A Field Survey of Nutrient Inputs to Lumsden Pond, Kings County, Nova Scotia

Prepared for

Kings County Wildlife Association

By

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1.0 BACKGROUND

Results of a water quality monitoring program carried out over the last several years at selected lakes within the Gaspereau River watershed (Brylinsky, 1999; 2000) have revealed a trend of increasing phosphorous levels within Lumsden Pond (Figure 1). The reasons for this trend are not entirely clear, but it has been suggested that the various small streams and brooks entering the Pond may be subject to adjacent land-use activities that result in high nutrient loadings. The major objective of this study was to carry out a preliminary survey of the water inputs to Lumsden Pond to determine if there were any obvious sources of high nutrient loads to the Pond.

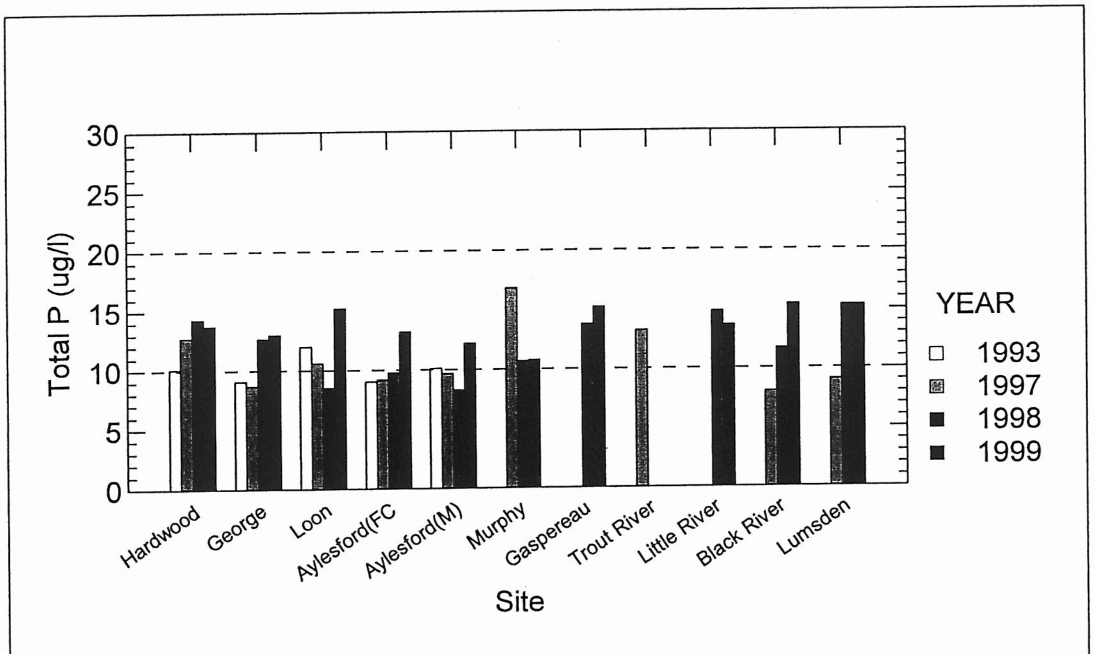

Figure 1. Average annual (ice-free period) concentration of total phosphorous over time for Lumsden Pond and other lakes being monitored within the Gaspereau watershed.*

2.0 APPROACH

Lumsden Pond receives most of its water input from Black River Lake via a canal that initially leads to the Hollow Bridge generating station and then into the Pond via another shorter canal. It also receives water inputs from Black River Lake via

* Hardwood Lake is located outside the Gaspereau watershed and serves as a control site.

Black River, which flows between Black River Lake and Lumsden Pond. In addition there are a number of small streams that either enter Black River above Lumsden Pond or enter directly into Lumsden Pond.

Surveys were carried out during early and late summer. The early summer surveys focused on the smaller streams and brooks and were carried out during this time because run off from their drainage areas was relatively high (most of these smaller streams become dry or have very low flows during the late summer). However, some of these systems were also surveyed during the late summer. The late summer survey concentrated mainly on Black River, from the point where it exits Black River Lake to where it enters Lumsden Pond. Additional survey points included Lumsden Pond at the Davidson Road Bridge and the exit of Lumsden Pond at the Hellgate headpond. Sampling of Black River was delayed until late summer because concern has been expressed that a fish hatchery, located at the upper reach of Black River and which discharges its effluent into the River, may be a significant contributor of nutrient loading to Lumsden Pond. Late summer would likely be the time of year when nutrient loading from the hatchery would be greatest since this is the time of year when water temperatures are highest and fish potentially most stressed leading to high metabolic rates and therefore high waste production.

