APPENDIX B

MEMORANDUM - NEARY TO O'NEILL,

OCTOBER 31, 1991

Ontario
Ministry of the Environment
Minis[redacted] de l'Environnement

Water Resources Branch

Bellwood Acres Road
P.O. Box 39
Dorset, Ontario Canada
P0A 1E0
(705) 766-2412
(705) 766-2418

Chemin Bellwood Acres
C.P. 39
Dorset (Ontario) Canada
P0A 1E0
(705) 766-2412
(705) 766-2418

Fax: (705) 766-2254

October 31, 1991

MEMORANDUM

TO: T. J. O'Neill
District Officer
Ministry of the Environment
Muskoka Haliburton District Office
483 Bethune Drive
Gravenhurst, Ontario
P0C 1G0

FROM: Bernie Neary
Supervisor, Lake Management Studies Unit
Limnology Section
Dorset Research Centre

RE: **Dysart et al., Sewage Treatment Plant Expansion**

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1. Background

The Ministry of the Environment has some outstanding concerns regarding the impact of the proposed expansion of the sewage treatment plant in Haliburton on the water quality of Grass and North Kashagawigamog Lakes. As a result of discussions with the Municipality of Dysart et al., we undertook to model the consequences of various expansion scenarios on the lake system. This memo outlines the results of those modelling runs.

During the preparation of the Environmental Study Report by Totten Sims Hubicki, comments were solicited from residents and cottagers on the lakes in the vicinity of Haliburton. Several cottagers indicated that was their perception that the water quality in Lake Kashagawigamog chain has declined. This is corroborated by an examination of the self-help data collected on both South Kashagawigamog and Canning Lakes. Both sets of data show a long-term trend to higher levels of chlorophyll and lower Secchi depth, consistent with slow eutrophication of the lake chain (see Figure 1).

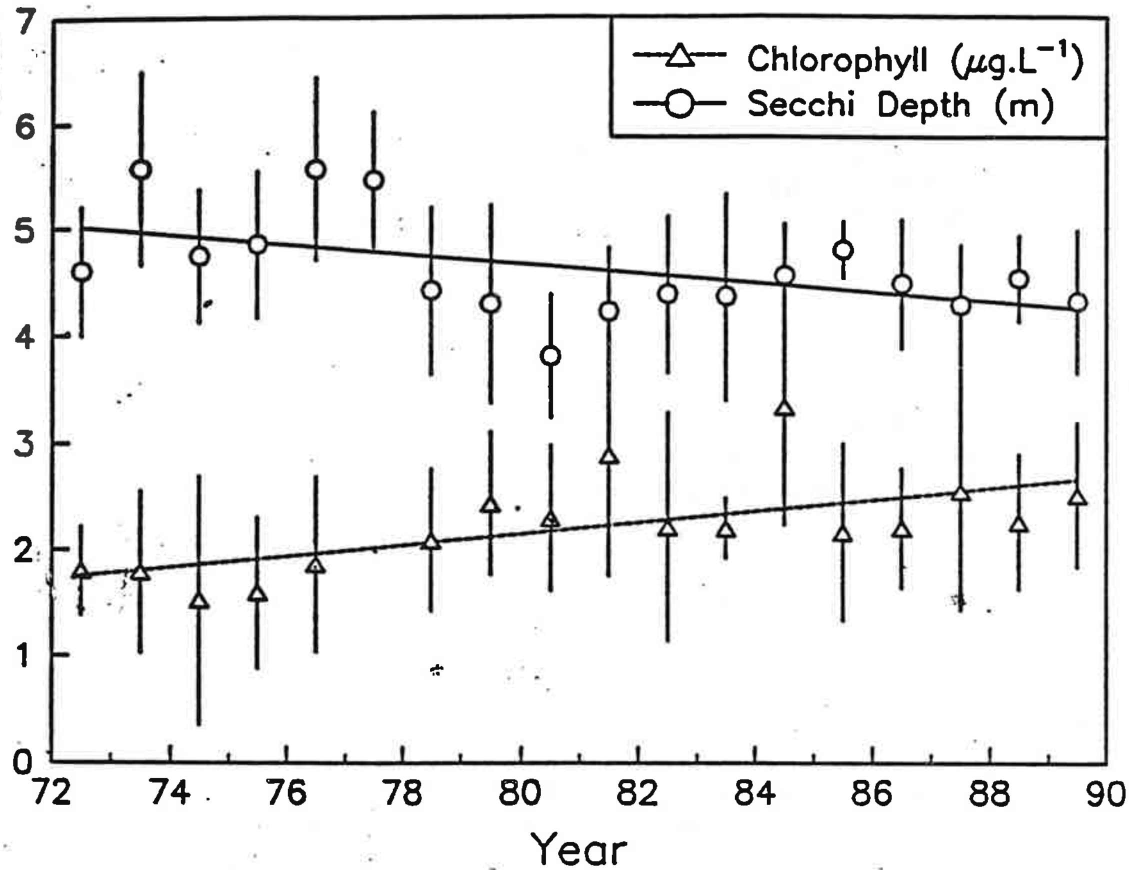

Figure 1: Chlorophyll and secchi depth in Canning Lake, 1972-1989. Data were collected under the Central Region's Cottager Self-help Program.

