander Bay is not. Northland Engineering (1993) reported that water from Callander Bay does mix with Lake Nipissing. This influence could be substantial but is un-quantified.

3.3 - We recommend that further investigations of the mixing of Lake Nipissing with Callander Bay be investigated, to assess the degree of mixing and resultant effect on phosphorus concentrations in the Bay.

Recommendation 4 – Septic Systems

Refinement of initial estimates by the NBMCA showed that there are 986 septic systems within 300m of Callander Bay and its tributary streams, and that 589 of these lie within the IPZs that were identified for Source Water Protection Planning. The significance of septic systems as a phosphorus source is uncertain because of uncertainty in the retention of phosphorus in soils, although failing systems will certainly represent a phosphorus source.

> 4.1 – Periodic septic inspections are therefore recommended for systems within 100m of an IPZ. Any systems identified as failing should be replaced or remediated.

Septic systems contribute anywhere from ~6% to ~20% of the total loading of phosphorus to Callander Bay, dependent on assumptions regarding phosphorus mobility from that source. The study suggests that septic system phosphorus is mobile, based on agreement with modelled and measured estimates for Wasi Lake. The importance of soils in phosphorus mobility, however, suggests that some confirmation of soil characteristics would inform the assumptions.

> 4.2 We recommend that samples of B horizon soils be taken from 6 locations within 100m of surface water in each of the Callander Bay and Wasi Lake watersheds and analysed for mineral content and phosphorus adsorption capability to inform the likelihood of septic phosphorus mobility.

> 4.3 – We recommend that mapping of surficial soil depths be obtained for the watershed to identify areas of high risk from septic systems based on soil depth, slope and proximity to surface waters. These areas would be targeted for septic reinspections and for enhanced setbacks from surface water for new approvals.

Recommendations for Mitigation

Phosphorus loads from diffuse human sources represent a high proportion of the total load to Wasi Lake (32%) and Callander Bay (41%), which can be controlled by management practices (Figure 16).

Figure 2. Schematic illustrating phosphorus loads that can be controlled by management techniques.

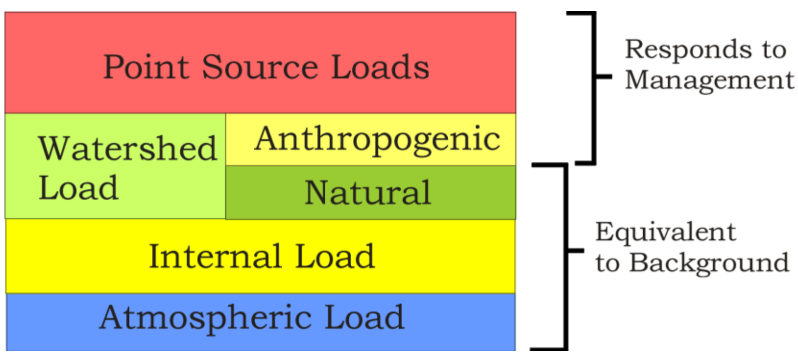


Table 1. List of Best Management Practices to Reduce Diffuse Phosphorus Sources in the Callander Bay Watershed

Category	Best Management Practices	Regulated (R)/ Voluntary (V)
Urban		
Stormwater Management	Source controls (pet waste collection, street cleaning, reduced fertilizer)	V
	Lot level controls (e.g. grading, infiltration, green roofs)	V
	Conveyance (transport) controls (permeable pavement, pervious pipe, grass swales)	V
	Stormwater treatment (e.g. constructed wetlands, sand filters, OGS[1])	V
	Stormwater Ponds	V
	manufactured BMP systems (alum additions, etc)	V
Riparian	Buffer strips, riparian maintenance in urban areas	V
Agriculture		
Runoff from Crops	Match fertilizer application to crop nutrient requirements and soil properties	V
	Crop rotations	V
	Proper fertilizer application timing	V
	Cover crops during non-grow season	V
	Improved fertilizer storage	V
	Reduced or no tillage	V
	Buffer strips (Vegetated areas along waterways), riparian maintenance	R
	Irrigation management (e.g. low water-loss technologies, reduced system leakage, optimal irrigation timing)	V
Livestock Operation	Restrict livestock access to surface water	R
	Rotation of grazing pastures	
	Minimizing runoff from livestock yards	V
	Milkhouse wash water treatment	V
Runoff from Farm Yards	Stormwater retention ponds, constructed wetlands, berms (soil barrier), planted waterways etc.	V
Manure	Manure storage controls	V
	Manure treatment (dewatering & nutrient removal systems)	V
	Manure land application practices (e.g. crop requirements)	V
	Distance from waterways, buffer strips between piles and waterways	R
Airborne Nutrients	Wind breaks (trees, hedges etc. to reduce soil erosion)	V
Biosolids	Restrictions on timing of applications	R
	Setbacks, application factors (soil type, slope, compaction)	R
Shoreline Development		
Septic Systems	Design/installation and initial inspection	R
	Use of best available technology	V
	Maintenance - pump regularly etc.	V
	Follow-up inspections	V
	Use of phosphate free products (into septics)	V
Overland Flow	By-laws regulating new lot sizes in Official Plans	R
	Limit use of lawns and fertilizers	R/V
	Buffer strips, riparian maintenance	V
Recreation	Grey water (non-sewage wastewater) disposal from boats	V