Figure 2 shows the location of each sampling site and Table 1 lists the general characteristics of each site. Appendix I contains a complete database indicating the dates each site was sampled, the parameters sampled and the value measured for each parameter.

3.0 WATER QUALITY PARAMETERS MEASURED

The water quality parameters monitored included total phosphorous (TP), orthophosphate (PO4), nitrate (NO3), dissolved oxygen (DO), percent dissolved oxygen saturation and temperature. Total phosphorous and orthophosphate were measured using the ammonium molybdate procedure as described in Wetzel and Likens (1990). Nitrate was measured using the low-range cadmium reduction method as described in the HACH Water Quality Handbook (1997). All samples for nutrient analyses were collected in acid washed polyethylene bottles. Dissolved oxygen and water temperature were measured using a Yellow Springs Instrument Model 54 Oxygen Meter.

The water quality parameters of most interest to this study are total phosphorous and percent dissolved oxygen saturation. It is these two parameters that are most commonly used to assess the health of freshwater systems. Phosphorous is the major limiting factor in freshwater ecosystems and excessive input of this

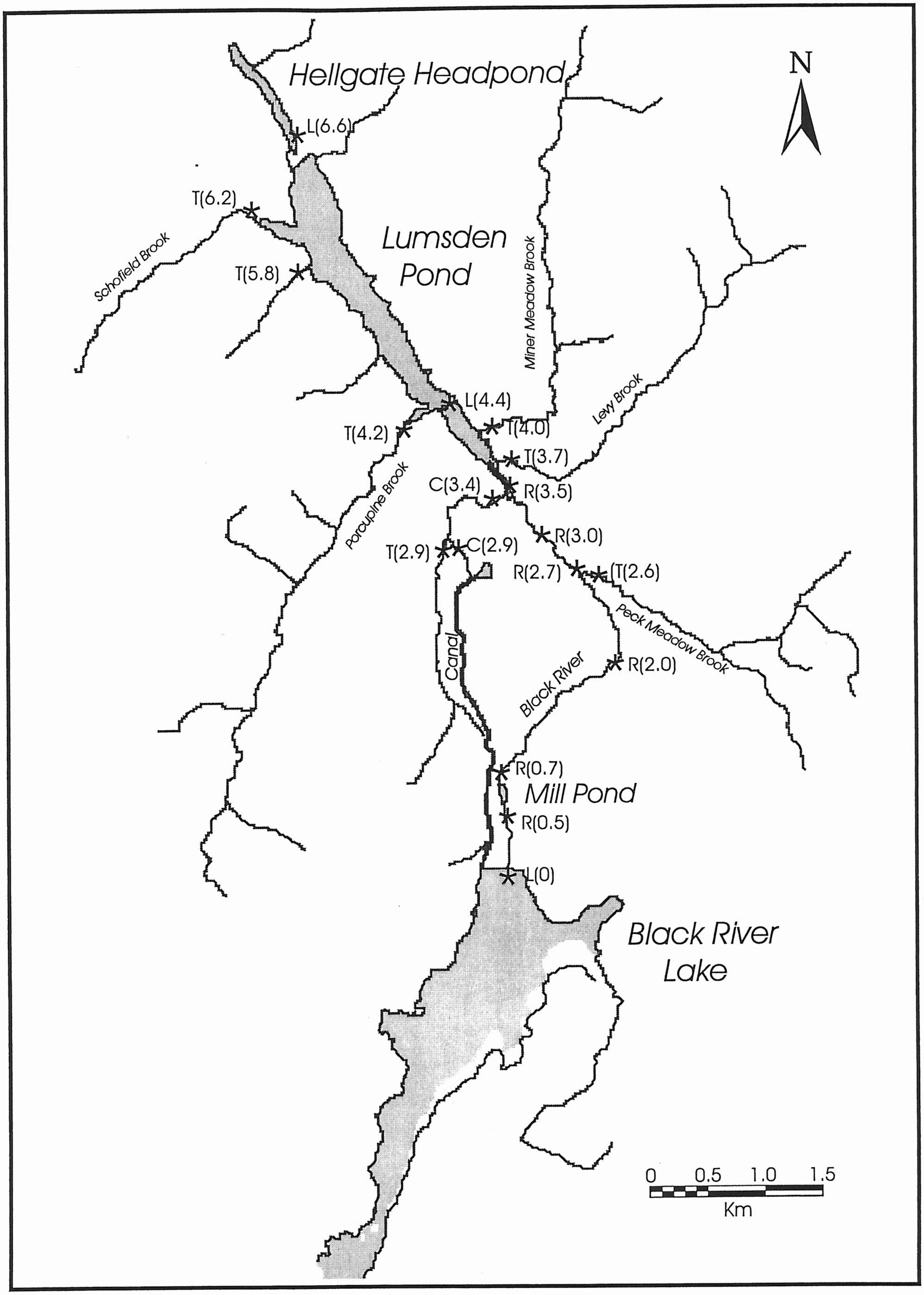

Figure 2. Location of sampling sites. Letters refer to type of system as follows: R-river; T-tributary; L-lake; C-canal. Numbers indicate the approximate distance (km) of the site downstream from Black River Lake.

Table 1. Main sites surveyed.	
Site #*	**Site Description**
L(0)	Black River Lake at location of the water input pipes to the fish hatchery
R(0.5)	Black River at the road bridge just above Mill Pond (this is also the inflow to Mill Pond)
R(0.7)	Mill Pond outflow at dam
R(2.0)	Black River at a point 2 km below Black River Lake
T(2.6)	Peck Meadow Brook just above where it enters Black River
R(2.7)	Black River just above the point where Peck Meadow Brook enters the River
R(3.0)	Black River at Bridge leading to Hollow Bridge Generating Station
T(2.9)	An unnamed tributary that enters the Hollow Bridge Canal just below the Hollow Bridge Generating Station
C(2.9)	Hollow Bridge Canal just below the Hollow Bridge generating station
C(3.4)	Hollow Bridge Canal just above where it joins Black River
R(3.5)	Black River at the point where it enters the upper part of Lumsden Pond
T(3.7)	Levy Brook just above where it enters Black River