Lakes do not exist in isolation, and activities both in their immediate watershed and on upstream lakes will have an impact. I have looked at the sewage treatment plant scenario as it affects the part of the Drag River system below Haliburton. In doing so, I considered activities on upstream lakes, of which the major one is Drag Lake. There are a large number of severed but vacant lots on this lake, and the impact of developing those lots was considered to generate likely scenarios for the phosphorus concentrations in the lakes of the Drag River chain. The set of lakes considered in the modelling exercise is shown in Figure 2.

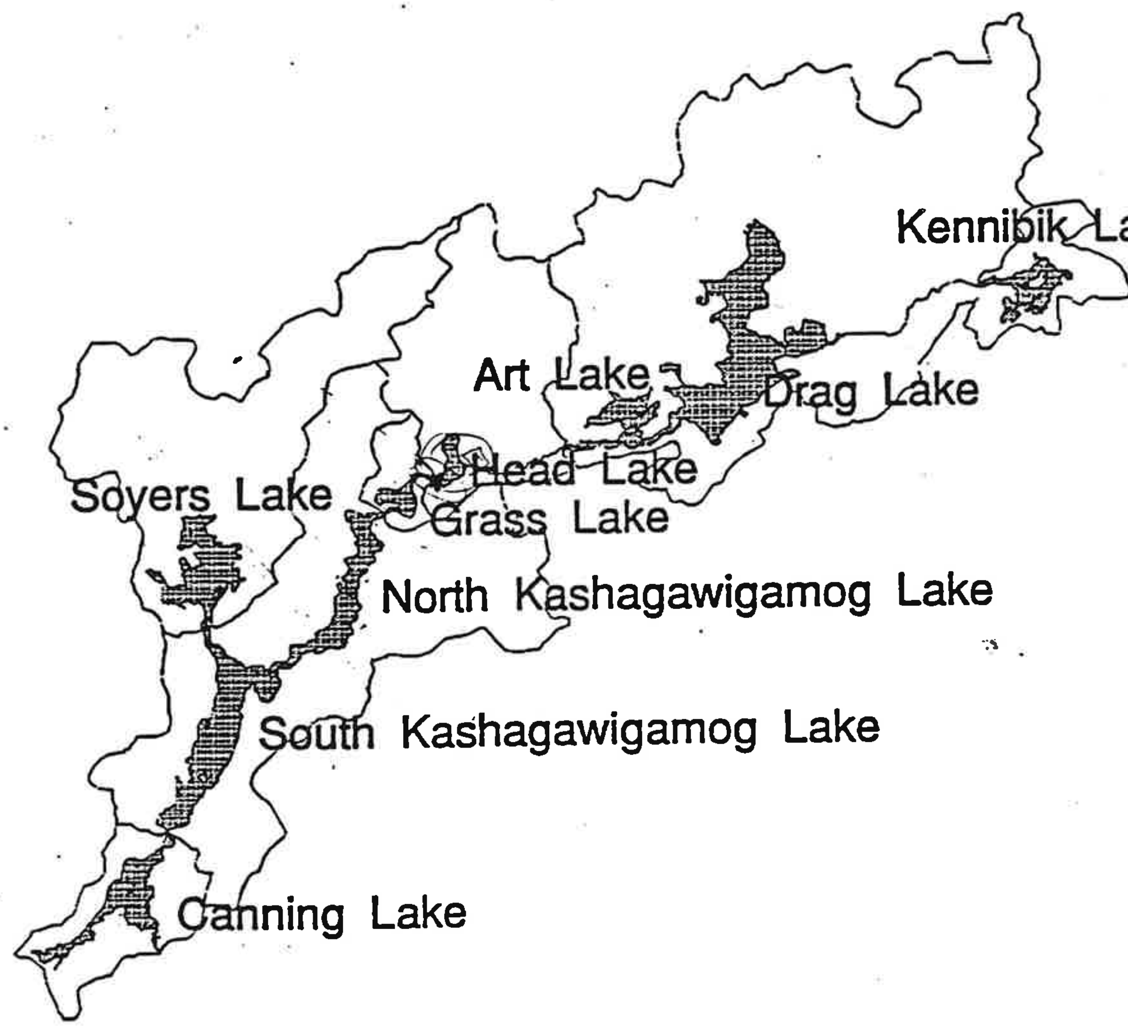

Figure 2: The Drag River watershed, showing lakes included in the modelling set.

2. Methods and Data Sources

The model used here is the Trophic Status Model (TSM) developed as a result of the Lakeshore Capacity Study. The model is fully described in Dillon et al., (1986)[1]. The chlorophyll predictions are made using modifications of the TSM equations according to Molot and Dillon (1991)[2]. The approach for modelling the effects of upstream development is described in Hutchinson et al. (1991)[3].

