Comments on Stantec Community Studies for Sandy Lake (a Future Serviced Community): Significant omissions & misinterpretation of data related to the water quality of Sandy Lake

by

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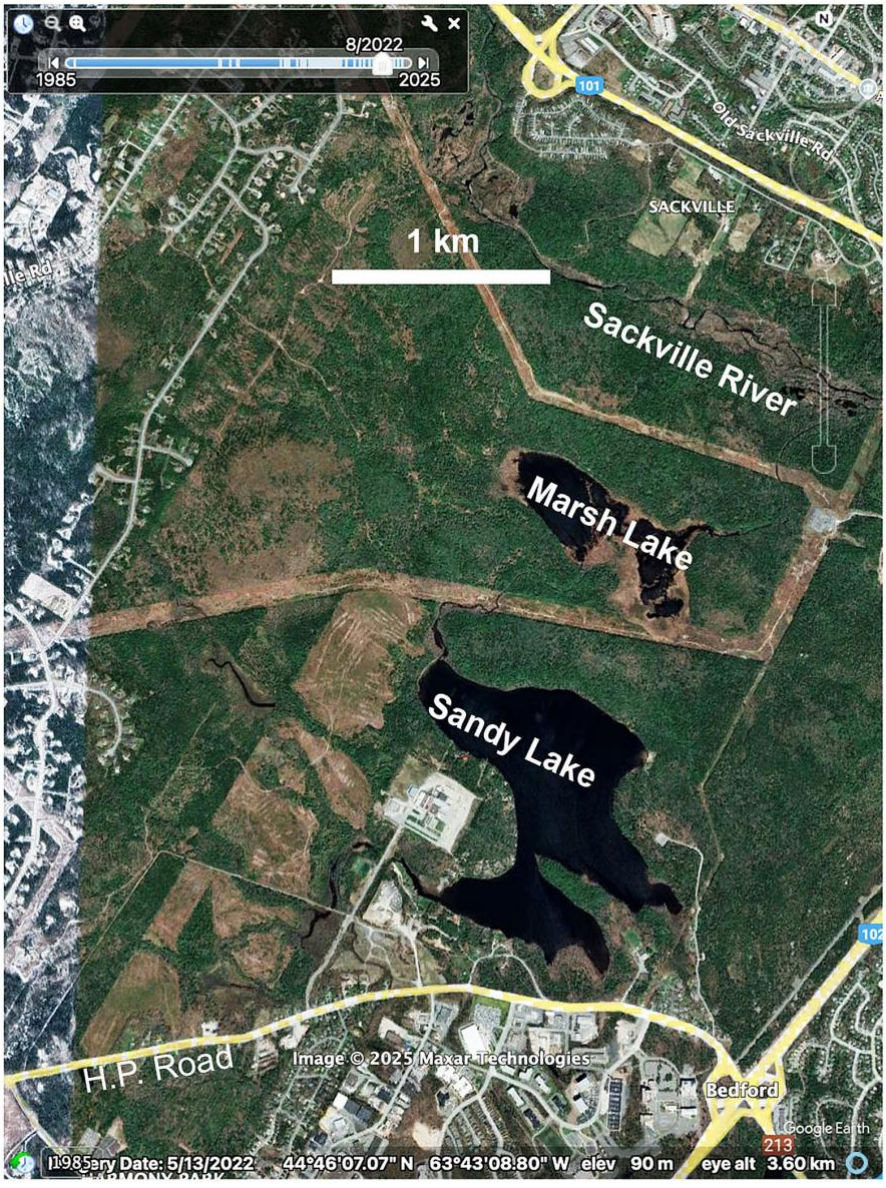
July 18, 2025



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Acronyms, abbreviations

HRM: Halifax Regional Municipality
MOM: Metalimnetic Oxygen Minimum
NNIP: No Net Increase In Phosphorus
P: phosphorus e.g., as in Total P, Internal P Loading
SLCA: Sandy Lake Conservation Association
SLV: Sandy Lake Volunteers
WQ: Water Quality

1. Introduction/Overview

On May 16, 2025, the Nova Scotia Government/Dept. of Growth and Development announced (bolding inserted): "Community studies are complete for two areas identified by Halifax Regional Municipality (HRM) for growth – **the Sandy Lake special planning area in Bedford** and the Highway 102 west corridor lands in Halifax" and that "the municipality will now undertake secondary planning for the two areas."

From the News Release [1]:

> Recommendations focused on the areas most suited for development and suggested secondary planning work in both study areas. They include:
>
> • developing a master infrastructure plan outlining transportation, water and wastewater requirements
> • outlining actions and mitigation measures to protect the environment and enjoyment of parklands.

Stantec Consulting Ltd. was awarded the contract to conduct the Future Serviced Communities Studies for four Special Planning Areas, including Sandy Lake.[2]

In the leadup to these studies, I shared and discussed with Stantec Consultants a large set of observations (data) pertaining to the current state of Sandy Lake obtained 2017-2024 by the Sandy Lake Volunteers (SLV*). [3] I also brought to their attention related observations obtained in 1971 and 2021 by other observers. [4].

*SLV: Sandy Lake Volunteers. I initiated, organized and conducted the limnological observations with the help of 3 volunteers who are lakeside residents and members of the SLCA (Sandy Lake Conservation Association); they have professional backgrounds and standards, two have science degrees. Initially I borrowed equipment from the Community-Based Environmental Management group at St. Mary's University, later from the Atlantic Water Network. From Aug 2022 onward, we carried out the same observations plus some additional sampling as volunteers with and equipment provided by the Halifax LakeWatchers Program. Chris Kennedy provided guidance on how to conduct the additional sampling required for the Halifax LakeWatchers Program. For the last two years, I have not been present on all sampling occasions, but the same SLCA volunteers were involved and were fully capable of handling the measurements. In the fall of 2024, we began some collaboration in our studies of Sandy Lake with Prof. Linda Campbell at St. Mary's University.

However this input, although acknowledged, is *not* reviewed or and made use of in the relevant Community Studies conducted by Stantec [5]:

- Sandy Lake Land Suitability Analysis.pdf
- Sandy Lake Summary Report.pdf
- Sandy Lake Watershed and Stormwater Management Study.pdf

These "Missing Data" provide evidence that Sandy Lake, while classified as lower level mesotrophic based on Total P, is currently in a highly precarious state with very low deep water oxygen levels and occurrence of "Internal P Loading" in some years; there is also a

worrisome "metalimnetic oxygen minimum" in shallower waters. The lake's precarious state, in combination with the site of the proposed developments being in an area that can be expected to be highly sensitive to development,* greatly increase the likelihood that inadvertent effects of development, particularly during the construction phase, could trigger very difficult-to-reverse declines in the water quality of Sandy Lake.

* The development(s) would occur in an area of concentration of headwater streams and 24 associated wetlands close to the lake; those watercourses have a disproportionately large influence on the Water Quality of Sandy Lake, providing well over 50% of flow into Sandy Lake. The 74 ha Sandy Lake supports a diversity of wildlife, and is valued recreationally for swimming, paddling, fishing, ice sports. In 2004, the Bedford Lions Club donated $500,000 to construct facilities for an accessible swimming beach, since taken over by HRM. Sandy Lake is a headwater lake, draining via Peverills Brook into the 22 ha Marsh Lake (declared a Treasured Wetland in 2021), and thence into the Sackville River. Sandy Lake Watershed is the largest or second largest subwatershed in the Sackville River Watershed (depending on how the tertiary watersheds are aggregated) where the Sackville Rivers Association has been working to improve water quality and bring back Atlantic salmon; those efforts have included habitat improvement on Peverills Brook to facilitate migration of gaspereau, American eel and brook trout as well as salmon. **[6]**

Had these missing data been included and appropriately considered by Stantec, I believe much more cautionary mitigation measures would have been recommended, or even that there would be a recommendation that no or only very minimal development should be considered for this site.

That is my opinion, not as a practicing professional limnologist or environmental planner, but as a retired academic biologist. I am not a specialist in limnology but I do have related education, experience and publications. **[7]** My familiarity with Sandy Lake derives from many days spent from 2017 onward conducting limnological observations and natural history type observations on the entire lakeshore, and over much of the surrounding terrain and associated surface waters and wetlands. While these observations were initiated in response to a request received from the SLCA (Sandy Lake Conservation Association) in the spring of 2017 to conduct a "floral survey", they were and continue to be conducted and reported entirely independently of the SLCA and related advocacy groups. **[3]**

I asked (May 28, 2025) a senior planner at Stantec and the individual with whom I had most communication, why the Stantec Reports did not reference any of the information that I shared with them. I sent a follow-up inquiry to Stantec on July 14, 2025; he responded July 15, 2025, thanking me for my input and commenting that they "did not intend to ignore your input", and noted that the Sandy Lake work was accepted. So I am left to speculate on why my input was in fact "ignored".

Volunteer observations, now commonly referred to as "Citizen Science" are sometimes dismissed in such reviews, especially if the volunteers are seen as advocates of a particular perspective; I guess the assumption is that such observations cannot be trusted. I have addressed that possibility at some length below, pointing out my professional qualifications and the steps I take to ensure my independence as a scientific observer. However, more important from a scientific perspective, our observations of very low oxygen in deep water and of the highly unusual MOM ("Metalimnetic Oxygen Minimum") in shallow waters were also observed by another observer entirely independently; her observations, conducted in 2021, were likewise not cited by Stantec. It turns out as well that the MOM shows up in one of profiles obtained by Stantec in 2023 (they make no comment about it).