T(4.0)	Miner Meadows Brook just above where it enters Black River
L(4.4)	Lumsden Pond at the Davidson Road bridge
T(4.2)	Porcupine Brook just above where it enters Lumsden Pond
T(5.8)	An unnamed brook entering Lumsden Pond on its west shore
T(6.2)	Lower Schofield Brook just above where it enters Lumsden Pond
T(-)	Upper Schofield Brook where it crosses the road to Black River village
L(6.6)	The upper portion of the Hellgate headpond (assumed to represent the output from Lumsden Pond)

*Letters refer to type of site as follows: R-river; T-tributary; C-canal; L-lake. Numbers indicate the approximate distance (km) of the site downstream from Black River Lake.

nutrient is the most common cause of the poor water quality that results from intensive algal blooms. Algal blooms also often lead to a depletion of dissolved oxygen, which in turn causes the build-up of toxic substances such as hydrogen sulphide, ammonia and methane. Orthophosphate and nitrate concentrations are not as easily related to water quality because they vary greatly in concentration due to their high biological turnover rates. However, we chose to measure these nutrients as well because they are the forms of nutrients often associated with runoff from land-use activities such as agriculture and forestry.

The levels of total phosphorous and dissolved oxygen that may result in poor, moderate and good water quality are summarized in Table 2.

Table 2. Guidelines for interpreting water quality.			
Parameter	**Poor**	**Moderate**	**Good**
Total Phosphorous (μg/l)	>20	10-20	<10
Dissolved Oxygen (%)	<50	50-80	>80

4.0 RESULTS

Tributaries

There was little evidence that any of the tributaries leading into Black River or Lumsden Pond contained exceptionally high levels of either phosphorous or nitrate (Table 3). Total phosphorus levels seldom exceeded 10 μg/l and orthophosphate and nitrate levels were in most cases near the limit of detection. This was true for both the early and late summer surveys. The only site that had somewhat elevated levels of nutrients was Schofield Brook which had a total phosphorous concentration of just below 20 μg/l at its lower end during the late summer. The nitrate levels were also elevated. However, the amount of flow into Lumsden Pond at this time was very low and it is unlikely that this would account solely for the high levels of phosphorous that appear to be typical of Lumsden Pond.