Lake morphometry data was obtained from the Ministry of Natural Resources Lake Inventory. Watershed areas were determined by digitizing the watersheds from 1:50000 maps. The physical lake characteristics are shown in Table 1.

The data for cottages, permanent residences, and vacant lots were obtained from information sent by the Municipality of Dysart et al to T. O'Neill[4]. These data are shown in Table 2.

It should be noted that the development figures for Kashagawigamog Lake represent only that portion of the North Basin which is included in Dysart et al. Some of the North Basin and all of the South Basin are in the Municipality of Anson, Hindon, and Minden. Development figures for North and South Kashagawigamog Lakes were obtained from data in the Totton, Sims, Hubicki Phase I and II Environmental Assessment Report[5]. The development

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[1] Dillon, P.J., K.H. Nicholls, W.A. Scheider, N.D. Yan and D.S. Jeffries. 1986. 'Lakeshore Capacity Study. Trophic Status.' Ministry of Municipal Affairs. Toronto, Ontario. 89p.

[2] Molot, L.A., and P.J. Dillon. 1991. Nitrogen/phosphorus ratios and the prediction of chlorophyll in phosphorus-limited lakes in central Ontario. Can. J. Fish Aquat. Sci. 48:140-145.

[3] Hutchinson, N.J., B.P. Neary and P.J. Dillon. 1991. Validation and Use of Ontario's Trophic Status Model for Establishing Lake Development Guidelines. Lake and Reservoir Management 7(1):13-23.

[4] Letter to T. O'Neill from D.L. McCallum, Clerk-Administrator of Dysart et al., April 15, 1991.

[5] Totten, Sims, Hubicki Associates. 1989. Haliburton Sewage Treatment Plant Expansion for the Municipality of Dysart et al., Ministry of the Environment Project No. 3-0706. Class Environmental Assessment Phases 1 and 2 Report.

Table 1: Physical characteristics of the lakes in the Drag River modelling set.

Lake	Area ha	Mean Depth m	Max Depth m	Volume $10^6 m^3$	Watershed* ha
Kennibik	155.4	7.0	25.0	10.87	857.9
Drag	1002.6	20.1	55.5	201.52	11338.3
Art	126.4	7.6	28.0	9.63	1045.3
Head	62.2	2.6	5.6	1.62	16382.3
Grass	63.6	3.4	9.5	2.16	16456.0
Kashagawigamog N	315.0	9.5	22.9	29.90	20986.0
Soyers	329.2	19.0	48.8	62.55	4822.2
Kashagawigamog S	493.0	15.2	39.7	74.00	27489.0
Canning	244.0	6.7	22.3	16.35	28652.9

* The watershed areas include the cumulative watersheds of upstream lakes.

figures for Soyers and Canning Lakes were obtained from the Ministry of Natural Resources Lake Inventory database, although these data may be out of date.

Table 2: Current Development and Vacant Lots on the Drag River Chain of Lakes

Location	Vacant Lots	Cottages	Homes	Commercial
Kennibik Lake	5		1	
Drag River	4			
Drag Lake	168	276	22	4
Drag River	17	1	15	
Art Lake	17	27	2	
Little Soyers	1	1		
Head	10	1	20	
Grass River	2	1	3	
Grass Lake	12	24	34	1
Birch Narrows River	4	28	18	
Kashagawigamog Lake	11	90	62	8

For the purposes of modelling, several development figures had to be estimated. For example, the number of vacant lots on Soyers, Canning, North and South Kashagawigamog Lakes was unknown. The figure of 11 vacant lots from Dysart et al. for North Kashagawigamog Lake was used, although since part of that lake is in Anson, Hindon, and Minden it is probably an underestimate. A figure of 20 vacant lots each was used for South Kashagawigamog, Soyers, and Canning Lakes. This number was arbitrarily selected, and may significant underestimate the number of vacant lots on these lakes which may be developed.

3. Results

a) Predicting Current Conditions

The TSM performed very well in predicting the current phosphorus levels in the lakes. A comparison between

