Soil & Water Conservation Society of Metro Halifax (SWCSMH)
310-4 Lakefront Road, Dartmouth, NS, Canada B2Y 3C4
Email: limnes@chebucto.ns.ca Tel: (902) 463-7777
Master Homepage: http://lakes.chebucto.org

Ref.:	LakeEcho2014 (9 pages)
To:	Harbour East - Marine Drive Community Council (HEMDCC), HRM
From:	S. M. Mandaville Post-Grad Dip., Professional Lake Manage. Chairman and Scientific Director
Date:	January 15, 2014
Subject:	LAKE ECHO- HRM's synoptic data of 2006-2011 is of considerable concern, and suggested restoration parameters

Please feel free to ask me any questions, and I will endeavour my level best to respond either via emails and/or in person at one of your meetings, if invited to do so. Written informally.

Restoration parameters for consideration by the HEMDCC are suggested on page-3.

I have provided a synopsis of the relevant data from various known sources referenced appropriately (see page-5). These are all deep station values (shallow zone values may differ considerably). A summary of the historical phytoplankton have been noted on pages-8 & 9.

Of specific interest are the TP (total phosphorus), the primary limiting nutrient, and Ch*a* (chlorophyll*a*) which is representative of the `algal production'.

HRM's TP data varied widely, 4-48 µg/l, with a mean of means of 14.7 µg/l during the years 2006-2011. That is an unexpected and alarming range, and very high compared with our modelled hindcast pre-cultural (+0.173 kg/ha.yr precipitation) value of 4.3 µg/l.

HRM's Ch*a* data had a wide range as well, 0.79-19.8 µg/l during the years 2006 to 2011 which is also high.

I also include the predictive phosphorus modelling conducted by my team some years back (results updated in page-5, and the pictorial model in page-7).

……../2

Environment Canada (2004) published a table which was derived from the 18-country OECD peer consensus (http://lakes.chebucto.org/TPMODELS/OECD/oecd.html) which I reproduce below:-

Table 4.1 Trophic classifications of lakes, with their corresponding phosphorus and chlorophyll concentrations and transparency (Secchi depth) (sources: Wetzel 2001; Vollenweider and Kerekes 1982).

Trophic level	Total Phosphorus ($\mu g \cdot L^{-1}$)		Chlorophyll *a* ($\mu g \cdot L^{-1}$)		Secchi depth (m)	
	Wetzel (2001)	Vollenweider and Kerekes (1982)	Vollenweider and Kerekes (1982)		Vollenweider and Kerekes (1982)	
			Mean	Max	Mean	Min.
Ultra-oligotrophic	< 5	< 4	< 1	< 2.5	> 12	> 6
Oligo-mesotrophic	5-10	4-10	< 2.5	< 8	> 6	> 3
Meso-eutrophic	10-30	10-35	2.5-8	8-25	6-3	3-1.5
Eutrophic	30-100	35-100	8-25	25-75	3-1.5	1.5-0.7
Hypereutrophic	> 100	> 100	> 25	> 75	< 1.5	< 0.7

To further understand the relevance of Ch*a* values, kindly note that the Kings County of Nova Scotia set a maximum objective <u>Ch*a* values in the low range of 2.5 µg/l</u> for 18 lakes. I herewith insert a scan from their policy in my archives:-

Kings County adopted water quality objectives for 18 lakes in the county, through amendment of MPS and LUB. The maximum objective value of chlorophyll-a for most of these lakes is 2.5 µgm/L. Seven of the lakes' objectives were set below the level of 2.5. Based on predictive modelling, the estimated maximum number of dwellings that could be added to the contributing area without exceeding the threshold value was established. This number of dwellings was set as a limit for development in the LUB. Policy in the MPS enables application for a permit with a development having "near-zero impact" through site standards or performance standards. Primarily this condition is expected to be met with septic field fill with a 20 year phosphorus input retention and a requirement to replace the fill every 20 years. A condition in adopting these limits was implementation of an annual monitoring program for a minimum of six years. The sampling required was to be completed by volunteers.

Page 9-12

……../3

Suggested deliberation for restoration by the community council:

(i) See the CCME's fact sheet (2004) for the phosphorus guidance framework (http://documents.ccme.ca/download/en/205/).

(ii) The CCME's framework recommends a maximum enrichment of 50% increase over the hindcast value of TP, and to not exceed the trigger range. The hindcast cultural (+0.173 kg/ha.yr precipitation) value is 4.3 µg/l, hence 50% increase results in a conc. of 6.4 µg/l, and the relevant trigger range is 4-10 µg/l. Hence 7.0 µg/l should be the goal which has been exceeded significantly based on HRM's data of 2006-2011. Any higher value may result in severe degradation as exemplified in the CCME document.