Table 3. Phosphorous and nitrate concentrations at the tributary sites.

Site	Date Sampled	Total Phosphorous (μg/l)	Ortho-Phosphate (μg/l)	Nitrate (mg/l)
Peck Meadow Brook	21 June 00	6.2	3.6	0.000
Unnamed Brook flowing into Hollow Bridge Canal	01 August 00	8.1	1.2	0.024
Levy Brook	21 June 00	3.8	0.0	0.016
Miner Meadow Brook	21 June 00	4.2	0.0	0.008
Porcupine Brook	21 June 00	5.3	1.5	0.084
Porcupine Brook	01 August 00	6.0	0.2	0.022
Unnamed Brook flowing into Lumsden Pond	21 June 00	8.1	1.2	0.024
Lower Schofield Brook	21 June 00	12.2	6.9	0.042
Lower Schofield Brook	01 August 00	19.3	12.0	0.189
Upper Schofield Brook	01 August 00	14.7	6.0	0.112

Black River

The results of the three late summer surveys carried out at Black River showed consistently high phosphate concentrations near the effluent of the fish hatchery (Figure 3). The levels measured were typically more than an order of magnitude greater than that of the water entering the hatchery from Black River Lake. These levels decreased little at the effluent of Mill Pond indicating that most of the phosphorous entering the pond also leaves it, and that the pond has little ability to retain the nutrient outflow of the hatchery.