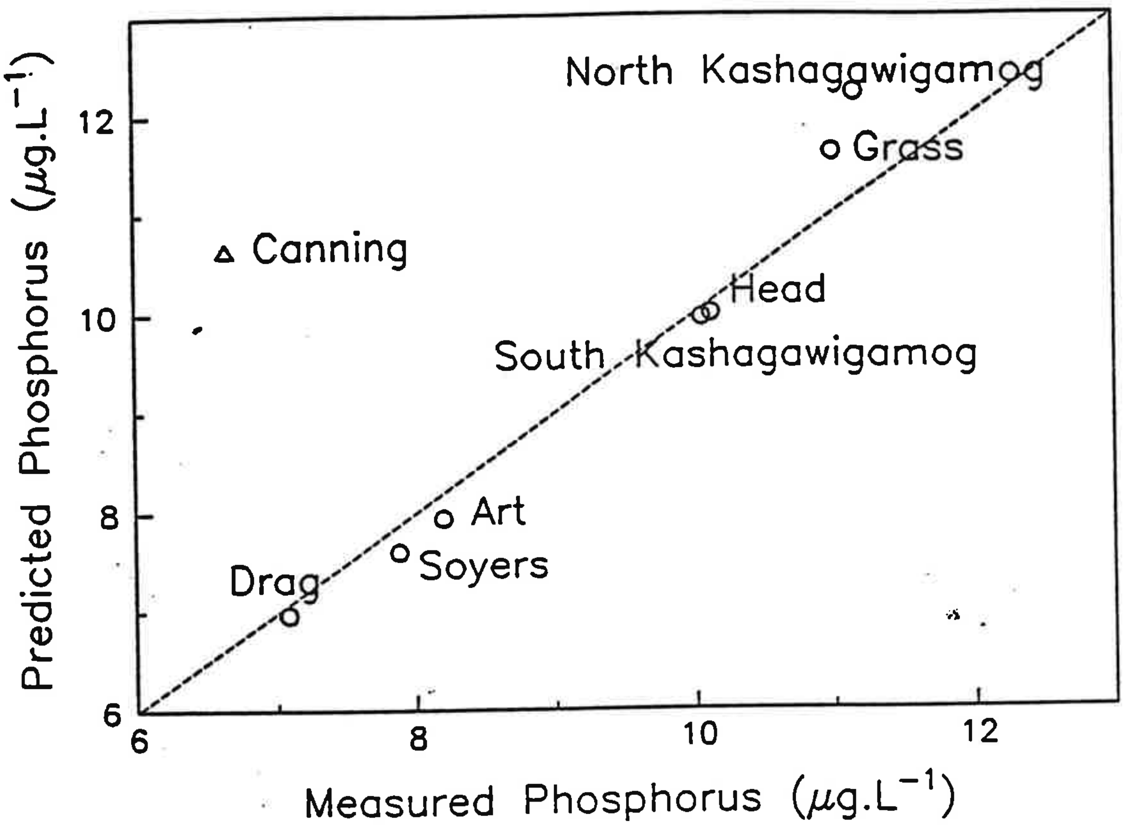

Figure 3: Comparison between phosphorus concentration predicted in the modelling study and levels measured at spring turnover 1991.

predicted and measured phosphorus is shown in Figure 3. In this and all cases where the 'measured phosphorus' is referred to, the average of duplicate 1991 spring overturn phosphorus concentrations in the lakes have been converted to mean ice-free phosphorus to enable comparison with modelled results. The Trophic Status Model produces estimates of the mean ice-free phosphorus concentrations in lakes.

Figure 3 also shows a 1:1 line for reference. The only lake for which there was a significant disagreement between the measured and predicted phosphorus concentration was Canning Lake. During the spring turnover of 1991, duplicate samples were taken from this lake, and measured at 6.6 and 6.7 µg.L^{-1} phosphorus. The model predicts a concentration of 10.53 µg.L^{-1}. Despite the fact that the duplicate measurements agreed, one has to suspect the measured value, since the measured and predicted phosphorus in South Kashagawigamog Lake is about 10 µg.L^{-1}, and it supplies the vast majority of the inflow water to Canning Lake. We will be conducting further phosphorus sampling on Canning Lake in the spring of 1992 to try and resolve the discrepancy. Sampling September, 1991 showed that the phosphorus concentration of Canning Lake was similar to that of South Kashagawigamog Lake, suggesting that a sampling error in the spring of 1991 produced the anomalous result. If Canning Lake is excluded, the predicted and measured phosphorus in the Drag River lakes are very highly correlated (r^2=0.97).

b) Predicting Background Conditions

Table 3: Modelled, measured, and predicted background concentrations of mean ice-free phosphorus (µg.L^{-1}) in lakes on the Drag River system.

Lake	Background	Modelled	Measured
Kennibik	3.68	4.53	-
Drag	5.03	6.97	7.08
Art	6.68	7.94	8.20
Head	7.61	10.00	10.12
Grass	7.31	11.61	11.00
Kashag N	6.75	12.21	11.16
Soyers	5.76	7.19	7.88
Kashag S	5.31	9.96	10.05
Canning	5.03	10.53	6.65

The Trophic Status Model can also be used to predict the 'background' conditions of the lakes. This is done by mathematically removing all of the cottages and point sources of phosphorus on the system. The predicted background concentrations of the lakes in the chain (along with the current modelled and measured phosphorus concentrations) are shown in Table 3. All of the lakes on the system have had their phosphorus concentration increased by lakeshore development. In terms of relative increase, North and South Kashagawigamog Lakes and Canning Lakes have experienced the most eutrophication relative to estimated background conditions.

c) Predicting Conditions with Existing Vacant Lots Developed

In addition to existing development, point sources, and urban development, there are a large number of existing severed lots which do not currently have cottages or homes built on them. The impact of developing these lots is shown in Figure 4. The range of phosphorus concentrations arises from assuming all of the lots will be used seasonally (the lower bound), or all of the lots will have permanent residences built on them (upper bound). The large number of vacant lots on Drag Lake (168) will raise the phosphorus concentration of that lake by 0.8-2.0$\mu g.L^{-1}$, depending on the type of development. It will raise the amount of phosphorus being exported by Drag lake by 30 to 87 kg per year. This about the same as the Haliburton sewage treatment plant (54.4 $kg.yr^{-1}$).

