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.:	Bell_Lake2013	(5 pages)
To:	**Chair & Members, Harbour East-Marine Drive Community Council, HRM**	
From:	S. M. Mandaville Post-Grad Dip., Professional Lake Manage. Chairman and Scientific Director	
Date:	September 03, 2013	
Subject:	**BELL LAKE, Dartmouth**- unexpected enrichment, i.e., degradation, primarily based on HRM's synoptic data of 2006-2011	

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, hence may have typos.

When I recently analyzed HRM's data, I was quite shocked with the high values of TP (total phosphorus) as well as Ch*a* (chlorophyll*a*), the latter representative of the algal production, especially for sampling years of 2007, 2008, and 2010. These are unexpected in a protected lake with almost no development in its watershed.

I have provided a synopsis of the data from various sources referenced appropriately (see page-3).

I also include the predictive phosphorus modelling conducted by my team some years back (see page-5). The prime purpose of predictive modeling is to anticipate nutrient enrichment even before it occurs so that regulatory agencies can take the `precautionary approach' and protect the lake, hopefully in perpetuity.

We have not studied the zoobenthos (i.e., the indicator organisms within the sediments) there yet since we were confident that the lake would never get negatively impacted. We have to reconsider our past decision now.

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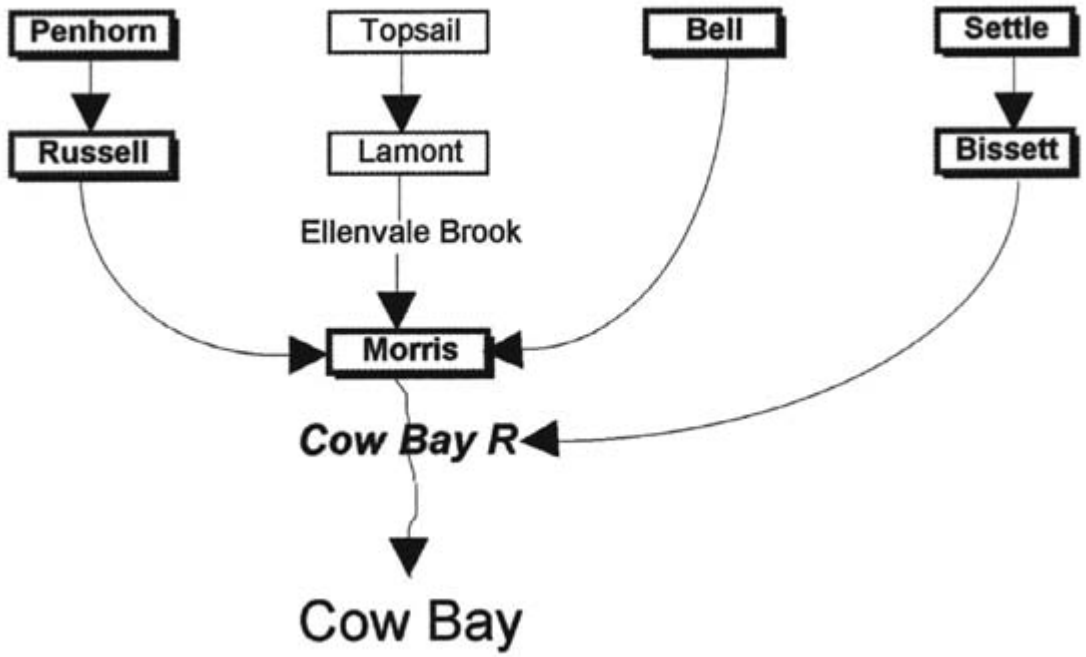
Question(s) to the Community Council: The City of Dartmouth did everything it could to protect the lake and did not allow any development to occur in its watershed, the area being small though. I understood from one of the residents that only tiny parts of backyards of a few homes may drain into the lake. Hence, where is the increased phosphorus (the limiting nutrient) accruing from? It would not be from birds (i.e., bird feces) since it is not close to Sullivans Pond. I doubt if large quantities of dog feces are entering the lake since, allegedly, no storm sewers drain into the lake. There does not appear to be any sanitary sewer pumping station overflows into the lake either.

Regarding `internal loading' from bottom sediments, I doubt the severity in Bell Lake since there is plenty of oxygen based on rare historical measurements.