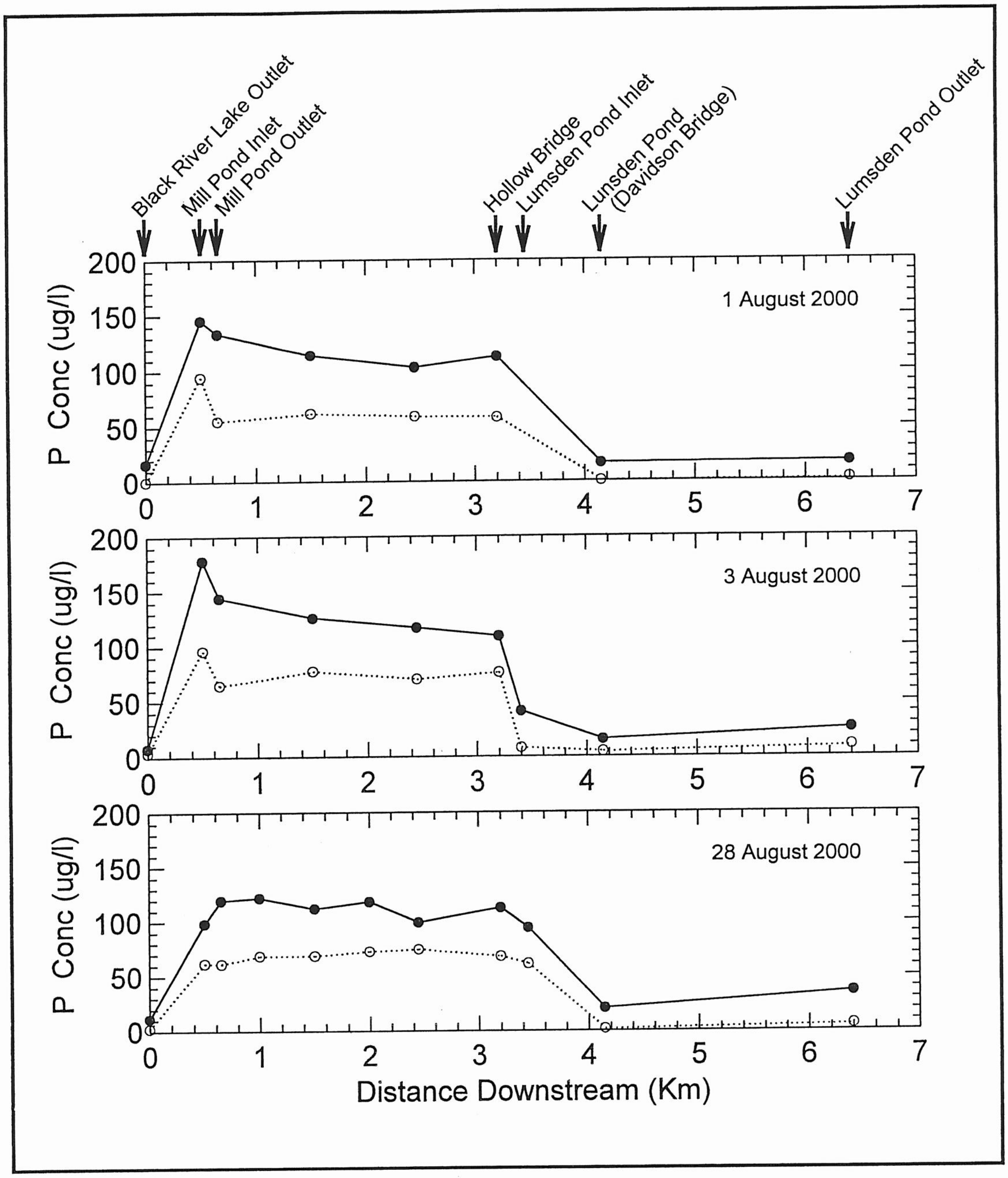

Figure 3. Results of late summer survey of total phosphate (•) and orthophosphate (o) concentration along the Black River transect.

Phosphorous levels remained elevated downstream to the point just beyond where Black River intersects the outflow of the Hollow Bridge Canal. At this point both total phosphorous and orthophosphate levels decreased to levels near that of Black River Lake, and then remained low at the inflow to Lumsden Pond as well as at Davidson Bridge and the Lumsden Pond outflow. Thus, it appears that the total phosphate and orthophosphate originating at the hatchery becomes diluted by the low nutrient effluent of the Canal, to the extent that they do not appear to constitute a major nutrient input to Lumsden Pond.

The results for nitrate concentration were quite different (Figure 4). Although nitrate levels were slightly greater at the hatchery effluent compared to Black River Lake, they exhibited a consistent and relatively large downstream increase until the point at which Black River intersects the Hollow Bridge Canal where, like phosphorous, the level decreased to relatively low values. Based on the information presently available, it is difficult to provide an explanation for this trend. One possible explanation is that the nitrogen leaving the hatchery is largely in the form of ammonia, which then becomes oxidized to nitrate as it travels downstream. The trend of relatively low levels of dissolved oxygen near the hatchery effluent, and increased levels of dissolved oxygen downstream (see Figure 5), lend support to this hypothesis.