The issue of trust of volunteers and vetting of volunteer observations goes well beyond this particular case; probably more than 50% of all monitoring of surface waters and Nova Scotia and the bulk of their care is conducted by volunteer individuals and groups.*

*Such volunteer activity is well documented in appendices to AECOM 2020: "Halifax Regional Municipality Water Quality Monitoring Policy and Program Development", Prepared by: AECOM Canada Ltd., Sep 2020 , 99 pages + Appendices. Available at https://www.halifax.ca/sites/default/files/documents/city-hall/boards-committees-commissions/210211rwabsp911.pdf

The information and comments I present related to the occurrence and significance of "Internal P Loading" at Sandy Lake have broader relevance. Recent monitoring and research have revealed a relatively high frequency of low deep water oxygen and signs of Internal P Loading in Halifax area lakes and in lakes elsewhere in Nova Scotia. However, it appears that the implications for the use of phosphorus load models to predict the effects of development and for related mitigative measures to protect water quality have received little attention at the policy level.

2. The SLV Observations

2a. Why the observations? An earlier Sandy Lake Watershed Study equivalent to that conducted by Stantec (2025) and on the same Study Area was conducted by AECOM in relation to the earlier proposals for a development on the west side of Sandy Lake; the report (which I refer to as "AECOM 2014") was released in 2014. **[8]** In brief, based on Total P (Total Phosphorous) levels, AECOM concluded that Sandy Lake was in a Lower Mesotrophic State* (Total P 12 µg/L).* Modelling indicated that their Water Quality Objective for Total P (18 µg/L) would be approached or slightly exceeded if no mitigative measures were implemented; with implementation of modest mitigative measures it would reach 15 µg/L and with more stringent measures, only 13 µg/L. AECOM concluded: "The results suggest that changes in lake phosphorus concentrations from development can be mitigated by reducing the phosphorus load from wastewater effluent and Advanced Stormwater Management."

* "**Lakes range from an oligotrophic to a eutrophic state in a lake trophic classification system**. An **oligotophic lake** is one that is characterized as having a high degree of water clarity, sufficient supply of oxygen at all levels and fewer conditions to promote the growth of algae and plants within the lake. The upper limit of total annual phosphorus loading for an oligotrophic state is 10µg/L. The **mesotrophic state** is the transitional stage between oligotrophic and eutrophic on the continuum. A mesotrophic lake has an accumulation of sediments, a higher concentration of phosphorus and algae (often measured as chlorophyll), and some loss of oxygen at the lower levels of the lake. The range of total annual phosphorus loading for a mesotrophic state is 10 - 20µg/L. **A eutrophic lake** contains high concentrations of phosphorus and algae (chlorophyll) and is rich with plant nutrients. A eutrophic lake is characterized by poor water clarity, little or no oxygen at lower depths, an abundance of plants and the emergence of algae blooms. A lake is considered to be in a eutrophic state when total annual phosphorus exceeds 20µg/L. The process of eutrophication is naturally occurring and typically takes thousands of years to complete. In a developed watershed, a lake can become eutrophic in a few decades. One of the key contributors to an accelerated rate of eutrophication, known as **cultural eutrophication**, is the abundant release of phosphorus to receiving waterbodies..." From HRM Municipal Planning Strategy for Planning Districts 14/17 posted at https://www.halifax.ca/media/83903

However, AECOM 2014 also noted that “the degree of influence of urbanization on water quality in Sandy Lake can only be approximated using the phosphorus load model because of limitations arising from assumptions and uncertainty in the application of the model”. They proposed “a robust water quality monitoring plan for the Sandy Lake watershed to provide a further assessment of current conditions and to evaluate the impacts of development on the water quality.”

AECOM recognized that Total P is not in itself a direct measure of the trophic state of a lake, but rather is an indicator of the state of the lake, and that direct measurements on a lake including limnological profiles are required to determine the actual state of the lake. Such monitoring was *not* implemented following HRM acceptance of the AECOM report.

With the help of volunteers from the Sandy Lake Conservation Association, I conducted a set of observations in early fall 2017 which included a "limnological profile" at the deepest spot in the lake. I was simply curious: I wanted to get some idea of state of the lake indicated by direct measurements, and I had related experience in addressing such a question.

Those initial observations raised significant concerns about the state of the lake, notably deep water oxygen was very low and there was some salt stratification of the water column.**[9]** Observations were conducted subsequently and are ongoing to provide more information on the state of Sandy Lake and associated surface waters.

2b. Our sampling With the help of volunteers from the SLCA (Sandy Lake Conservation Association), I obtained limnological profiles* at a deep spot (17.5 m), close to but not at the deepest spot (20-21 m) in Sandy Lake and at two other sites on Oct 3, 2017. (Subsequently, with the help of volunteer Ed. G., who had conducted a bathymetric survey of the lake, we were able to locate deep spot more precisely.**[9]**)

*The "limnological profiles" consist of measurements of water temperature, oxygen content, conductivity and pH at one meter or shorter intervals from the water surface to the bottom.

I followed up with surveys of Sandy Lake and feeder streams for salt levels (measured as Specific Conductivity) and conducted further limnological profiles, again with help from SLCA volunteers. **[10]** Beginning in the fall of 2022, we conducted the limnological profiles in collaboration with the Halifax Lake Watchers Program, i.e. we became volunteers for that program, which has involved observing the same limnological profiles at the deepest spot plus some additional sampling. The latter has included measurements of Total P at the surface and near the bottom at the deepest spot in the lake, data which can provide some direct evidence of the occurrence (or not) of Internal P Loading. **[11]**

2c. The Stantec Watershed Study makes no use of the SLV Observations The raw data and interpretations were shared and discussed with Stantec in meetings in May and June of 2023 and updates were sent to Stantec subsequently right up to the late fall of 2024.**[3]** Remarkably, Stantec chose not to include the SLV Observations amongst the historical data they reviewed for the Sandy Lake Watershed Study or for the Sandy Lake LSA.

Examples of the limnological profiles are shown in Fig 1 below. The only limnological profiles Stantec cites are those they themselves collected in 2023, which they describe as conducted at the “Sandy Lake Deep Zone” but their sampling extended only to 4 or to 10 meters depth (Stantec Sandy Lake Watershed Report,[5] Fig 1-3, page 10;, profiles given for Apr extended 0-4 m, those for May, June, July, Aug to 10 m; (no data are shown for Sept or Oct). Clearly, such observations are not sufficient to characterize a dimictic lake such as Sandy Lake*

*__Dimictic__: a lake that stratifies and subsequently turns over twice in a year. See Halifax LakeWatchers 2023-2024 Report [12] for a description of typical Halifax area lakes and related terms and processes.

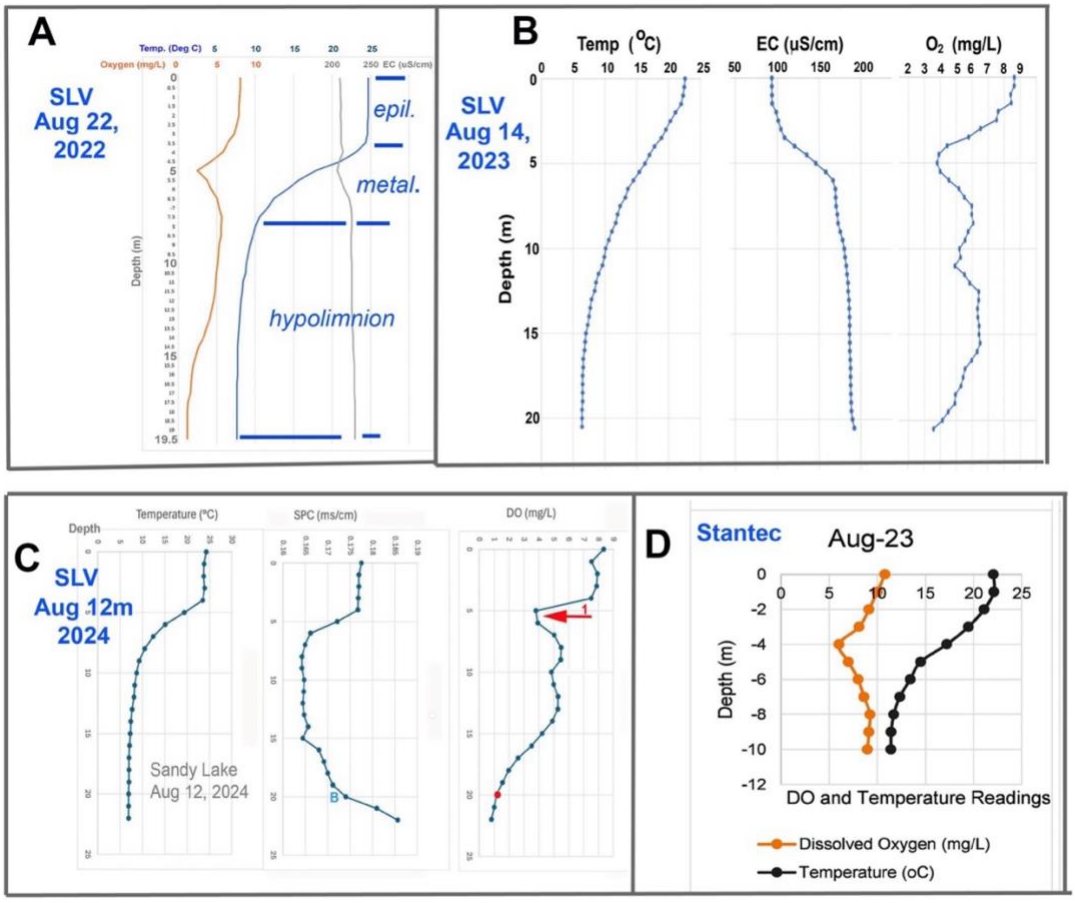

Fig. 1. More recent (2022 onward) late summer or early fall limnological profiles for Sandy Lake. A, B & C obtained by Sandy Lake Volunteers, D by Stantec (Stantec Sandy Lake Watershed Study, Fig 1-3, page 10)**.** Lake strata defined by the temperature gradient are indicated in A (epil.=epilimnion, metal.=metalimnion). The red arrow in D points to a "Metalimnetic Oxygen Minimum", observed also in the other profiles including the Stantec profile. Note similarity of the oxygen and temperature plots B & D where they overlap depth-wise (0 - 10 m), i.e the Stantec data provide some independent verification of the features documented by SLV volunteers, as does the Aug 2021 profile obtained by C. Doucet (see Fig 2 below)

3. What the "missing data" tell us about deep water oxygen levels

Fig. 2 shows the dissolved oxygen levels close to the bottom of Sandy Lake at or near its deepest point during late summer from 1971 to 2024**.** These data were not cited by Stantec, except for the 1998 data point which is cited by Stantec, but without reference to its depth.