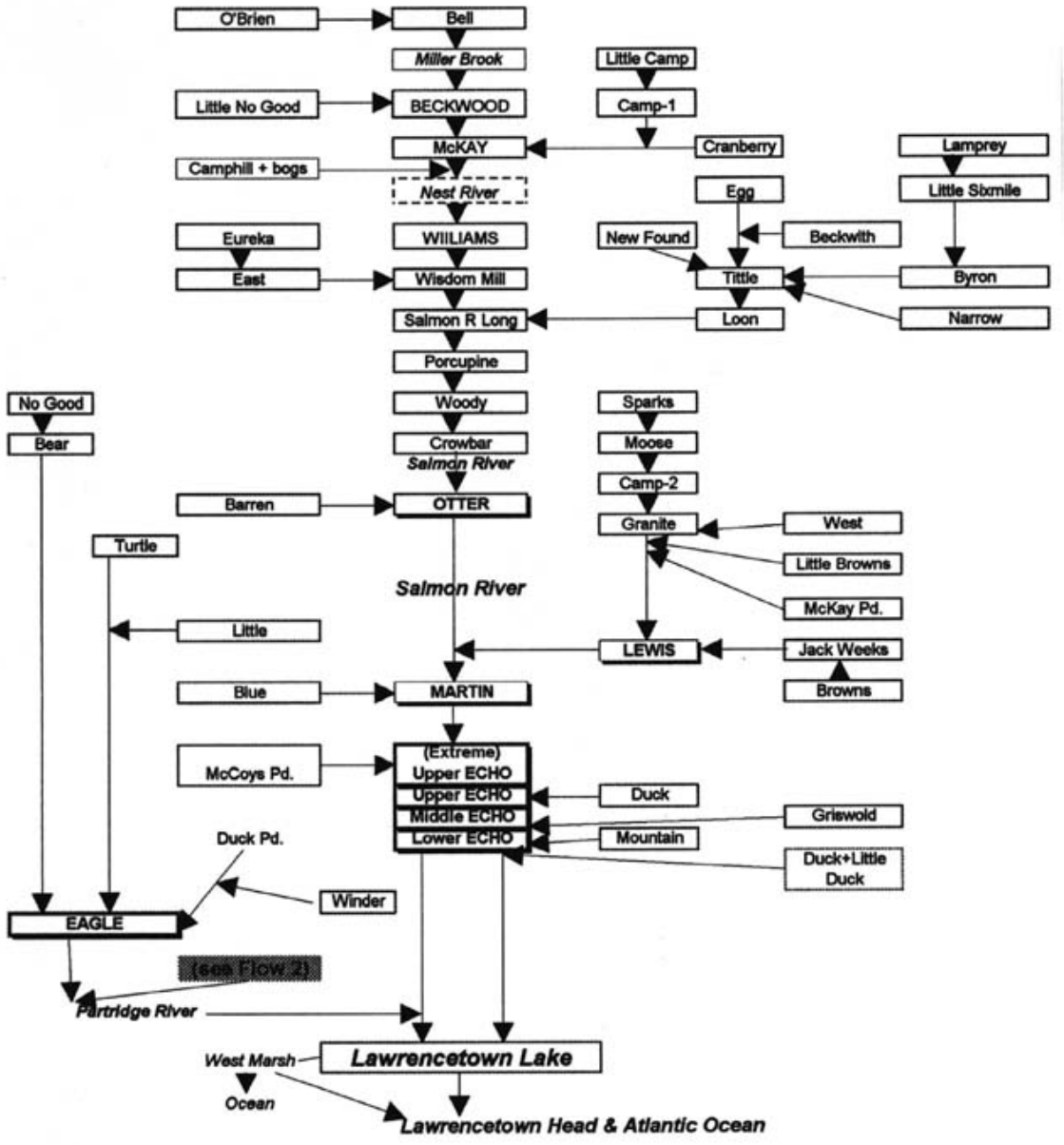
Total phosphorus (TP) trigger ranges for Canadian lakes and rivers (CCME, 2004)

Trophic status	TP (µg/l)
Ultra-oligotrophic	< 4
Oligotrophic	4-10
Mesotrophic	10-20
Meso-eutrophic	20-35
Eutrophic	35-100
Hyper-eutrophic	> 10

Per the CCME (2004), the framework offers a tiered approach where phosphorus concentrations should not (i) exceed predefined 'trigger ranges'; and (ii) increase more than 50% over the baseline (reference) levels. The trigger ranges are based on the range of phosphorus concentrations in water that define the reference trophic status for a site (i.e., hindcast values). If the upper limit of the range is exceeded, or is likely to be exceeded, further assessment is required. When assessment suggests the likelihood of undesired change in the system, a management decision must be made.