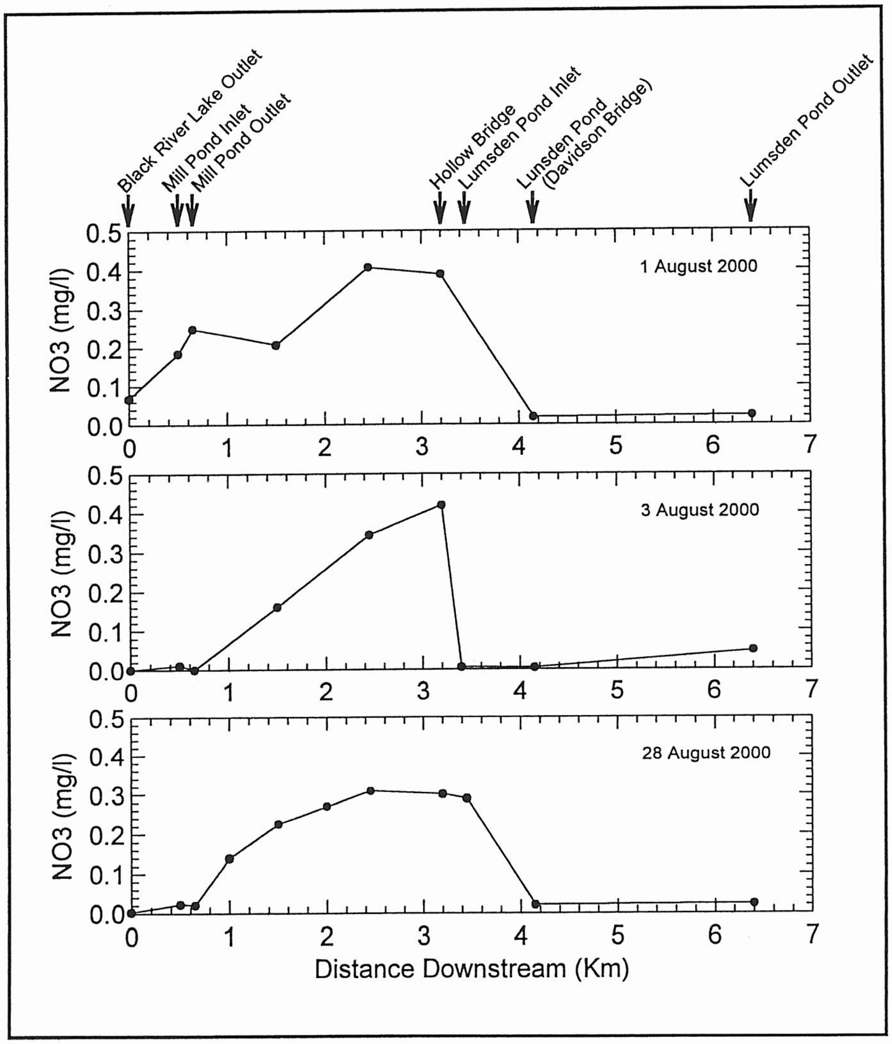

Figure 4. Results of late summer survey of nitrate concentration along the Black River transect.

Dissolved oxygen saturation levels (Figure 5) were low at both the inflow and outflow of Mill Pond but quickly recovered to near 100 % saturation within about 2 km downstream. During one survey the level observed at Mill Pond was within the range considered to be harmful to most aquatic organisms.*