The data indicate a trend of gradual decline in deep water oxygen from 1971 to 2019. After 2019, there was an abrupt drop to values near or below 1 mg/L over the years 2021-2024 except in 2023 when the oxygen level was 5 mg/L; in 2024 it returned to a very low level.

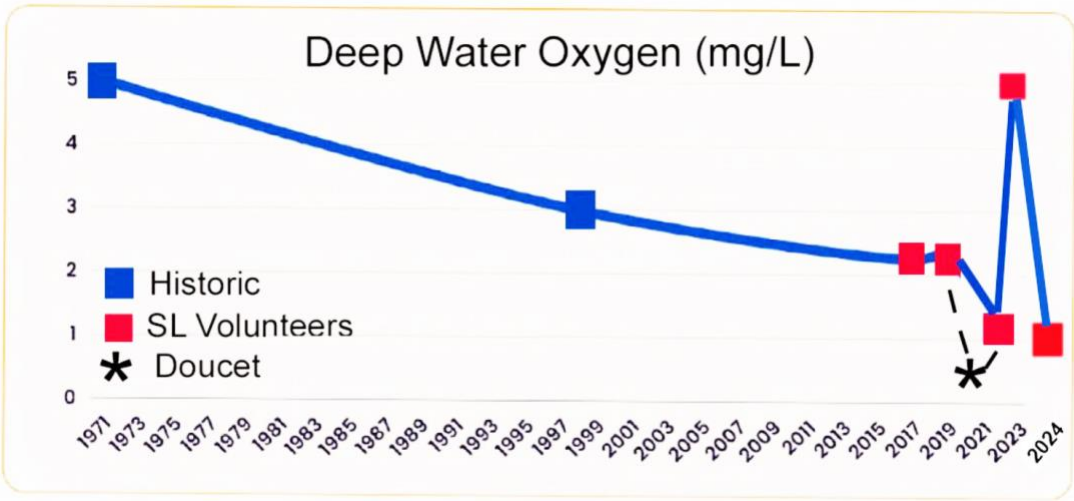

Fig. 2: Historic Deep Water Oxygen values for Sandy Lake (Bedford) during or close to peak the peak summer stratification period. View Notes #**13** for sources.

Comparison of the top-to-bottom profile data for spring and late summer samplings in 2022, 2023 and 2024 illustrates a freshening of the entire water column (i.e. reduced conductivity values) between the spring and late summer in 2023, but not in 2022 or 2024. The freshening in 2023 occurred during a period of exceptionally high precipitation and flooding in the area of Sandy Lake. **[14]** Thus it appears that the spike in oxygen in 2023 was associated with a transient, mid-summer disruption of lake stratification and consequent re-aeriation of the deeper waters associated with the severe flooding. The next year, 2024, deep water oxygen was again very low. Hence In addition to not including the deeper waters, the Stantec 2023 profile observations were conducted in a year that proved to be highly anomalous in regard to oxygen levels.

These low deep water oxygen levels are of concern for two major reasons:

(i) Low oxygen levels cause a marked deterioration of the cool deep water refuge for salmonids in summer. Summer temperatures in the hypolimnion of circa 6 to 15°C and oxygen levels above 3-5 mg/L are required to support salmonids. **[15]** As well as supporting brook trout, Atlantic Salmon have been returning to the Sackville River Watershed including Sandy Lake through the efforts of the Sackville Rivers Association. Sandy Lake is

the largest or second largest sub-watershed in the Sackville River Watershed (the rank depending on how tertiary sub-watersheds are aggregated), thus the loss or potential loss of habitat for salmon in Sandy Lake is of major concern.

(ii) **There is increased likelihood that intervals of hypoxia (low oxygen) in deep water could result in anoxic conditions (no oxygen) at the sediment surface and associated "Internal Phosphorus Loading"* accelerating eutrophication and marked deterioration of water quality.**

*Nürnberg and LaZerte 2016 describe Internal P Loading as "phosphate released from anoxic sediment surfaces to overlying water"; this P input is in addition to that from annual external, catchment loading. Numberg (2004) states that "2 mg L^{-1} measured by a DO probe about 1 m above the sediment usually coincides with anoxic conditions at the sediment surfaces located at that depth." Water with <2 mg L^{-1} oxygen is classically defined as "hypoxic" (Tellier et al., 2022). While usually associated with hypoxic deep waters, significant Internal P Loading has also in shallow areas overlain by oxic waters of eutrophic lakes (Zhao et al.,2023). These and additional references explaining Internal P Loading are given in Note **[16]**.

4. Evidence for Internal P Loading at Sandy Lake

There is already some direct evidence for occurrence of Internal P Loading in deep waters of Sandy Lake. In 1979, Total P of surface samples was 7 µg/L or less, well under the upper limit (10 µg/L) for oligotrophy (the 'clean' state of a lake); the transition to mesotrophic status based on Total P occurred circa 2001 (re AECOM 2014 Fig 9 **[8]**). AECOM 2014 cites data showing that by 2008-2011, deep water Total P on some samplings was much higher than surface water P, which they attributed to oxygen deprivation. From AECOM 2014:

Table 1. Sandy Lake Surface and Deep Total P values 2008-2011. From Table 5 in AECOM, 2014 **[8]**

Sample Date	Total P (µg/L)		Source
	Surface	Deep	
2008: Sep 3	11	15	AECOM 2014 **[8]**
2010: May 24	10	**26**	AECOM 2014 [8]
2011: Aug 8	6	5	AECOM 2014 **[8]**

***From* AECOM** [8]**:"** Table 5 compares the phosphorus concentrations of shallow (epilimnion) to deep (hypolimnion) samples from three sampling events. Total phosphorus concentrations in the shallow surface (epilimnion) samples are less than in the deep (hypolimnion) samples in two of the three examples. Although the data are limited, this suggests that the deeper portions of Sandy Lake may be fully or partially oxygen- deprived during certain times of the year, a situation that may arise when decomposing organic matter consumes available oxygen at depth. This in turn promotes the release of phosphorus from lake sediments, which is recorded in the water samples."

More recent, deep water phosphorus values during late summer stratification in Sandy Lake were obtained Casey Doucet in 2021 [4], and by SRV/HLW* in 2022, 2023 and 2024. [17]

*SRV/HLW: SLV volunteers as volunteers with and following procedures of Halifax LakeWatchers

Table 2. Sandy Lake Surface and Deep Total P values 2021-2024.

Sample Date	Total P (µg/L)		Source
	Surface	Deep	
2021: Aug 16-23	~8.0	~ 23	Doucet 2022 [4]
2022: Aug 22	-	4.7	SRV/HLW [15]
2023: Aug 14	8.8	8.7	SRV/HLW [15]
2024: Aug 12	5.2	40	SRV/HLW [15]

The 2024 deep water Total P value is by far the highest yet observed for Sandy Lake.

The combination of the long term trends in hypolimnion oxygen decline with very low levels since 2021 and the elevated deep water P levels in some years illustrate very clearly that Sandy Lake is in a precarious state now. That's before any major development has begun.

5. Other Relevant Observations

5a. Salt Levels

From Stantec Sandy Lake Watershed and Stormwater Management Study, p.8:

> Chloride in freshwater environments is an anthropogenic environmental stressor (Szklarek et. al 2022) and can negatively impact freshwater aquatic life when concentrations are in excess of 120 mg/L (1CCME CWQG-FAL). By decade, the chloride values in Sandy Lake have had an increasing trend (Appendix A), starting with a value of 13.7 mg/L in 1980, average chloride values for the 1990's was 29.5 mg/L, 35.5 mg/L in the 2000's, and 45.3 mg/L in 2010 to present. Although these baseline chloride values do not exceed CCME CWQG-FAL, land use planning mitigation strategies can be applied when planning development in the area to reduce further increases in chloride concentrations. As development increases within a watershed, it is expected to see increased chloride values due to developments and road salt accumulation entering watercourses (Bermarija et al 2023).

Stantec does not reference or make use of electrical conductivity measurements which are highly correlated with chloride and are commonly used to estimate chloride values and/or salt levels. Stantec discusses environmental impacts of chloride only in relation to its toxicity at higher levels, and in the LSA, to assess the influence of urban runoff or erosion within the watershed on lake water quality.

From the Stantec Sandy Lake Land Suitability Analysis, p 25 (bolding inserted):

> Historical sources of chloride within the watershed include septic systems, animal waste, potash fertilizer, and drainage from contact with road-salt chemicals. Chloride concentrations in Sandy Lake are low, with median concentration of 28 mg/L and maximum concentration of 50 mg/L. The CCME CWQG-FAL limit for chloride is 120 mg/L for long term exposure. Total Suspended Solids (TSS) concentrations are generally low in Sandy Lake with a median value of 2 mg/L and a maximum value of 5 mg/L. **The low chloride and TSS concentration suggest that Sandy Lake is not significantly affected by urban runoff or erosion within the watershed.**

The conclusion that "Sandy Lake is not significantly affected by urban runoff or erosion within the watershed" is surely at variance with the assumptions and conclusions of the Watershed Study, which I pointed out in a response to the Draft LSA. **[18]**

Also concerning is that Stantec makes no reference to possible effects of increasing salt levels on water density and hence on lake stratification and seasonal turnover. In fact, lake stratification and seasonal turnover - key processes in most of our lakes - are barely mentioned in the Stantec reports. (Perhaps that's because their limnological measurements extended to only 10 m depth, not deep enough to characterize conditions in the hypolimnion; they give no explanation why sampling was so limited.)