……../4

The Lake Echo flow chart developed by us



……../5

Data (deep station) archives archives (shallow area data can vary significantly)

Source of field data	Date(s) of sampling	#s of sampling events and type of sampling	TP (µg/l)		Ch*a* (µg/l)	
		Deep stn.	mean	range	mean	range
Hinch (col=8)	July-Oct. 1984	5#s, vw, means of 3 mid basin stns	6.4	-	0.7	-
SWCSMH's Predictive Modelling (also see graph on page-7)		Pre-cultural (+0.173 kg/ha.yr precipitation)	4.3	-	-	-
		Based on 1980 land use stats	6.9	-	-	-
HRM (col=46)	2006	2#s (1 m.)	11.0	8 – 14	2.43	1.87 – 2.98
HRM (col=44)	2007	3#s (1 m.)	9.3	9 – 10	8.49	2.31 – 19.8
HRM (col=108)	2008	3#s (1 m.)	12.0	4 – 17	2.46	1.98 – 2.97
HRM (col=89)	2009	3#s (1 m.)	15.0	12 – 20	3.89	2.07 – 5.30
HRM (col=59)	2010	3#s (1 m.)	27.0	13 – 48	5.53	2.41 – 10.49
HRM (col=101)	2011	3#s (1 m.)	13.7	11 – 18	3.78	0.79 – 5.92

(Acronyms & brief explanation on next page)

……../6

Acronyms & brief explanation of the aforesaid table

arms depth.= sampling at arms depth
surf.= surface samples
1 m.= 1 metre depth sampling

Hinch- Hinch, P.R., and J.K. Underwood (NSE-Nova Scotia Env. Dept.)
SWCSMH's predictive modelling- Computer modelling carried out by the Soil & Water Conservation Society of Metro Halifax
HRM- Halifax Regional Municipality (2006 to 2011; the Ch*a* values are means of the 2 methodologies reported)

Basic Morphometric and Hydrologic data

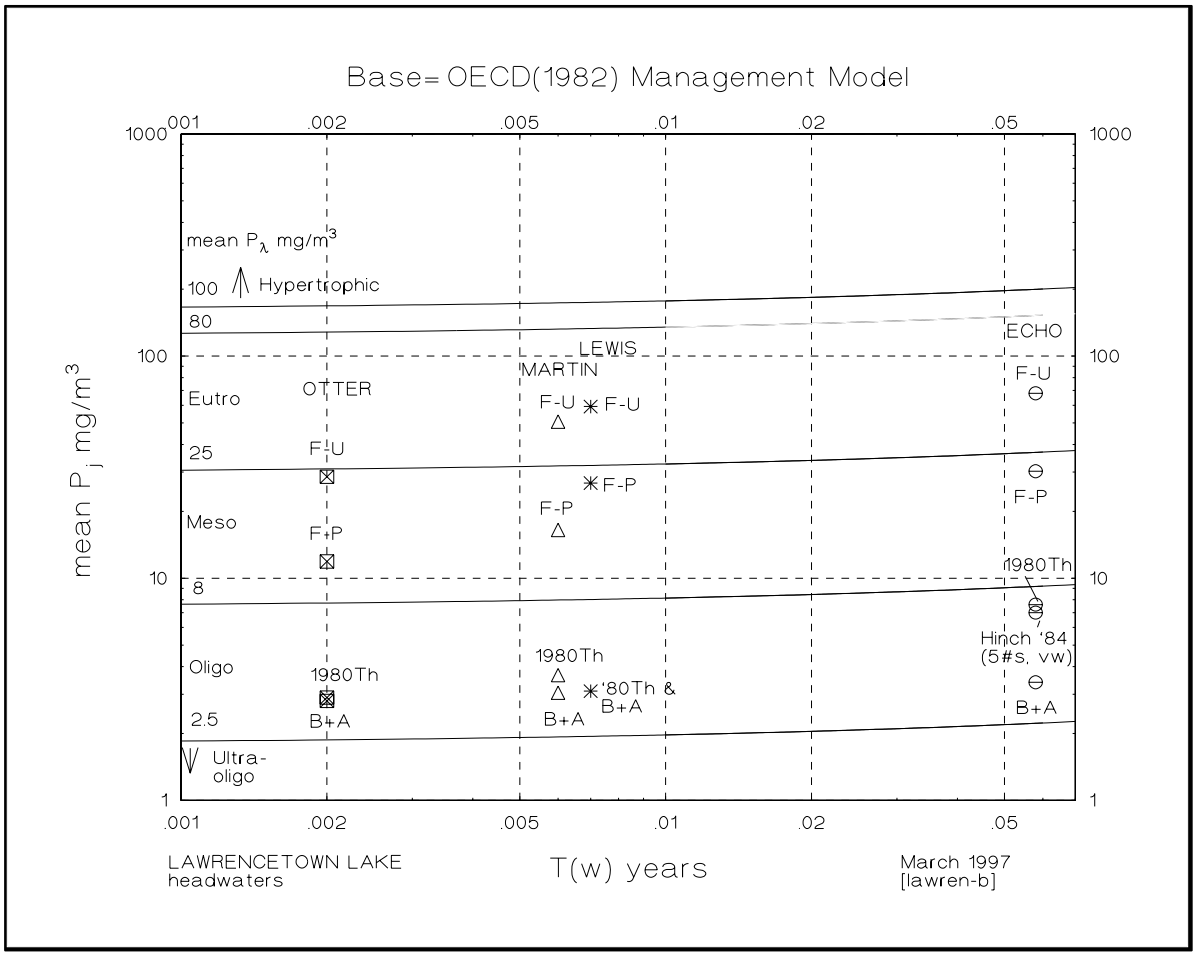
(computed by us from bathymetric maps supplied by the Provincial Fisheries Dept.)