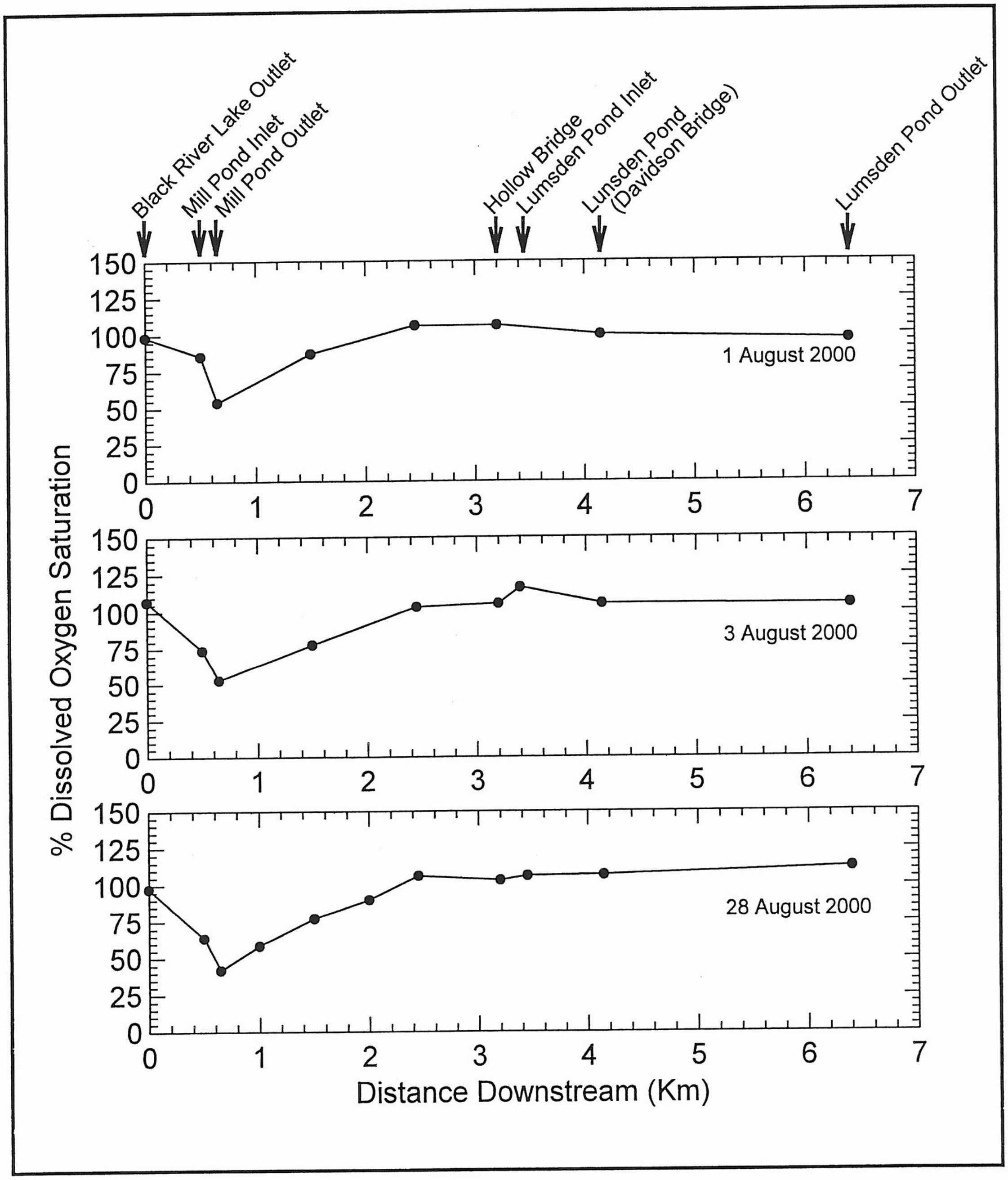

Figure 5. Results of late summer survey of percent dissolved oxygen saturation along the Black River transect.

* Most aquatic organisms become stressed when the level of dissolved oxygen saturations falls below about 50 %.

Water temperature at the inflow to Mill Pond was about 5 °C less than at Black River Lake and remained relatively constant downstream until Black River mixed with water from the Hollow Bridge Canal, at which point it rose to about the same level as at Black River Lake (Figure 6).