Our observations of conductivity values together with some historical data provide much more detail on the long term trends in salt content of Sandy Lake (Fig.3 below). I made use of the relationship of Chloride to Percent Land Area Developed for the Halifax region given by Scott (2019) to estimate how much further salt levels might may rise with and without development - those estimates suggest that salt content could rise to toxic levels, and possibly levels high enough to impede seasonal turnover. **[19]**

Given the current state of Sandy Lake and the already low deep water oxygen levels, impedance of seasonal turnover by increased salt levels could be expected to result in a more extended period of oxygen depletion which would further stimulate Internal P Loading. This is not a radical concept. Such possible effects were anticipated by AECOM 2020 in relation to their recommendations for lake water quality monitoring in HRM, and are discussed in the LakeWatchers 2022-2023 report. **[20]**

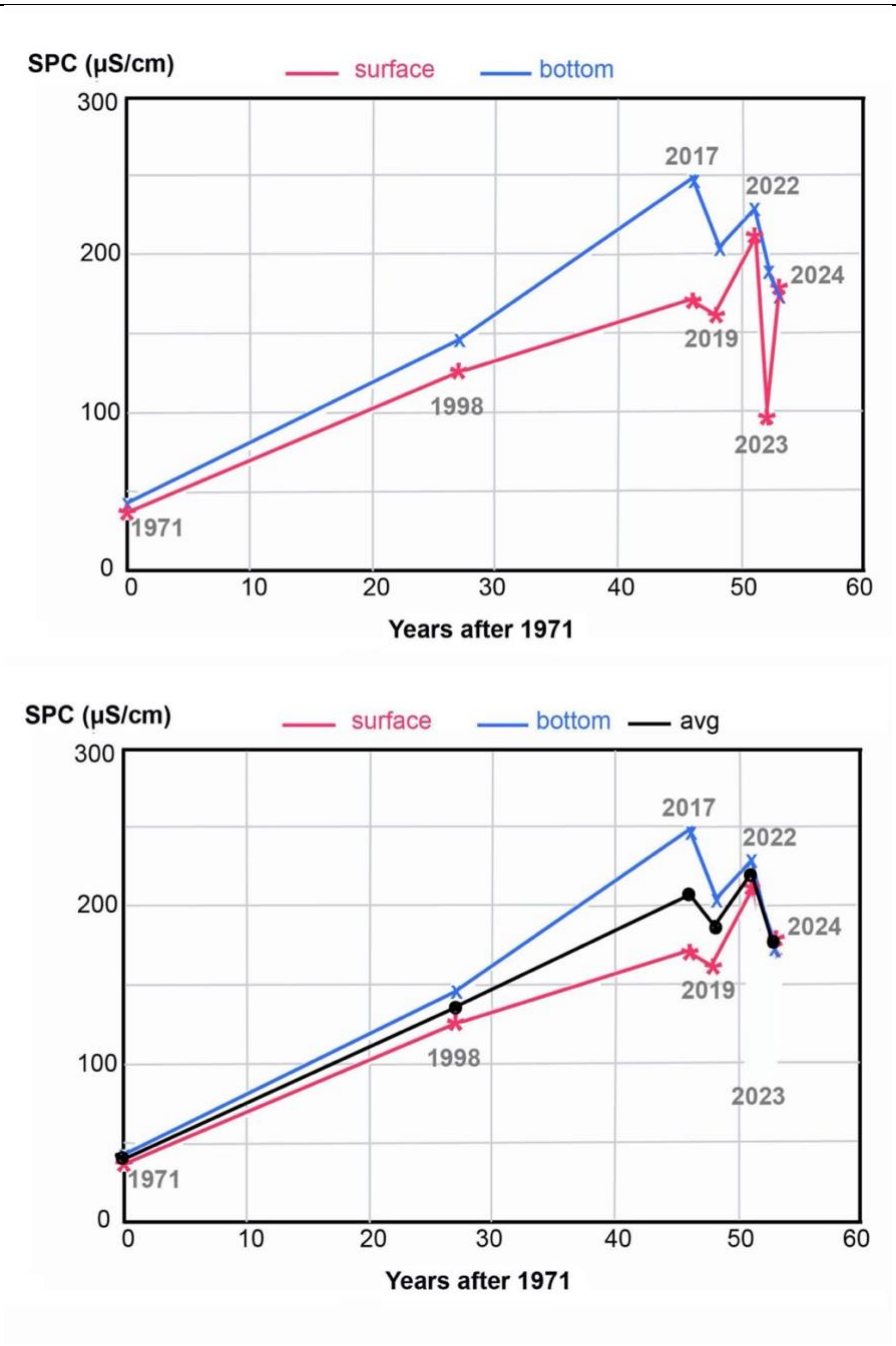

Fig. 3. Specific Conductivity values for surface water and deep-near- the-bottom water at Sandy Lake, late summer 1971 to 2024. In the lower figure, the 2023 data are excluded and the averages between surface and deep samples are plotted. SPC is a measure of salt content. The greater the difference between the surface values (red) and deep values (blue), the more the differences in salt content contribute to stratification. Based on the spring limnological profile for 2025 and ongoing monthly measurements of conductivity of lake water [21], it seems likely that the late summer values for 2025 will be significantly higher than in 2024.

5b. Metalimnetic Oxygen Minimum

"Metalimnetic Oxygen Minimum" (MOM) refers to a dip in the oxygen level in the metalimnion, the layer of sharp temperature change from the warmer surface water above (in the epilimnion) and the cooler deeper waters below (in the hypolimnion).

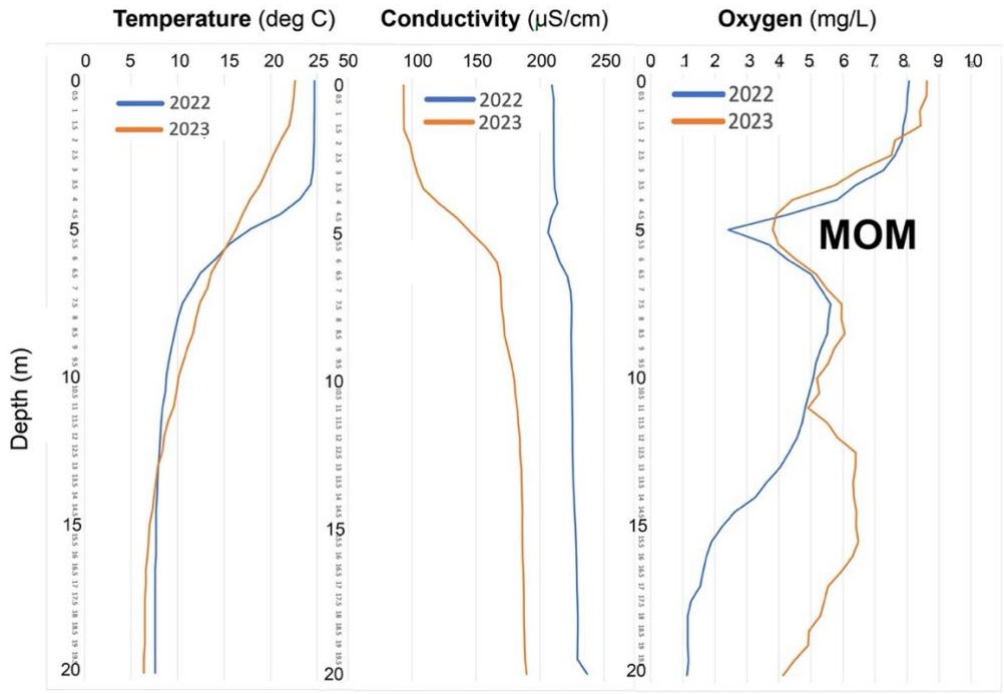

Fig. 4. Late summer profiles for Aug 22, 2022 and Aug 14, 2023 illustrate occurrence of a Metalimnetic Oxygen Minimum (MOM). It occurred at approx. 5 m depth, in the metalimnion (or thermocline) layer. The same dip in oxygen is seen in Stantec's oxygen profile for Aug 2023 (0-10 m only, see Fig 1 above). Note the less marked thermal stratification and the much lower conductivity values over the whole water column in 2023 compared to 2022 - this is some of the evidence suggesting that heavy rainfalls & flooding earlier in the summer* weakened thermal stratification and flushed the whole water column with lower salt content water. But the MOM was still present in the 2023 August profile, suggesting it must have re-formed quite quickly due to high oxygen consumption in the metalimnion and/ or in sediment in the shallows of the lake. In 2023, there was a curious second dip at 12 m depth; I have suggested it may have been due to the original MOM being pushed down by the flooding. **[22]**

*We had very high rainfall events in July and August of 2023 with flash floods associated with the rainfall on July 21 & 22 and Aug 5 affecting the Sandy Lake/Bedford area, the latter much less so than the earlier dates. Sandy Lake was impacted by overflow from a sewage pumping station on Farmers Dairy Lane during the July event); the overflow was contained by July 26. The water level in Sandy Lake increased by 5-6ft and remained well above historic levels until late in Aug. **[23]**

When I first noted this dip, it was for the Aug 22, 2022 profile. I was skeptical about its reality as the oxygen readings were taking too much time, I felt, to equilibrate and I wrote a note to LakeWatchers (who had provided the measuring equipment) to suggest that the sensor membrane may need to be replaced. In the late fall of 2022, Casey Doucet reported on limnological observations she had conducted on a suite of lakes in HRM including Sandy Lake in 2021 for her Masters of Applied Science research at Dalhousie University.**[4]** Her plot of oxygen versus depth for Sandy Lake in mid-August 2021 **[4, 24]** showed almost precisely the same thing: a dip in oxygen to approx. 3.2 mg/L at 6 meters, in the metalimnion.