The impact on the lakes downstream is quite measurable, and has significant effect as far as Canning Lake. It should be noted that if the number of vacant lots on the lakes in Anson, Hindon and Minden (Soyers, Canning, and South Kashagawigamog) are higher than the numbers estimated, the impacts will be higher.

d) Predicting the Oxygen Regime in North Kashagawigamog Lake

The Ministry of the Environment's position on the Dysart et al. sewage treatment plant expansion is based on the designation of the north basin of Kashagawigamog lake being 'Policy 2' because of low levels of dissolved oxygen in the hypolimnion of the north basin. There is a new model under development which enables the prediction of oxygen profiles, and this has been run on North Kashagawigamog

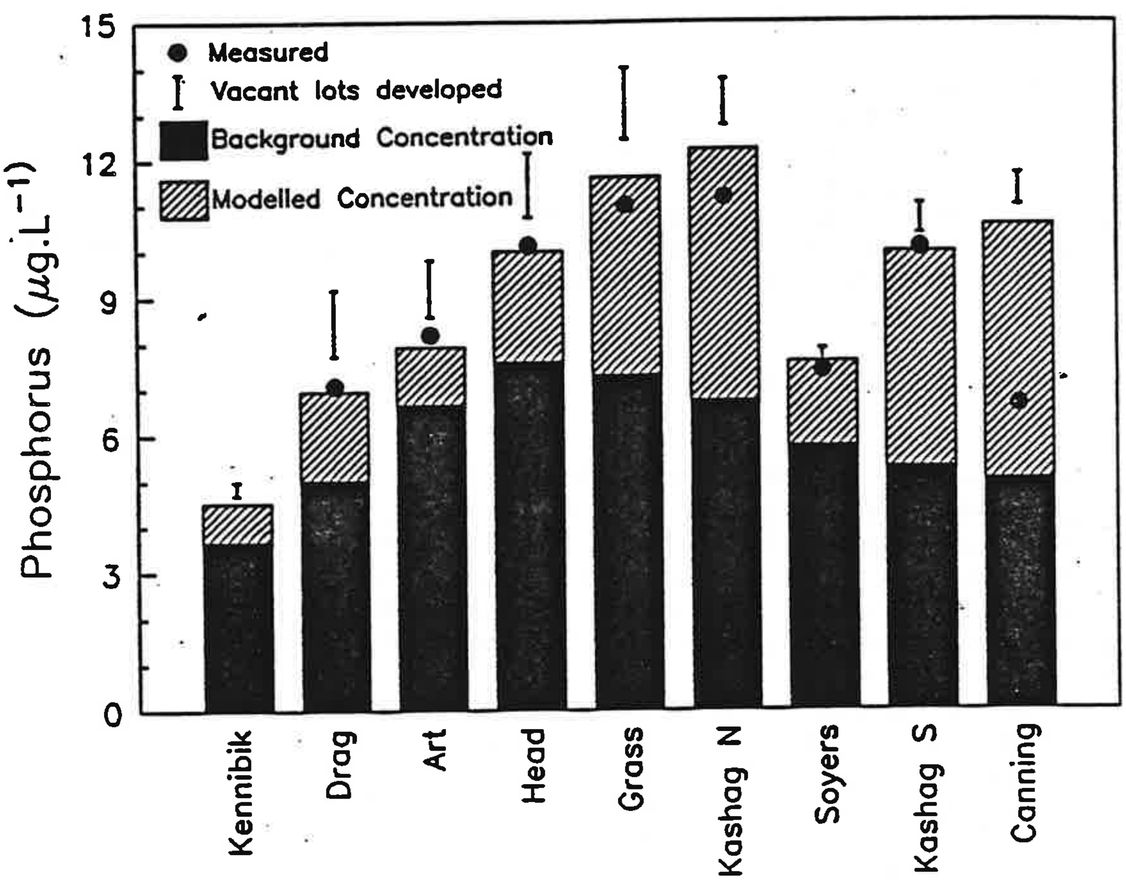

Figure 4: Measured and modelled phosphorus concentrations in the Drag River chain, showing predicted background phosphorus concentration in the lakes.