- Shoreline length= 21.273 km
- Surface area= 212.2 ha
- maximum depth= 10 m; mean depth= 3.2 m
- volume= 6.73×10^6 cu.m.
- watershed (local)= 925.6 ha; watershed (total)= 11738.5 ha
- Flushing rate= 17.4 times/yr (approx.)
- In-lake TP retention= 0.18

- Zr , Relative depth= 0.6 % ……. (for most lakes, Zr < 2%. Deep lakes with small surface areas exhibit greater resistance to mixing and usually have Zr > 4%).
- DL, Shoreline dev.= 4.1 ……. (DL is important because it reflects the potential for development of littoral communities which are usually of high biological productivity).
- Dv, Deve. of volume= 1.0 …….. (For the majority of lakes, Dv will be greater than 1 (i.e. a conical depression).
- Index of Basin Permanence (IBP)=0.32×10^6 cu.m/km …… (The IBP is a morphometric index that reflects the littoral effect on basin volume. Lakes within the Atlantic National Parks (IBP < 0.1) are dominated by rooted aquatic plants and indicate senescence (excessive shallowness, high water color and high TP).

……../7

Our predictive model utilizing the 18-country OECD (Organization for Economic Co-Operation and Development) peer consensus base models



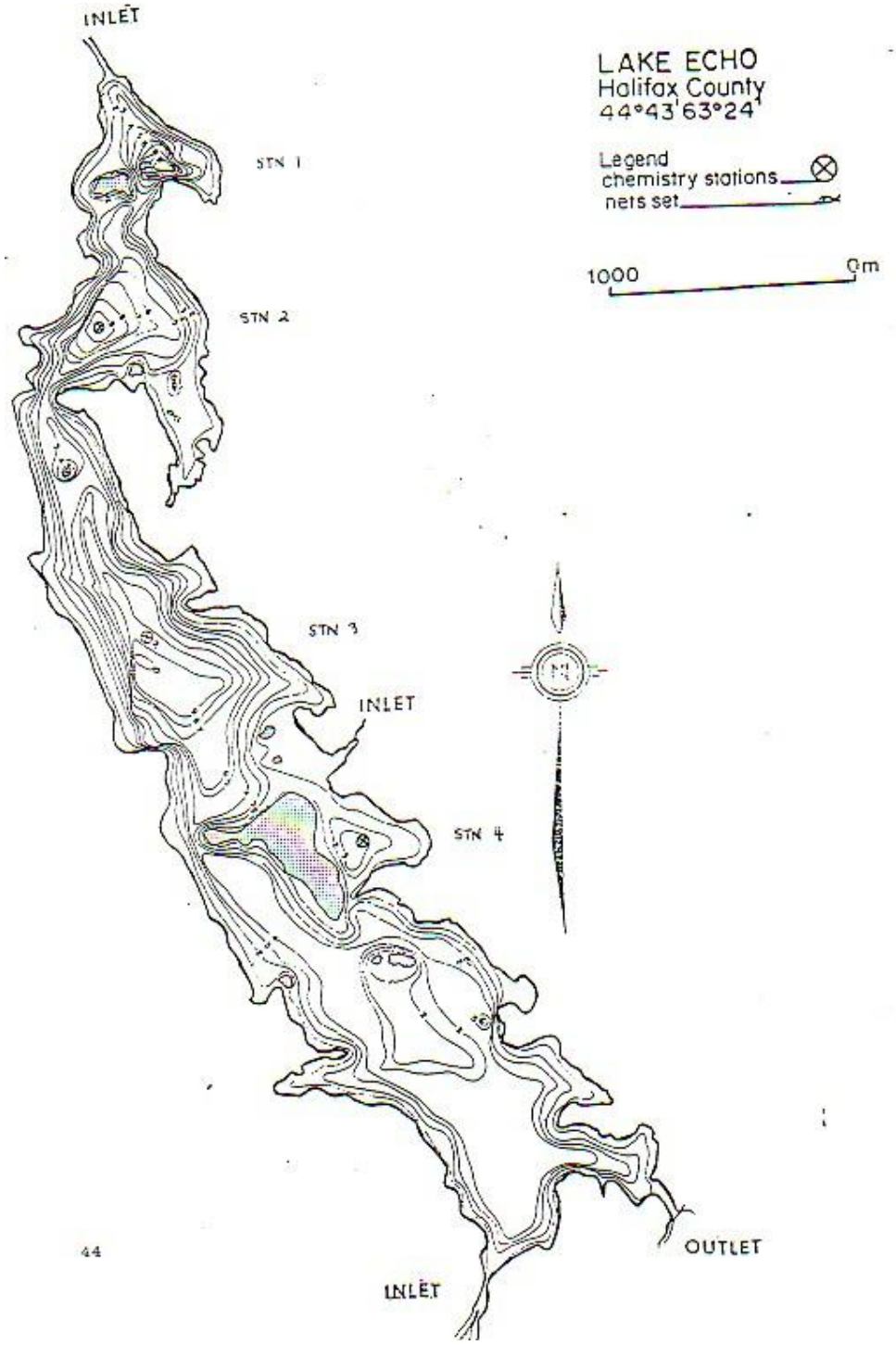
Notes for the log-log graph above:-

The X-axis is the water retention time. The Y-axis is the inflow TP concentration. The pelagic (i.e., open water) phosphorus concentrations are shown as curved lines with values of 2.5, 8, 25, 80, and 100 µg/l expressed as total phosphorus (TP)) delineating the OECD management model categories of nutrient enrichment. Chlorophyll*a* values have not been plotted though they can be with some more work. We have also not updated the model with the latter field data of various sources inclusive of HRM's from the Table since it will get cluttered.