So I knew this dip was real. Then we observed the dip again in Aug 2023 and again in 2024 – 4 years in a row altogether (2021, 2022, 2023, 2024); there is also some suggestion of it in our 2017 and 2019 profiles.**[25]**

I have not been able to locate any studies specifically referencing Metalimnetic Oxygen Minima in Nova Scotia which may indicate that to date it has not been a common phenomenon. Regardless, climate warming and increasing urbanization could lead to its more common occurrence. In Brylinski's 2002 report on the Nova Scotia Lake Hypolimnion Project, Metalimnion Oxygen Minima appear to present in 4 of the 20 lakes surveyed. **[26]** Of the 4 lake profiles for HRM area lakes presented by Doucet, 2022 **[4]** that were 15 m depth and greater, distinct dips in the metalimnion oxygen were present in the two (one of them Sandy Lake) that also exhibited very low oxygen and highly elevated Total P levels near the bottom.

About the Metalimnetic Oxygen Minimum, Mi et al. 2020 **[27]** comment:

> Many recent studies have reported a decline in DO concentration in temperate stratified standing waters…All these studies focused on oxygen depletion in the hypolimnion and the mechanisms involved were fully characterised. In contrast, little attention has been paid to DO loss within the metaliminon and the occurrence of metalimnetic oxygen minima (hereafter MOM) is far less understood.
>
> The metalimnion is the layer of high temperature and density gradients at the transition between the upper continuously mixing epilimnion and the hypolimnion. The occurrence of MOMs is affecting aquatic biogeochemistry, limnetic communities and has been described in many lakes and reservoirs worldwide (Wetzel, 2001). A MOM forms a barrier for many organisms and therefore influences the vertical distribution and biomass production of invertebrates (Horppila et al., 2000) and fish (Liljendahl-Nurminen et al., 2008). Rice et al. (2013) illustrated that metalimnetic hypoxia can cause fish kills in Lake Norman. Additionally, McClure et al. (2018) reported the occurrence of MOM in the Falling Creek Reservoir and indicated that the phenomenon can significantly change greenhouse gas dynamics. In drinking water reservoirs, a MOM can induce water quality deteriorations due to release of manganese or other unwanted substances and may require management interventions.

In regard to Sandy Lake, the occurrence of a Metalimnetic Oxygen Minimum and its apparently quick re-formation after the episodic flooding unfortunately adds yet more reason to be concerned about the state of the lake currently and the possible impacts on lake water quality of the proposed major development on its headwaters. The oxygen

minima for years 2021 to 2024 were in the range 2.4 to 3.8 mg/L well below CCME water quality guidelines for dissolved oxygen in freshwater for the protection of both coldwater and warmwater fish **[28]**.

What caused the Metalimnetic Oxygen Minimum? It may be relevant that at Sandy Lake, a lot of surface water flows into the lake over extensive shallower areas in the South Basin and thus is exposed to the sediment surface in the southern basin well before it reaches the area of our profile, also that some of these waters come from the more developed areas and areas where new development is planned or proposed. **[29]**

Another possibility and I think more likely: enhanced consumption of oxygen in shallow waters associated with a massive flow of wood chips into the northern basin of the lake following clearcutting of the developer properties in 2013. Climate warming could be expected to enhance the effect by increasing rates of respiration in shallower waters and sediments. It's possible as well that those woody materials eventually made their way to the deepest area and contributed to the sudden drop in deep water oxygen in 2021 and subsequently (Fig 2 above). **[30]**

The occurrence of the Metalimnetic Oxygen Minimum in Sandy Lake needs to be acknowledged and calls for further investigation. The Stantec reports make no mention of our observations or any comments related to Metalimnetic Oxygen Minima. However, as pointed out in relation to Fig 1 above, a Metalimnetic Oxygen Minimum is present in Stantec's 2023 Aug Profile.

5c. Algal Blooms

Stantec cites closures of Sandy Lake beach Park due to fecal bacteria contamination but not closure due to algal blooms. There was a beach closure on Aug 7, 2019 due, apparently, to a bloom of diatoms (Green Algae). I viewed the bloom when it first appeared on Aug 6 as I had taken a child there for swimming that morning and the lifeguards had just closed the beach.

Fig. 5. Sandy Lake Beach just closed on Aug 6, 2019 (left) and at right, views of the water & bottom. View post on www. versicolor.ca/sandylakebedford for description. **[31]**

I alerted Councillor Tim Outhit about the bloom, he contacted HRM and they issued a Risk Advisory on Aug 7 "due to possible blue-green algae bloom". The advisory was lifted on Aug 8 as "Following initial water testing, the municipality has confirmed there are no toxin-producing strains of cyanobacteria present in the water." **[31].** It's still not completely clear what it was, "it", it being, apparently or possibly, a bloom of diatoms – that's according to info. forwarded by Councillor Tim Outhit, received from Cemeron Deacoff (Water Resources Specialist, Planning and Development, HRM) on Thurs, Aug. 8, 2019 (bolding inserted):

> We received the lab results late yesterday afternoon that the specimens identified in the lab were **principally diatoms** (a form of algae), with trace amounts of one species of cyanobacteria that does not produce any toxins. Correspondingly, staff (i.e., P&D Acting Director Eric Lucic) has approved lifting the PSA. Corporate Communications is now drafting that PSA.

The bloom coincided with a rapid drop in lake level. I discovered later on that the drop in water level was associated with removal of beaver dams on Peverill's Brook, the watercourse draining Sandy Lake. I postulated that the rapid movement of water disrupted stratification allowing nutrient-rich deeper waters to move into euphotic surface waters, stimulating the bloom. **[31]**

Initially HRM issued a public advisory about the bloom, describing it as a possible blue-green algae bloom. Another BGA warning/notice of report was issued in June of 2021, June of 2022, and for Sep. of 2024. There was some controversy about these blooms, HRM Councillor Outhit maintaining at one point that the Aug 7, 2019 bloom was due to pollen not green algae, and that I exaggerated the significance of BGA warning of 2022.[32]

On Nov 6, 2024, a BGA (Blue-Green Algae) bloom occurred in Sandy Lake, which is unusually late for NS. It was observed by one of the SLV volunteers who took samples which I subsequently examined, tentatively identified as a BGA, and passed them on to qualified experts who confirmed it as "*Dolichospermum* (formerly *Anabaena*),a cosmopolitan buoyant N-fixing cyanobacterial genus found in Canadian lakes". [33] Our various volunteer observations provide strong evidence that the bloom coincided with the fall turnover of the water column which would have mixed the phosphorous-rich deep water throughout the water column, stimulating the bloom in the well lit surface waters. This was the first confirmed BGA bloom in Sandy Lake; the circumstances were somewhat unusual but were well documented and were reported in a formal publication. [33]

Both the Aug 6, 2019 green algal bloom and the Nov 6, 2024 BGA bloom appear to have been associated with breakdown of lake stratification and mixing of phosphorus-rich deep waters with euphotic surface waters. The events add to the evidence for occurrence of Internal P Loading in Sandy Lake.

6. Mitigative Measures/the No Net Increase in P Loading Policy

Stantec recommends a broad set of mitigative measures to reduce impacts of any development on the local ecological functions and on the water quality of Sandy Lake. In regard to maintaining water quality of Sandy Lake, the overall strategy advised by Stantec is one of No Net Increase in P Loading in order to maintain Sandy Lake in its current lower mesotrophic state as assessed by Total P values.

The No Net Increase in P Loading strategy (NNIP) reflects water quality objectives adopted under the current (2014) Regional Plan [34] :

1. Achieve public health standards for body contact recreation; and
2. Maintain the trophic status of lakes and waterways to the extent possible.

NNIP is a developing strategy for HRM lakes and watersheds more broadly. [35]
As I understand it, the procedures to achieve NNIP were introduced to HRM in the "Proposed River-lakes Secondary Planning Strategy", a Presentation to Regional Council For First Reading – October 2, 2012. **[36]** From that document:

> **No Net Increase in Phosphorus Loading Policy**
>
> - No net increase in phosphorus over current levels for any large scale residential development to be considered by a development agreement.
>
> - Phosphorus export coefficient study required for pre- and post development.
>
> - If phosphorus is predicted to exceed current levels then the proponent will have to reduce density and demonstrate how stormwater run-off can be treated naturally on-site

The policy is currently formally applied only in Planning Districts 14/17 (Shubenacadie Lakes).

> This policy requires large-scale development subject to this policy to prepare a study demonstrating that the development will contribute no net increase in phosphorus to the water bodies in the plan area (approx. roughly Lake Charles through to Shubenacadie Grand Lake), and demonstrate how development impacts will be mitigated to meet the no net phosphorus increase requirements. - from "Municipal Planning Strategy for Planning Districts 14/17 with amendments to October 13, 2023" **[37]**

Policy RL-22 in that document embodies the approach Stantec advises for Sandy Lake (see Note **[37]** for details.

There are similar initiatives being made in other jurisdictions, perhaps most intensively in Ontario and Alberta. HRM and NS more broadly have made use of those experiences as well as of a high level of related research and experience in Nova Scotia.

7. Internal P Loading is not addressed by most NNIP models and policies/why it is relevant

I suggest the following aspects of Internal P Loading are pertinent to Sandy Lake, and probably to more than a few other lakes in HRM and Nova Scotia more broadly:

(i) **Internal P Loading is not addressed by the predictive models currently used by HRM and Nova Scotia, or by related strategies and remedial actions, but is on the radar screens of current monitoring programs and NS-based research.**

The Brylinski 2004 model used by HRM and similar models consider only *external* P loading and the lake itself is assumed to by a net sink for total P (re: the "Retention coefficient). Likewise the current NNIP policies/remedial actions address only external P loading.