Table 2. Examples of Effectiveness of Best Management Practices for Phosphorus Load Reduction from Agriculture and Septic Systems

BMP Category	Specific BMP	Phosphorus Load without BMP	Phosphorus Export Reduction (%)
Milkhouse wastewater treatment	Flocculator	0.69 kg TP/cow/yr (excluding manure); 2.76 kg TP/cow/yr (including manure)	95-99
	Vegetated Filter Strip		7.2 – 100
	Settling Basins		5 – 67
	Constructed Wetland		45% - 99
	Anaerobic Lagoon		54-91
	Facultative Pond		5.5 – 91 (most > 80)
	Aerobic Lagoon		30-47
Manure storage	Daily Spreading	15.2 kg TP/cow/yr	90
	Dry & Roof		90
	Earthen		60-80
	Lagoon/flush		40-80
	Open Lot		70 +/- 20
	Pits & slats		95
	Scrape/storage tank		85-90
	Dairy pile manure	15.6 kg TP/cow/yr	80
Clean water diversion	Roof Diversion for Feedlot manure	Same as for Manure Storage	70
	Roof Diversion for Stockpiled Dairy Manure		80
	Berm Diversion for Feedlot Manure		70 for portion of runoff that is being retained by berm (often ~half)
Restrict livestock access to streams	Fencing Off (providing alternative water source)*	0.46 kg/cow/yr (Beef) 0.23 kg/cow/yr (Dairy) (from manure only)	100 (effect on manure only)
	Fencing Off	Erosion loss to be calculated for access area	75 – 98 reduced TP loss from erosion
Conservation tillage	Disk	1 kg/ha/yr	93
	Ridge Till		59
	Reduced Till		85%
	No Till		61%
Buffer strips for streams through crop land	Width ≤ 5 m		56%
	Width 6-10 m		67%
	Width 11 + m		74%
Cover crops			60%
Fragile land retirement			30%
Septic systems	Improve failing septic systems (only if within 50 m of a surface water body)	0.6 kg TP /capita/yr	70%

Notes: Source: South Nation Conservation 2003. "Phosphorus Loading Algorithms for the South Nation River". Updated Source Accounting Methodology for the Rural Water Quality Program (prepared by Chris Allaway, University of Ottawa).
**Providing alternative water source does not guarantee 100% reduction, but can still be effective (77% of reduction in stream bank loss and 98% in TP loading)*

BMPs provide large opportunities for reducing the phosphorus contribution of diffuse sources from agricultural lands and septic systems to Callander Bay.

Once data gaps have been filled for agricultural areas and septic systems, appropriate BMPs can be selected to best address phosphorus loadings from these sources.

Recommendation 5 "No Regrets" Mitigation

Although some specific recommendations for more information are presented above, there are Best Management Practices that produce environmental benefits that should be implemented to protect Callander Bay, even in the absence of complete documentation of their relative importance.

5.1 – Efforts to reduce the attractiveness of nearshore areas as habitat for Canada geese would reduce loading of phosphorus and bacteria to Callander Bay and its tributaries. This can be done by enhanced plantings of emergent vegetation in the littoral and riparian areas to discourage use by geese.

5.2 – Efforts to improve management of livestock and manure runoff to keep both away from surface waters provides immediate benefits in restoring riparian habitat (through elimination of grazing pressure and trampling) and reduced bacterial and nutrient loading. A survey of watershed streams should be undertaken to identify candidate streams or stream areas, investigate cooperative programs for fencing and riparian zone protection, and means to divert runoff away from manure piles to reduce the effectiveness of runoff as a pathway for loading to surface waters.