But the HRM had never conducted the Temp-DO (dissolved oxygen) *vs* depth profiles at the deep station during the critical summer months in order to establish potential `internal loading' of phosphorus from bottom sediments.

The Cow Bay River watershed flow chart



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Data archives

Source of field data	Date(s) of sampling	#s of sampling events and type of sampling	TP (µg/l)		Ch*a* (µg/l)	
			mean	range	mean	range
Geolimnos	Jul 1980-Jun 1981	18#s (vol. wtd.)	8.6	7.5 - 9.5	2.6	1.6 - 4.1
BIO	Apr. 1980	1# (surf.)	9(?)	-	-	-
NSE	Dec. 1984	1# (surf.)	2	-	-	-
SWCSMH	May-Oct., 1990	3#s (arms depth)	6	4.4 - 7.5	0.6	0.43 - 0.74
SWCSMH's Predictive Modelling (also see graph on page 5)		Pre-cultural	2.4	-	-	-
		Serv. Res. @ 0.52 kg/ha	4.2	-	-	-
		Serv. Res. @ 1.1 kg/ha	7.1	-	-	-
BIO	Apr. 1991	1# (surf.)	2(?)	-	1.212	-
Dartmouth Eng. Dept.	Aug. 1991	1# (surf.)	-	-	1.6	-
Mandell	1991-92	30#s (surf.)	5	2 - 9	1.41	0.62 - 3.33
BIO	March, 2000	2#s (surf.)	7	-	2.74	-
HRM	2006	2#s (surf.)	5	3 - 7	1.59	1.05 - 2.12
HRM	2007	3#s (surf.)	14	3 - 17	6.91	0.86 - 17.78
Christina's modelling	2008	Hindcast	5.3	-	-	-
		2008 modelling	12	-	-	
HRM	2008	3#s (surf.)	36.5	3 - 70	1.90	1.49 - 2.33
HRM	2009	3#s (surf.)	8	8 - 8	3.84	3.33 - 4.49
HRM	2010	3#s (surf.)	24	20 - 25	2.49	2.29 - 2.77
HRM	2011	3#s (surf.)	7	6 - 10	3.20	0.79 - 6.18
Thiyake's Paleo Inference Model	1850's (i.e., pre-industrial)	Queen's University Diatom Inference Model	4.79			
	2005-2006		3.16			

(Acronyms & brief explanation of the aforesaid table on next page)

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Acronyms & brief explanation of the aforesaid table:-

vol.wtd.= volume weighted
arms depth= sampling at arms depth
surf.= surface samples

Geolimnos- Hart & Scott, later with CWRS, Dalhousie University
BIO- Bedford Institute of Oceanography, Dartmouth
NSE- Nova Scotia Environment Dept.
SWCSMH- Soil & Water Conservation Society of Metro Halifax report (1991)
SWCSMH's predictive modelling- Computer modelling carried out by the Soil & Water Conservation Society of Metro Halifax
Mandell- Paul Mandell's MSc thesis (1994) at Dalhousie University
HRM- Halifax Regional Municipality (2006 to 2011; the Ch*a* values are means of the 2 methodologies reported)
Christina's modelling- Christina Rina Soliman's MSc thesis (2008) at Trent University, Peterborough, Ontario
Thiyake- Thiyake Rajaratnam's MSc thesis (2009) at the Queen's University in Kingston, Ontario under a major NSEC grant. The grant was for the first ever paleolimnology conducted on lakes across Nova Scotia (I calculated the antilog values from her reported log values based on the diatom inference model)

Basic Morphometric and Hydrologic data of Bell Lake
(computed by us from bathymetric maps supplied by the Provincial Fisheries Dept.)