This is the case in many jurisdictions, perhaps because the phenomenon of Internal P Loading, while known for a long time has not been a widespread concern until relatively recently. It's emergence appears to be related to increasing anthropogenic eutrophication* and to increased strength and duration of lake stratification associated with climate warming, **[38]**

*Internal P Loading occurs "naturally" as Total P levels increase and deep water oxygen levels drop to hypoxic levels (<2 mg/L)

Internal P Loading is well recognized by researchers at Dalhousie University and in NSE (Nova Scotia Dept of Environment and Climate Change); recent monitoring has indicated it may now be quite common in HRM lakes and elsewhere in Nova Scotia lakes.**[39]**

In a study designed to understand drivers of eutrophication of lakes in SW Nova Scotia affected by mink fur farming, The Dalhousie/NSE researchers incorporated Internal P Loading into the Brylinski 2004 model by treating it as a separate point source mass input in the model, estimating the input from relationships given in the literature of internal P Loading to lake morphology characteristics, and to release rate of P which required an estimate of the anoxic factor, a measure of how many days in a year the sediment surface of a lake is anoxic. From the discussion:

> The storage and release of P from lake sediments will continue to be an issue even after external P loads are reduced. In this study, we had limited information for estimating internal P loads, but our results indicated that it could be a significant source of P. The release rate of P from lake sediment is dependent on the concentration and forms of P within the lake sediments, trophic state, timing and extent of stratification, and oxygen levels at the sediment-water interface. Climate change is expected to exasperate the process of internal loading. Recent studies have shown that climate change, specifically increasing air temperature and decreased wind speed have contributed to increased internal P loading (Favot et al., 2019; Magee and Wu, 2017). The combination of increased air temperature and decreased wind speed leads to a warmer epilimnion, a cooler hypolimnion, and longer and stronger periods of stratification. Longer periods of stratification lead to greater deoxygenation of the hypolimnion and anoxia at the sediment surface which are ideal conditions for internal P loading. Of note are the differences in stratification and dissolved oxygen levels we observed between 2008 and 2017, which resulted in contrasting internal P

load estimates. Further monitoring should be undertaken in these lakes to better understand how climate influences inter-annual variability in thermal profiles, dissolved oxygen levels, and internal P loading. - Van Heyst et al., 2022. Application of phosphorus loading models to understand drivers of eutrophication in a complex rural lake-watershed system. In *Journal of Environmental Management*
https://www.sciencedirect.com/science/article/abs/pii/S0301479721020727?via%3Dihub

(ii) **Internal P loading can be quantitatively very significant, even exceeding inputs from external loading. [40]**

(iii) **Internal P loading/Lake anoxia acts or can act as a runaway process; once it get's going, it self-stimulates resulting in accelerated eutrophication and deterioration of lake water quality.** The mechanism has been described as "Anoxia Begets Anoxia (ABA) feedback":

From **Anoxia begets anoxia: A positive feedback to the deoxygenation of temperate lakes by A.S.L. Lewis et al., 2023 in Global Change Biology [41]**

..we analyze a positive feedback, derived from decades of aquatic research, by which anoxia (i.e., DO at or near 0 mg/L) during a given year begets increasingly frequent and severe occurrences of anoxia in subsequent years. In this "anoxia begets anoxia" (ABA) feedback, anoxic conditions promote internal phosphorus release, thereby stimulating phytoplankton growth and subsequent decom- position, which in turn fuels increased heterotrophic respiration and further accelerates hypolimnetic DO declines over time (Figure...) .

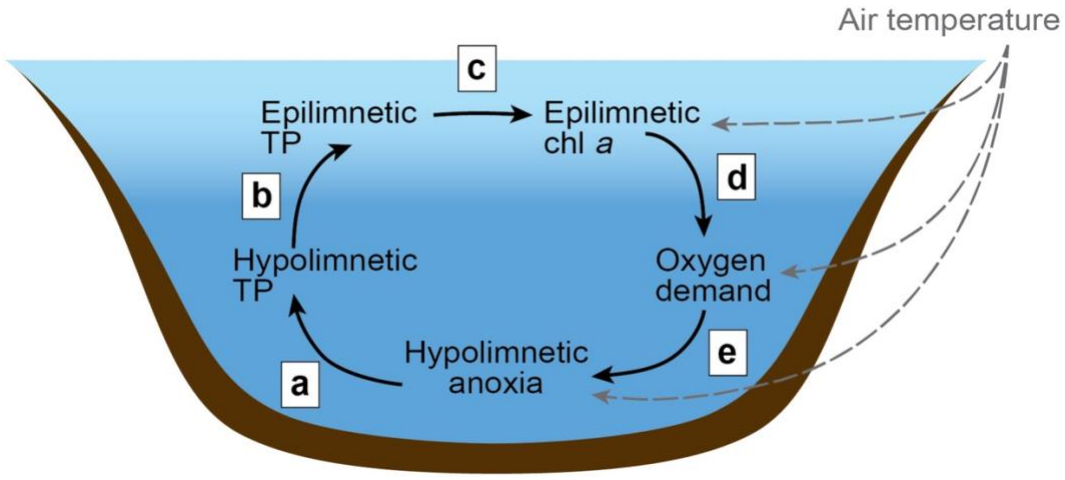

FIGURE... **The proposed positive feedback through which "anoxia begets anoxia" (ABA).** Hypolimnetic anoxia results in internal hypolimnetic total phosphorus (TP) loading (a), which in turn increases epilimnetic TP (b) and stimulates phytoplankton growth, resulting in increased chlorophyll *a* (chl *a*; c). Phytoplankton decomposition fuels increased oxygen demand rates (d), which further drive hypolimnetic oxygen declines (e). This feedback can be externally influenced by increased air temperatures (gray dashed lines), among other factors.

It's not clear whether we have yet reached a run-away that stage in Sandy Lake but the trend in bottom oxygen values suggests we are heading in that direction - for the years 2021 to 2024 when we have near surface and near bottom TP values, there was evidence of Internal P loading in two of those years (2021 and 2024) and near bottom oxygen values were low on three of the 4 years; the exception was 2023 when it appears intensive flooding disrupted stratification for a period, as discussed above.

(iv) **Internal P loading is not controlled or is not readily controlled by reducing External P Loading and can delay lake recovery for decades, if not longer. [42]**

(v) **Other types of mitigative actions could be required to address Internal P Loading.** External organic loading, regardless of its P content, can cause oxygen declines. A possible example: I have suggested that the massive influx of coarse woody debris, which is likely not a significant source of P **[43]**, to the northern basin of Sandy Lake following clearcuts in 2013 (Fig. 6 below) may be responsible for the ongoing Metalimnetic Oxygen Minimum, and perhaps is even the cause of the sudden drop in deep water oxygen after 2019.**[30]** If so, it illustrates a delayed and then protracted response to the initial disturbance - clearcutting with onsite retention of coarse woody debris occurred in 2013; the sharp dip in deep water oxygen and a pronounced Epilimnion Oxygen Minimum is first evident in the 2021 limnological profile of Doucet (see note **[24]** and Fig 1 above (there was sampling in 2017, 2019, and 2021-2024 but no sampling in 2020).

There is evidence that climate warming has contributed to declining lake oxygen levels both by increasing the strength of lake stratification and by increasing the length of the summer stratification period **[44]**. This fact alone behooves us to adopt more stringent mitigation measures than required simply to *maintain* current TP levels, especially when those levels have increased substantially from pre-development levels.