Lake. The results are shown in Figure 5. The four lines on Figure 5 show the oxygen regime measured in September, 1991, the modelled oxygen profile using current conditions, the profile modelled using the estimated background conditions for the lake, and a profile generated for a phosphorus concentration representing all of the existing lot developed. Also shown on Figure 5 is a vertical line at 4 $mg.L^{-1}$ oxygen, which is the lowest oxygen level which

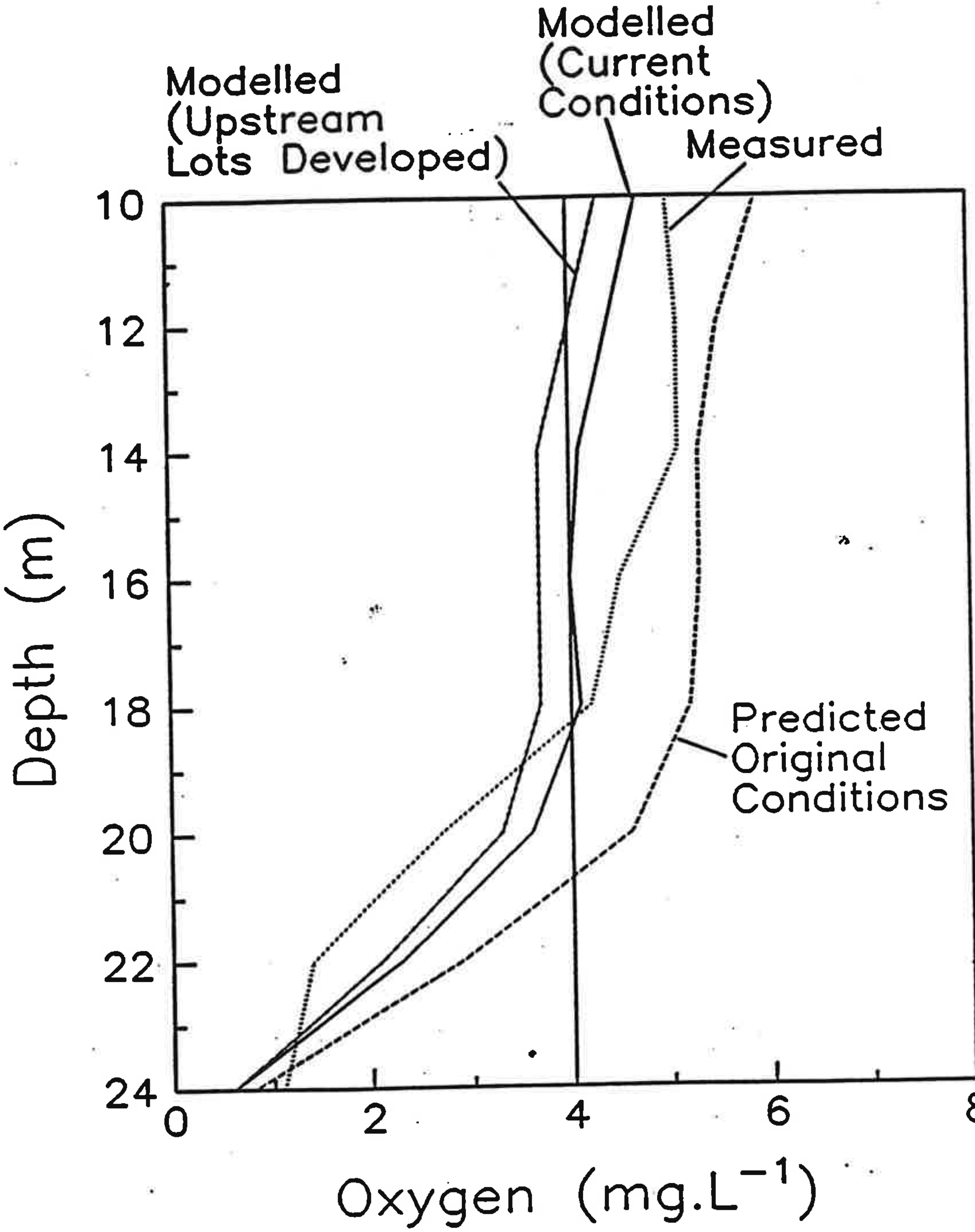

Figure 5: Measured and predicted oxygen profiles for North Kashagawigamog Lake.

can be tolerated by lake trout[6].

Clearly, the situation is not good for lake trout in North Kashagawigamog Lake. The current amount of development on the system has reduced the usable lake trout habitat in the lake from $301.2x10^4m^3$ to $248.2x10^4m^3$, a reduction of 17.7%. Regardless of the scenario on the sewage treatment plant, the development of the vacant upstream lots will reduce the usable habitat (there is no optimal lake trout habitat) to $119.2x10^4m^3$ or 39.5% of its original value. This represents the volume of the lake between 10 and 12 m deep.