Surface area=9.5 ha; watershed=19.9 ha; In-lake TP retention=0.80; maximum depth=8.5m; mean depth=3.1m; volume=0.300×10^6 cu.m.; Flushing rate=1.0 #/yr (approx.); Relative depth=2.4%; Shoreline dev.=1.5; Deve. of volume=1.1;
Index of Basin Permanence (IBP)=0.19×10^6 cu.m/km

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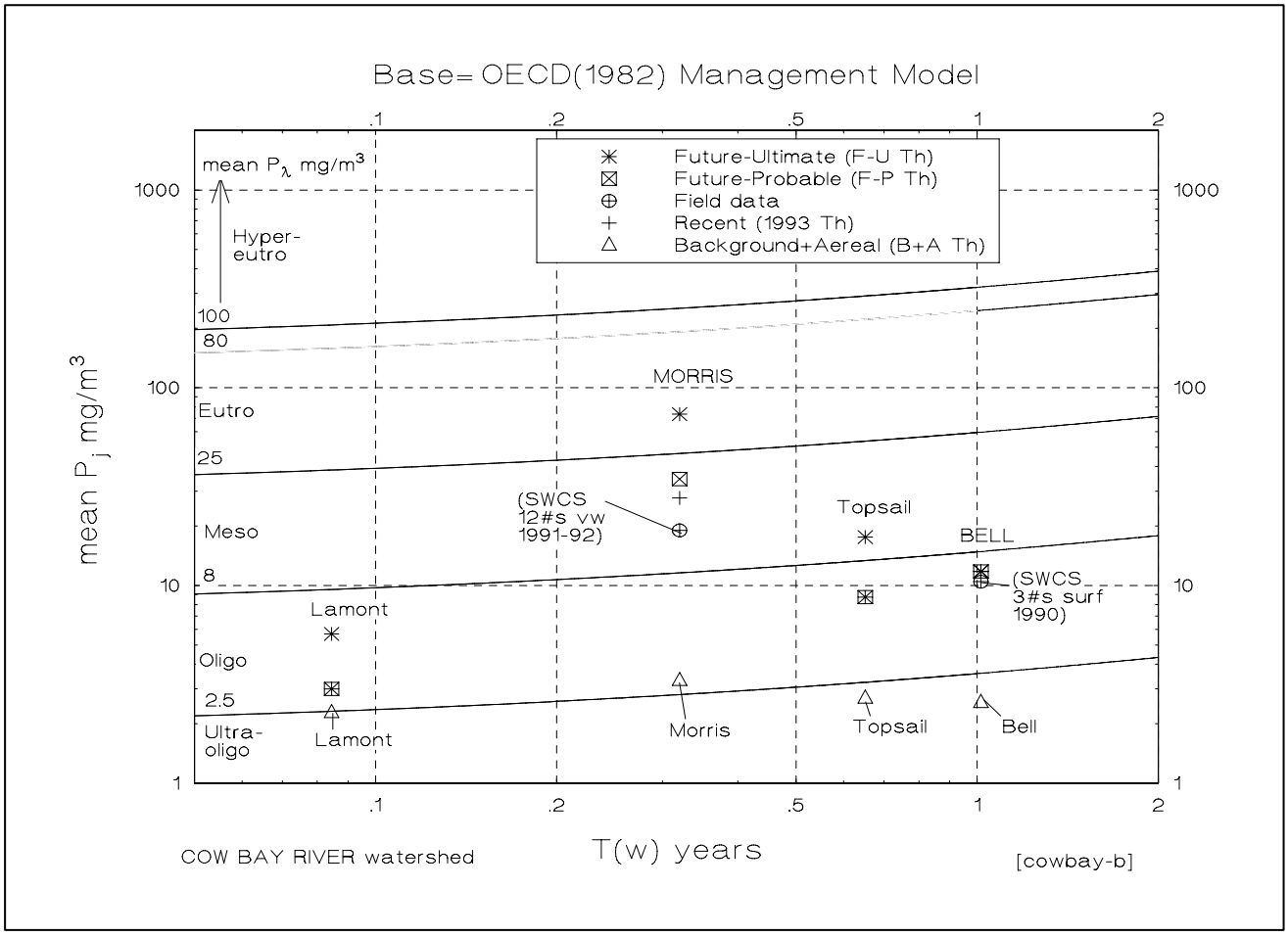
Our predictive model utilizing the 18-country OECD (Organization for Economic Co-Operation and Development) peer consensus base models



Notes for the graph above:-

The X-axis is the water retention time. The Y-axis is the inflow TP concentration. The pelagic (i.e., open water @ deep stn.) phosphorus concentration is shown as curved lines with concentrations of 2.5, 8, 25, 80, and 100 µg/l of total phosphorus (TP) respectively.

Shalom