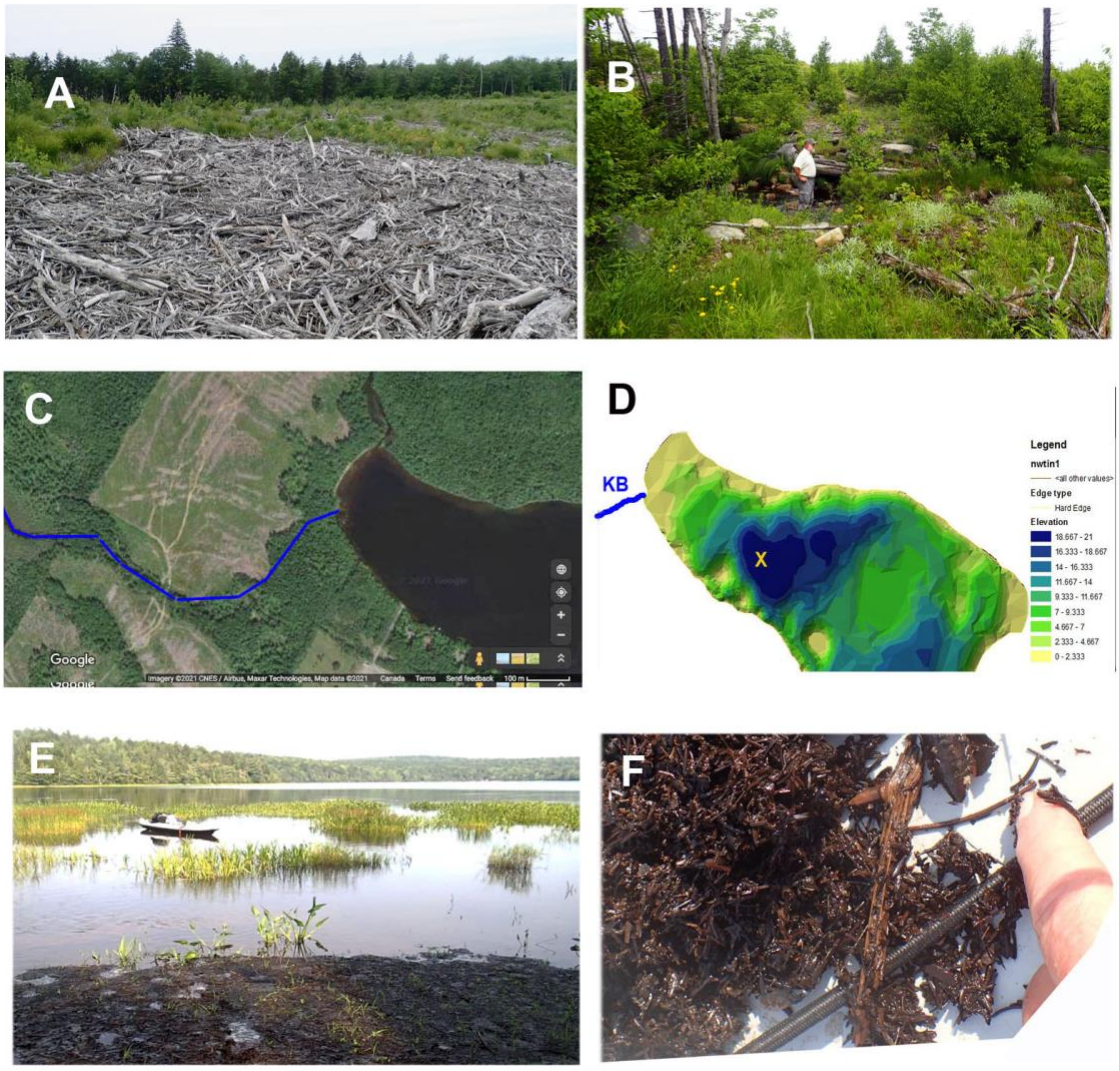

Fig. 6. Coarse woody debris from 2013 clearcut washed into Sandy Lake
A: Coarse woody debris in the clearcut area viewed June 21, 2017. **B: Road crossing Karen's Brook** - the riparian buffer zone was interrupted here. **C: Google Earth Map** imagery (Sep 5, 2015) shows clearcuts, Karen's Brook highlighted in blue, road crossing the brook, point of entry of brook into Sandy Lake. **D: Bathymetric map** (Ed Glover 2006 https://versicolor.ca/sandylakebedford/maps/) of north basin of Sandy Lake showing locations of entry of Karen's Brook and of our deep water sampling. **E. View, Aug 21, 2017 from near the mouth of Karen's Brook looking across the lake**, exposed deposits rich in coarse woody debris in foreground, these extend outward past the emergent vegetation which local residents say increased markedly in recent years. **F: Sample of the deposits rich in coarse woody debris**. More photos, details at https://versicolor.ca/sandylakebedford/waters/streams-wetlands/wetlands/lake-fringes/karens-brook-nw-beach/

This extract from an article by Williams James (2016) **[42]** provides a succinct overview of management issues related to Internal P Loading:

> From **Internal P Loading: A Persistent Management Problem in Lake Recovery** by Willaims James, 2016. Posted on nalms.org (North American Lake Society) at https://www.nalms.org/wp-content/uploads/2017/01/36-1-3.pdf
>
> Simply reducing watershed P loading to eutrophic lakes without also managing internal P loading may not be enough to reverse impaired water quality. Even though internal P loading is ultimately derived from the watershed, it can take years to decades to flush sediment P out of the system after watershed BMP implementation, resulting in delayed recovery and continued impairment. In addition, a symptom of decades of P retention as sediment in lakes is the buildup of a surface sediment P concentration bulge that is usually difficult to bury over time and persists as an important internal P source during hypolimnetic anoxia, stimulating and sustaining algal blooms despite other efforts of remediation... Unless controlled directly via P-adsorbing technologies such as aluminum salts, lanthanum-modified clays, or other measures, internal P loading from profundal sediments can provide a form of ecosystem feedback that maintains a eutrophic equilibrium that is resistant to management efforts.

Some of the "Other Measures" that have been used to address hypoxia/Internal P Loading (with variable success) are Aluminum precipitation, Clay amendment with added phosphorus-binding substances, Bottom water withdrawal, Dredging, Reduction fishing (biomanipulation), Mixing, Oxygenation. **[45]**

If Hypoxia/Internal P Loading is not addressed early on, such more extreme or unusual remedial actions may have to be assumed by the surrounding community as at Oathill Lake in Dartmouth. **[46]** Surely it's simpler, more beneficial and less costly to society at large to, as much as possible, avoid creating the conditions in the first place, or failing that, taking remedial action earlier on.

Fig. 7. Community volunteers set up Aquago for 2022 open water season on Oathill Lake in a densely settled neighbourhood of Dartmouth, N.S, Photo by Erale Hickey, with permission. More photos at https://www.flickr.com/photos/earle/51964726243/ The solar powered mixing device was installed in 2015. The deepest spot in Oathill Lake is 8.5 m, most of the lake is less than 5 m depth. Oxygen was depleted from 3 to 4 m depth to bottom over much of the summer season, now only in the deepest 1 to 1.5 m which occurs over a very limited area. Total P has declined significantly. The Aquago is one of a larger set of remedial measures introduced and maintained by the Oathill Lake Conservation Society. **[46]**

8 How to address Internal P Loading at Sandy Lake?

I offer a few thoughts/suggestions recognizing that there are much better qualified practicing professionals in NS in government service and academia who could address this question.

1. **Acknowledge that the conditions conducive to Internal P Loading occur in Sandy Lake now**, and that and Internal P Loading is occurring in some years.

2. Conduct further Investigations to better characterize Internal P Loading in Sandy Lake. Is it occurring just in deeper waters or also in shallower waters, e,g. associated with the deposits of coarse woody debris and/or and the metalimnetic oxygen minimum? Ideally such investigations would occur before any major development is initiated.

3. If/when new development is initiated, incorporate criteria related to Internal P loading in adaptive management e.g., by setting minimum oxygen levels for deep water which if exceeded require appropriate mitigative actions; set the target for Total P at the estimated predevelopment level, not the current level. **[47]**

4. **Implement more mitigative and precautionary measures than currently recommended to counter the currently unaccounted for Internal P Loading.** Disturbances in the initial construction phase of any new development at Sandy Lake especially need to be minimized, thus I am supportive of higher density, lower land footprint scenarios, and of recommendations given in the Stantec Watershed Report Section 5.3 Sediment Loading Mitigation. But even with those, because of the possibility of setting off runaway "Anoxia Begets Anoxia" and because the site of the envisaged development is located in an area of concentration of headwater watercourses close to the lake, it's critical to avoid the kind of mass sedimentation of waterways - likely carrying a lot of phosphorus and oxygen-consuming organic debris - that has been seen at the Southdale development in Dartmouth. **[48]** The erratic rainfall patterns we have seen in the last few years, notably the extreme flooding in July and Aug 2023, further increase the risk. **[49]**]

> *"The amount of sediment that could be released to surface waters during a construction site's short life can be substantial*"
>
> - B Lubkiner, 2007, in "Phosphorus Concentrations in Construction Stormwater Runoff: A Literature Review" https://apps.ecology.wa.gov/publications/documents/0703027.pdf

5. **Increase Riparian Buffer widths**. NS-based research shows clear benefits to increasing the buffers widths beyond the 30 m recommended by Stantec, e.g. to 50 or 70 m **[50]**, especially for mitigation of increased flooding and erosion associated with climate change. However, given the high concentration of headwater streams and associated wetlands in the Study Area, increases in buffer widths much beyond 30 may be incompatible with the desired numbers of residential units for this site.

6. **Choose another site of much lower ecological sensitivity within the same landscape**. If we consider, objectively and comprehensively, the precautions and mitigative measures that need to be taken to protect the water quality of Sandy Lake, given

(i) there is elevated risk associated with the current precarious state of the lake'
(ii) the site of the envisaged development is located in an area of concentration of headwater watercourses and associated wetlands close to Sandy Lake

it might well be concluded that it is simply not economic, and far too risky to proceed with any of the development scenarios evaluated in the Stantec Community Studies for Sandy Lake.

A simple, less risky and less costly option for the developer, for the province to achieve its housing goals, and for Sandy Lake could well be - even at this late date - to choose another site of much lower ecological sensitivity within the same landscape.

9. Why were the SLV observations not cited?

I asked (May 28, 2025) a senior planner at Stantec and the individual with whom I had most communication, why the Stantec Reports did not reference any of the information that I shared with them. I sent a follow-up inquiry to Stantec on July 14, 2025; he responded July 15, 2025, thanking me for my input and commenting that they "did not intend to ignore your input", and noted that the Sandy Lake work was accepted.

So I am left to speculate on *why* my input was, as acknowledged, ignored, or on the justification that might be offered for ignoring it.

Speculative reason # 1: The SLV data did not offer sufficient temporal resolution to be useful

In the Stantec Watershed Study, p. 3, the following rationale/criteria are offered for Stantec's use of historical data and for their own sampling regime (bolding inserted):

> Surface water data collection was completed by Stantec Consulting Ltd. (Stantec) monthly between April and November 2023 and was used in conjunction with the historical water quality collected intermittently since 1980 to characterize water quality in the SLSA. Data collected prior to 1980 was not included in this study in the detailed analysis due to the sparsity of measurements and their potential limitations in representing temporal trends accurately. Data prior to an including 1980 are generally limited to one measurement per year, which makes the data less reliable for detecting nuanced patterns or changes over time. It is also important to note that the primary objective of this study was to model changes in water quality under specific development scenarios rather than to evaluate historical water quality or long- term trends. **As such, data with sufficient temporal resolution was prioritized to support modeling and scenario-based analysis.** Field monitoring of water quality was conducted at select locations across the SLSA including in-lake, deep zone, watercourses, lake inlet, and lake outlets (Stantec 2024a). The data was used as a comparison tool for contaminant models as well as a measure of lake water quality.

If offered as a rationale for not making use of the SLV observations it is a pretty weak one, especially as Stantec's own sampling, while offering some "temporal resolution" was restricted to shallower depths (10 m max) - no explanation offered.

Further, as it turns out, the Stantec observations were conducted in a year (2023) which our observations in combination with those of Doucet in 2021 - do have some temporal resolution year to year suggest was highly anomalous, the summer stratification disrupted by excessive precipitation as discussed above. Stantec was surely aware of the extreme weather conditions:

> *Note that multiple extreme weather events throughout the 2023 field season (i.e., wildfires and floods) resulted in some unsafe and/or inaccessible areas within the SLSA*.
> - Stantec LSA Report for Sandy Lake, page 7.

Stantec cites "Dalhousie University (Doucet C)" as a source of historical water data for the year 2021 in the Stantec Watershed Study (Table 1.2, p.4, "2 samples for Nutrients, General Chemistry, Chlorophyll a, Metals"). "Dalhousie University (Doucet C)" also provides a set of data for Sandy Lake in 2021 that does have a fairly high "**temporal resolution" month to month over the open water season, a**nd in addition was obtained in a year of more typical summer rainfall*, and extended to 18 m depth.**[4]** Why were those data not made use of?