Of concern is the possibility that the hypolimnion of North Kashagawigamog Lake will develop anoxia. When this happens, phosphorus in the lake sediments can dissolve in the anoxic hypolimnetic water, adding an internal source of phosphorus to the lake. If this happens, the phosphorus concentration in North Kashagawigamog Lake will likely rise to about 15.6 $\mu g.L^{-1}$. The net effect is not only an increase in the phosphorus concentration of North Kashagawigamog Lake, but a significant decrease in the retention of phosphorus, and a resulting increase in the load to South Kashagawigamog Lake. Unfortunately, our modelling capability is not sufficiently advanced to predict exactly when anoxic behaviour will occur.

4. Modelling the Impact of the Sewage Treatment Plant Expansion

The problem with modelling the impact of the sewage treatment plant expansion is the uncertainty concerning the number of resort units which will be hooked up. My original understanding was that all of the units for the Pinestone Inn, Wigamog Inn, Locarno Resort, Lakeview Motel, Silver Beach Camp, Willow Beach, Langdon Apartments, Old Apple Tree, Commercial Block, Hydl Hills, Deer Lodge, and the Slipper Property were to be fed into the proposed sewage treatment plant sewer extension. The best data available is from a memo to file from Gary Epp of Totten

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[6] MacLean, N.G., J.M. Gunn, F.J. Hicks, P.E. Ihssen, M. Malhiot, T.E. Mosindy, and W. Wilson. 1990. Environmental and Genetic Factors Affecting the Physiology and Ecology of Lake Trout. Lake Trout Synthesis: Physiology and Ecology Working Group. Ontario Ministry of Natural Resources. 84 p.

Table 4: Results of poll of the resort owners by G. Epp of Totten Sims Hubicki regarding number of units available for connection to the proposed sewer extension.

User	Units at Present*	Design
Pinestone	52.5**	100
Wigamog	46.5	100
Locarno	29	46
Lakeview	9	18
Silver Beach	25***	35
Willow Beach	9	15
Langdon Apts	10	20
Old Apple Tree	****	9
Commercial Block	9	9
Hydl Hills	0	50
Deer Lodge	50	100
Slipper	0	50
Totals	244	552

* Units are Equivalent Residential Units, defined as being 0.75x(number of serviced rooms)

** 40.5 ERU are presently on a new filter bed system; the owner does not wish to connect these units to the sewer extension system

*** information from Rysco report

**** changed to residential

Sims Hubicki[7]. Data derived from that memo is shown in Table 4. The memo also contains the statement 'We believe that the 'Units at Present' represent the number of units

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7 Memo to file, G. Epp (Totten Sims Hubicki Associates), February 12, 1990. FAX transmitted to R. Dhillon, MOE Project Engineering Branch, February 13, 1990.

which are presently available for connection to the sewer extension system. We cannot, however, say how many of these will be required to be connected to the sewer extension.'

Developing modelling scenarios from this information is difficult, since the amount of phosphorus load which will be removed from North Kashagawigamog Lake and diverted through the proposed sewage treatment plant is uncertain. For example, the Pinestone indicates that 40.5 ERU's will not be connected - does this mean that we should assume that the full allocation of 100 ERU's will still be connected? In fact, what proportion of the existing or proposed units be connected?

For the purposes of discussion, I have constructed eight scenarios:

Scenario 1: This is the reference scenario, where the watershed has been modelled with no lakeshore or urban development. It represents an estimate of what the phosphorus concentrations in the lakes were like before European settlement.

Scenario 2: This is the modelled current conditions, with the STP contributing 54.4 kg phosphorus per year, and 254 resort units on North Kashagawigamog Lake.

Scenario 3: This is the 'do nothing', or baseline scenario. It is the same as scenario 2, but all upstream lots have been developed. Two-thirds of the vacant lots are used seasonally, and one third are developed as permanent homes on all of the lakes and rivers. No resort unit increase has been allowed, and the STP continues at current levels.

Scenario 4: The sewage treatment plant expansion does not occur, but the resorts increase their number of units to the amount indicated in Table 4 (552 ERUs). For brevity, this will be referred to as 'no STP, resorts expand'

Scenario 6: The sewage treatment plant expansion occurs as per the favoured option in the Totten Sims Hubicki Environmental Study Report, and all of the units are connected. The STP effluent will be 0.2 $mg.L^{-1}$ phosphorus. This scenario will be referred to as 'STP@0.2, resorts connect'.

Scenario 7: This is the same as scenario 6, but the STP effluent is at 0.3 $mg.L^{-1}$, and will be referred to as 'STP@0.3, resorts connect'. This scenario was included because there was some concern about the ability of the proposed STP to achieve the 0.2 $mg.L^{-1}$ phosphorus limit.

Scenario 8: This scenario has the sewage treatment plant expanding and operating at capacity with a phosphorus concentration in the effluent at 0.3 $mg.L^{-1}$. The resorts all expand to their fullest. This will be referred to as 'worst case'.