B+A Th= Background+Aereal TP
1980 Th= TP Based on the 1980 land use stats
F-P= Future-Probable TP conc.
F-U= Future-Ultimate TP conc.

……../8

Lake Echo bathymetro with the 4 stations at which phytoplankton was analysed by us; resurveys may be carried out in future
(the original map provided by the NS Fisheries Dept.)



……../9

Summary only of select phytoplankton analyses (does not include all yet). Refer to the map on previous page

(*cf.* SWCSMH, 1993. 120 pages. Refer to that report for the detailed listing of species.)

Samples were collected at four locations (numbered consecutively north to south) on this large lake, and each site provided distinct assemblages of phytoplankton.

Station-1 (deep stn. just south of Highway #7) was scarcely populated but predominantly Chlorophycean in makeup. Sphaerocystis was the dominant organism, and spherical, unicellular species and Desmids were also heavily represented.

Station-2 (deep stn. south of Station-1) presented a larger proportion of filamentous blue-green algae and Diatoms, and although a diversified quantity of Chlorophyta were evident, the overall density remained low.

The species makeup at Station-3 (deep stn. just north of Highway #107) was comparable to that at Station-1 with a large number of Desmids and other Chlorophyta. Chrysophycean and Myxophycean species were also slightly more common at this location.

The algal density was much higher at Station-4 (deep stn. immediately south of Highway #107) than the other sampling sites, but with a diminished species diversity. Desmids almost completely dominated this assemblage, but *Gloeocystis* and *Chlorella* species were also heavily represented.