*The significance of differences in summer rainfall is suggested by the data from the SLV Observations and those of Doucet 2022 that provide temporal resolution *year to year* from 2021 to 2024: the deep water (hypolinion) oxygen level in 2023 was anomalously high, and the SLV profile observations for the spring and late summer of 2022, 2023 and 2024 suggest that heavy precipitation and flooding resulted in a "freshening" of the entire water column in mid-summer of 2023 **[14]**.

Speculative reason #2: The Stantec folks involved were simply not very critical or curious scientifically.

The Doucet data that Stantec did make use of are *not* listed in Appendix A (Background Water Quality Data), while "Sandy Lake Resident" data, not cited in the Stantec Watershed Study Table 1.2, *are* listed. It appears the Stantec folks simply copied data from Appendix C of AECOM 2014 without much thought. Some further inconsistency: "Dalhousie University (Doucet C)" is not listed as a source of historical water data in the Sandy Lake LSA study (Table 3.10, p. 24).

There appears to be no identification in the Sandy Lake Watershed Report, pdf pages 101-109 of where Stantec's field samples labeled SW-01... to SW-09, and finally just "Sandy Lk" came from and it's not clear how these values were used in calculations, modelling etc. I am curious about the very high Total P values of the SW-01 samples; as the chloride and Total Coliforms were also high, I suspect SW-01 is a bottom sediment sample. What was the depth - 10 m? Was this porewater? How were the data used? Why were there distinct minima in chloride and Total P in Aug & Sept? (I suspect it relates to some destratification/freshening associated with heavy rains as I inferred from our profile observations 2022-2023-2024. **[14]**

In other regards Stantec's description/interpretation of water quality data are likewise sketchy. They discuss oxygen values without reference to depth - perhaps because their "deep water site" was only 10 m depth? - Or did they use a probe line that extended to only 10 m?

So I have to wonder: did Stantec avoid citing depths of their oxygen samples and avoid to mention lake stratification, differences in oxygen content between epilimnion and hypolimnion etc. - pretty fundamental stuff that was treated explicitly in the AECOM 2014 Sandy Lake Watershed Study - because they did not sample beyond 10 m? Likewise, is that why they don't cite the SLV Observations and the 2021 profiles reported by Doucet 2022?

Stantec's comments on "Internal Loading" in sections 1.3.1.1 (p.6 of the Sandy Lake Watershed Report) and 1.3.4 (p.8) portray some lack of or a very limited understanding of, the process.**[51]** More concerning, their comments are offered without any reference to evidence of its actual occurrence in Sandy Lake as provided by AECOM 2014 and Doucet 2022 as well as by SLV/Halifax Lakewatcher observations of Aug. 2024

Speculative reason #3: SLV observations were discounted because the observers were biased

Perhaps the SLV observations were discounted or Stantec could justify discounting them because they were not seen as objective, rather they were conducted as part of the campaign to "Save Sandy Lake", This explanation is suggested by the lone reference to my name and observations on Sandy Lake in the Stantec documents:

From: Sandy Lake Summary Report , p 17, bolding inserted

Aside from developers and property owners, Stantec also made contact early in the project with the SLSRRPC. The group has had a long-standing interest in protecting the lands in the Sandy Lake area and in the establishment of the Sandy Lake Regional Park. Representatives of the group met with Stantec Team members in Stantec's offices and had a follow-up meeting with Stantec online. They set out their position on development in the area and provided Stantec with an extensive list of background materials and studies relevant to consideration of the Study Area, the regional park proposal, and general environmental concerns, including studies and submissions prepared by Coalition members. They provided many of the documents to Stantec and have since continued to provide materials relevant to Sandy Lake.

The Coalition is opposed to development in the Study Area and would prefer all the proposed development lands to be incorporated in the proposed regional park. Failing its acquisition as parkland, they emphasized the need for **generous wildlife corridors** through the area and **substantial riparian buffers** around all watercourses. **They were critical of past water quality assessments and provided a study of local water quality prepared by member Dr. David Patriquin, a retired biology professor from Dalhousie University.** They also argued that assessment of the water quality should include the entire Sandy Lake-Sackville River watershed, not just the Study Area .

To be picky when it comes to bias, Stantec might have explained why they considered the suggested wildlife corridors as "generous", and the riparian buffers as "substantial". Both, although exceeding current minimal NS Gov. or HRM requirements, in fact have significant scientific bases. **[50]**

Regardless of who perceives who as biased, It's clear that I need to provide some clarification of my relationship to the Sandy Lake/Sackville River Regional Park Coalition (SLSRRPC).

I am not a member of the Coalition, rather I have served as a contact person (and they will tell you, not a very responsive one) on the Coalition for 3 member organizations in which I am a member (Woodens River Watershed Environmental Organizations, Halifax Field Naturalists and NS Wild Flora Society). I was asked and agreed to be a co-chair of the Coalition when it was formed in Dec of 2018 just to help it get going but resigned shortly thereafter to maintain the appearance as well as the fact of my independence as a scientific observer. I have not since then participated in any of the SLSRRPC steering committee meetings**,** save one when they asked me join them in bringing concerns about the environmental impacts of proposed development to the attention of Stantec in the May 2023 meeting, and they did not want to misrepresent my findings - but my documentation was prepared entirely independently. I have forwarded the results of ongoing studies to Stantec, on occasion for my convenience, I have sent them to Karen Robinson, co-chair if the SLSRRPC to forward Stantec, but without any consultation on the content.

My reports on Sandy Lake observations are my own, I place them directly on the www.versicolor.ca/sandylakebedford website to make them publicly available ASAP after they are obtained; these reports are prepared without any consultation with any Sandy Lake advocacy organizations or individuals.

Since my retirement (2008) I have conducted similar studies in similar relationships with other organizations - WRWEO/Chebucto Coalition in relationship to their efforts to protect the Five Bridge Lakes Wilderness Area (protected by the province in 2011) and two other properties on the Chebucto Peninsula (protected by NS Nature Trust in 2019); Williams Lake Conservation Co./Backlands Coalition in relation to efforts to protect the Williams Lake Backlands (protected by HRM/NCC as the Shaw Wilderness Park in 2020) and ongoing (French Village Conservation Woodland) **[7]** as well as in relation to Sandy Lake & Environs.

Call the SLV Observations "Citizen Science" if you wish, but I suggest don't dismiss volunteer observations out of hand as volunteers play a big role overall in water quality monitoring in Nova Scotia. **[52]**

More broadly, while "citizen science often faces scepticism and distrust from professional scientists and significant resistance from policymakers", data from Citizen Science is being recognized as "unparalleled as it represents evidence that is otherwise difficult for professional science to generate or obtain", and efforts are being made "to expand classical scientific methods to allow citizen science data to be incorporated and used". **[53]** One aspect of such expansion is developing criteria to assess the validity and the reliability of Citizen Science data. Comment B. Balázs et al. **[53]** (bolding inserted):

> From a more general research design perspective, **the validity and the reliability of data are most important**....Reliability implies long-term stability and consistency of data. **Data results should be able to be replicated repeatedly...**

If the skeptics were to look for independent validation (or not) of my Sandy Lake observations, they would find it. In fact, I would be less than 100% confident in the limnololgical profile observations and I could understand why others might have some reservations, were they the only profile observations on Sandy Lake but they are not. Thus I was reassured when an entirely independent set of observations by Casey Doucet in 2021, reported in 2022 **[4]** also indicated very low deep water oxygen levels and provided some direct evidence for Internal P Loading,

As well, Doucet's profiles exhibited the oxygen minimum in shallow waters that I had observed (she doesn't comment on it) and that I thought might be an instrument error. I only pursued it further when I had this reassurance that it was real, and then discovered the literature describing the MOM ("Metalimnetic Oxygen Minimum"). As it turns out, the MOM shows up as well in the Stantec profile for Aug 2023 (Fig. 1 above).

Finally, as some further reassurance of the reliability of the SLV observations, two issues that I identified as of concern in relation to Sandy Lake early on - low deep water oxygen

levels and increasing salt levels/some salt stratification are highlighted in the LakeWatchers 2022-2023 report as now probably common phenomena in Halifax area lakes.**[20]**

A comment in closing re: Stantec standards. It has been difficult for me to write critically of Stantec's Sandy Lake Reports as I have otherwise held Stantec's Environmental Consulting work in high regard, and I see this particular set of reports by Stantec/aspects dealing with Water Quality as aberrations, not up to their usual standards.* As well, my respect for Stantec derives from my familiarity with a half dozen or so individuals working with Stantec who are/were exemplary ecologists/naturalists. While a Prof at Dal I often encouraged students who were good naturalists to pursue a career with consulting companies such as Stantec and I was able to cite examples of students who did just that and were very satisfied with their career paths.

*E.g., as in Stantec Consulting Ltd. 2017. **Results of the 2017 Water Quality Survey of Eleven Lakes in Yarmouth and Digby Counties**. Prepared for Carleton River Watershed Area Water Quality Steering CommitteePosted at https://nsfa-fane.ca/wp-content/uploads/2018/03/007_Results2017waterCaretonRiver.pdf. It provides much more critical discission of results (than in the Stantec Sandy Lake studies), more critical sampling and clear recognition of the significance of lake stratification and of the potential for Internal P Loading and cites some evidence of its occurrence.

10. The Ask

Minister LeBlanc/Nova Scotia Government/Dept. of Growth and Development:

> I am not asking you to accept my contention that there are significant omissions & misinterpretation of data related to the water quality of Sandy Lake in the Stantec Reports.
>
> Rather I am asking you to accept that I raise some significant issues that call for follow-up investigation and to initiate such follow-up.

If that is simply not an option, then I appeal to those involved in Secondary Planning and in the actual developments at Sandy Lake to give serious consideration to the issues I have identified.

Respectfully,

David Patriquin

NOTES - Sep. Document.