5.3 – Water quality and aquatic habitat in streams throughout the watershed would be improved by maintenance of riparian buffer strips of natural vegetation. These would shade streams, filter out particulate pollutants, take up dissolved nutrients and provide coarse particulate matter (fallen vegetation) for habitat, structure and carbon source to the streams. A survey of watershed streams should be undertaken to identify candidates for riparian enhancement programs.

5.4 - Fertilizer applications to shoreside lawns are an unnecessary source of phosphorus load to surface waters. Stewardship initiatives should be undertaken to a) promote phosphorus free fertilizers or fertilizer-free lawns. A single application of 10:10:10 fertilizer to a 30m*30m lawn contains nearly 2 kg of phosphorus, and some of this may be mobilized to the water.

5.5 – Riparian buffer strips of natural vegetation provide habitat, filter particulate matter and take up dissolved nutrients. Naturalization of shorelines should be encouraged adjacent to Wasi Lake and Callander Bay.

5.6 – Urban runoff contributes up to 400 kg/yr, (6%) of the phosphorus load to Callander Bay. This represents ~ 20% of the human source. Stormwater pathways to Callander Bay should be investigated, and a catchment by catchment survey undertaken of the potential means to reduce this by promoting infiltration, stormwater detention, sheet flow through grassy swales and reductions in urban fertilizer use.

Implications for Source Protection Planning

The Technical Rules require delineation of an 'Issue Contributing Area (ICA) - area within which activities contribute to the concentration of a contaminant at a drinking water intake that is listed as a drinking water issue. For Callander - phosphorus was listed as a drinking water issue based on the documented occurrence of toxin-producing cyanobacteria blooms in Callander Bay and the known relationship between phosphorus concentrations and algal bloom activity. The ICA was defined as the entire vulnerable area of the Callander intake (i.e., all IPZ areas), which is the maximum area allowed by the Technical Rules. Some uncertainty if defined ICA captures the primary sources of phosphorus to Callander Bay from human activities.

Results of the phosphorus budget for Callander Bay indicate that a large portion of the land area in the Callander Bay watershed is encompassed by the Intake Protection Zones, or the Issue Contributing Area (ICA). Human sources of phosphorus in the ICA contribute a large portion (up to 84%) of the loading from human sources to Callander Bay. Therefore the ICA defined by HESL (2010) does capture the primary sources of phosphorus to Callander Bay from human activities in the watershed.

Recommend that the ICA remain as defined.

Phosphorus budget can be used to better inform the classification of threats (i.e., as significant, moderate or low) for drinking water source protection. Threats are defined by the Technical Rules as activities that contribute or potentially contribute to a contaminant at the intake. Therefore could rank human phosphorus sources according to their potential phosphorus loading contribution. This would, however, require refinements of the phosphorus budget to specifically account for loadings from different agricultural activities and from septic systems.

Conclusions

The phosphorus budget for Callander Bay derived from export coefficient modelling and measured phosphorus loads provides a reasonable estimate of phosphorus loadings from all major sources in the watershed, including natural sources (i.e., atmospheric deposition and runoff from undisturbed land areas) and human sources (i.e., agriculture, urban runoff, septic systems and STP effluent). Validation of the phosphorus budget with measured phosphorus loads in the Wasi River and by comparison of measured and modelled phosphorus concentrations in Wasi Lake provides a high degree of confidence in the total load estimates. Uncertainty in the relative contribution of phosphorus loadings from septic systems and different agricultural practices remains, however, but can be addressed with the collection of additional site-specific information.

Human sources account for approximately 41% of the total phosphorus loading to Callander Bay and 32% of the loading to Wasi Lake, a large portion of which can be controlled by Best Management Practices. Identification of the most appropriate BMPs for Callander Bay and Wasi Lake requires refinement of the phosphorus budget to better account for loadings from different types of agricultural practises and from septic systems. Nevertheless, a series of “No Regrets” BMPs can be implemented at low cost, and these will improve water quality and produce other benefits.

While considerable load reductions can be achieved by BMPs, the natural phosphorus loading to Callander Bay and Wasi Lake is large such that these water bodies may remain relatively productive with potential for algal bloom activity even if all human sources of phosphorus were eliminated. In particular, phosphorus concentrations in Callander Bay increased in the years after 1950, when the Portage Dam was built at the outlet of Lake Nipissing. Nevertheless, phosphorus load reductions and resultant reductions in phosphorus concentrations in Callander Bay and Wasi Lake over current levels would reduce the risk of cyanobacteria blooms.