The impacts of each of these scenarios can be modelled for the whole chain of lakes downstream of the STP outflow, along with their impact on oxygen profiles in each of the lakes. This produces an unwieldy amount of information, so I have simply shown the impact on the phosphorus concentration of Grass and North Kashagawigamog Lakes. The results of these modelling runs are shown in Table 5.

5. Discussion

Not surprisingly, there are trade-offs involved in any of the decisions to be made. Because of the limited capacity of the lakes in question and the degree of current development in the watershed, the lakes have eutrophied significantly from background conditions. The eutrophication will worsen as the vacant upstream lots are developed, to the point where the survival of a coldwater fishery in North Kashagawigamog Lake is in question.

From the standpoint of the protection of the fishery in North Kashagawigamog Lake, the best scenario is to allow the STP to expand, with the provision that all of the resorts hook up to the system, and that no further resort development occur on North Kashagawigamog Lake. The cost is to Grass Lake, where the phosphorus concentration increases to 14.3 $\mu g.L^{-1}$. Even if the STP operates at an effluent concentration of 0.3 $mg.L^{-1}$, this will be better for North Kashagawigamog Lake than the current situation (although Grass Lake will increase to 15.3 $\mu g.L^{-1}$).

The other scenarios indicate that expanding the sewage treatment plant without mandatory hook-up of all of the resort units will result in further deterioration of an already serious condition.

Table 5: Results of modelling sewage treatment plant scenarios on the phosphorus concentrations ($\mu g.L^{-1}$) in Grass and North Kashagawigamog Lakes.

Scenario*	Grass	North Kashagawigamog
Background	7.31	6.75
Current	11.61	12.21
Baseline	13.07	13.44
No STP, resorts expand	13.07	16.02
STP@0.2, resorts connect	14.30	11.94
STP@0.3, resorts connect	15.31	12.50
Worst case	15.31	17.27

* A fuller explanation of the scenarios are given in the text.

It should be noted that the whole system has been modelled with fairly conservative assumptions. Instead of using resort units, I have used ERUs. Our phosphorus export estimates for seasonal and permanent residences may underestimate phosphorus impacts from lawn fertilization and the use of phosphate containing products such as automatic dishwasher detergents. In fact, I was surprised at how closely we are modelling the current conditions in the lakes. I would have expected that some of the current development on the lakes would not be impacting the phosphorus concentration, but it appears that it is. Given the estimates of how long it takes for phosphorus to migrate from septic fields to lakes, I suspect that things may in fact get worse for the Drag River system than we are predicting.

The impact of runoff from the further urbanization of Haliburton is also of concern. I estimated the nutrient impact associated with urban runoff for the current situation (estimated at 13.1 $kg.yr^{-1}$), but for any of the future scenarios, I did not increase that estimate. Clearly, part of the STP capacity will be devoted to servicing the further development of the town. As the developed area of the town of Haliburton increases, so will the amount of urban runoff. The impact of more urban runoff will aggravate the problems identified here.

Given the deteriorating state of the entire lake chain, serious consideration should also be given to stopping all new lot development on the lakes. This will require the cooperation of the municipality. Clearly, the lake system is under considerable stress due to nutrient load, and every means should be given to prevent further eutrophication.

You are probably aware that the Water Resources Branch has developed a draft policy for commenting on lakeshore developments or other activities which impact on the phosphorus concentration of lakes. According to that draft policy, the recommended limit for phosphorus concentration of a lake is an increase of 50% over the modelled background phosphorus concentration. With existing upstream lots developed, Grass Lake will have experienced an increase of 78.8% over background, and North Kashagawigamog Lake will have increased by 99.1%. Both of these lakes would be already designated as being overdeveloped, and the recommendation would be not to tolerate further phosphorus increases. The preferred solution from the standpoint of North Kashagawigamog Lake will entail a further increase in the phosphorus concentration in Grass Lake, while the situation in North Kashagawigamog Lake will improve slightly. I would be interested to hear your views on the interpretation of this situation in view of the new policy.

A second point to note regarding the new policy is that because these lakes are so overdeveloped, it will have the effect of halting development on Art Lake. Art Lake is currently at 7.94 $\mu g.L^{-1}$ phosphorus, and has a modelled background concentration of 6.68 $\mu g.L^{-1}$, an increase over background of 18.9%. If considered on its own, it would have room for considerably more lakeshore development. However, since it impacts on Head, Grass, and the rest of the chain (in an ever-diminishing way), the new policy would halt development on Art Lake. Welcome to the brave new world of whole-watershed management.

A further consideration should be the method in which these results are conveyed to those groups with concerns about the system. Approving the expansion of a sewage treatment plant and predicting that it will ameliorate conditions in a lake is counterintuitive. The cottager associations on the lakes downstream should be advised of the manner in which those conclusions were reached.

I look forward to discussing the results of this exercise with you further.

Bernie

Bernie Neary

BPN/rbm
712/r

c.c. J. Beaver, Central Region
P. Dillon, Limnology
N. Hutchinson, Limnology