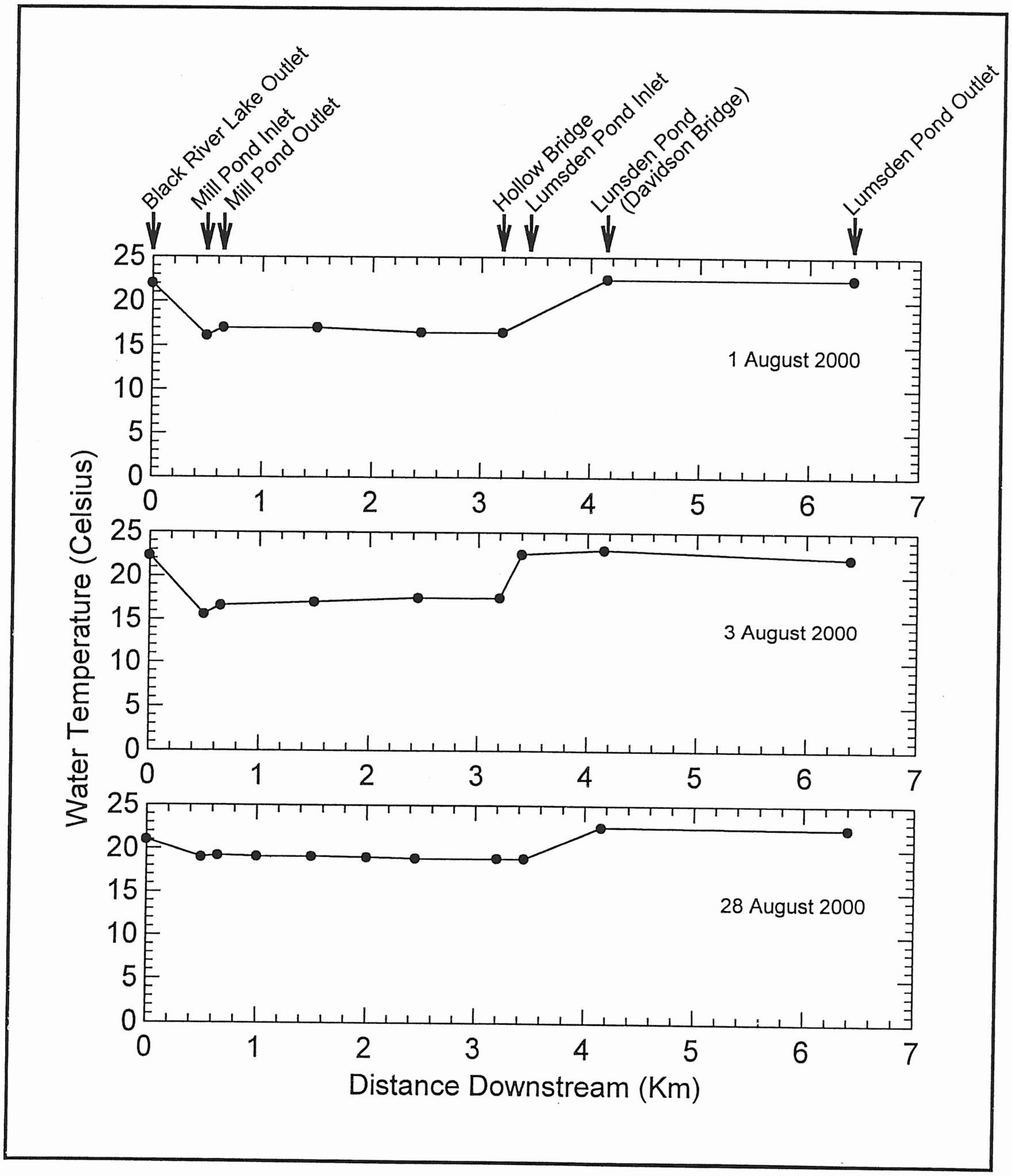

Figure 6. Results of late summer survey of water temperature along the Black River transect.

5.0 DISCUSSION

Based on the results of this study there does not appear to be a clearly identifiable source of high phosphorous inputs to Lumsden Pond. Although the effluent discharged by the fish hatchery located in the upper reach of Black River contains high levels of phosphorous, this appears to be assimilated and diluted within the River prior to reaching the input to Lumsden Pond. The assimilation of phosphorous probably occurs through both physical and biological processes. Physical processes would include absorption of dissolved forms onto sediments and sedimentation of particulate forms. Biological process would include uptake of phosphorous by mosses and other plants growing within the River. These processes, however, are not likely to continue indefinitely as there are limits to the amount of phosphorous that can be assimilated by these means. Dilution appears to occur largely where the outflow of the Hollow Bridge Canal intersects Black River which is located just prior to where Black River flows into Lumsden Pond.

Schofield Brook, the only tributary discharging into either Lumsden Pond or Black River that exhibited elevated phosphorous concentrations, probably contributes some nutrient loading to Lumsden Pond, but the levels observed, as well as the limited flow of this tributary, make it unlikely that it is a major contributor to the high phosphorous levels characteristic of Lumsden Pond.

There is some evidence to suggest that the high phosphorous levels observed in Lumsden Pond may be a result of accumulation of phosphorous present in the form of organic compounds that originate from the decomposition of coniferous material within the watershed. These are the materials that impart a brown colour to the water. Data collected as part of the volunteer water quality monitoring program shows there to be a correlation between water colour and total phosphorous concentration for the lakes being monitored, and that Lumsden Pond is one of the more strongly coloured lakes. If the phosphorous is largely in this form, it may be largely unavailable for use by algae, and could be the reason why, despite high total phosphorous concentrations, there does not appear to be correspondingly high algal concentrations (as indicated by the chlorophyll concentrations observed in the water quality monitoring program). This explanation, however, requires further testing and validation.

6. References:

Brylinsky, M. 1999. A summary of results of the 1997-1998 Kings County Volunteer Water Quality Monitoring Program. Report prepared for the Planning Advisory Committee of the Municipality of Kings and the Kings County Water Quality Monitoring Volunteers. 40 p.

Brylinsky, M. 2000. A summary of results of the 1997-1998 Kings County Volunteer Water Quality Monitoring Program. Report prepared for the Planning Advisory Committee of the Municipality of Kings and the Kings County Water Quality Monitoring Volunteers. 24 p.

HACH Company. 1997. Water analysis handbook, 3rd ed. Hach Company, Colorado.

Wetzel, R.A. and G.E. Likens. 1990. Limnological Analyses, 2nd ed. Springer-Verlag, New York.

Appendix I. Sites surveyed and values of each parameter measured.

Site Number	Site Description	Survey Date	Temperature (Celsius)	Dissolved Oxygen (mg/l)	Total Phosphorous (ug/l)	Ortho-phosphate (ug/l)	Nitrate (mg/l)
T(2.6)	Peck Meadow Brook	21-Jun-00	14.5	-	6.2	3.6	0.000
T(3.7)	Levy Brook	21-Jun-00	16.0	-	3.8	0.0	0.016
T(4.0)	Miner Meadow Brook	21-Jun-00	13.5	-	4.2	0.0	0.008
T(4.2)	Porcupine Brook	21-Jun-00	13.2	-	5.3	1.5	0.084
T(5.8)	Unnamed Brook	21-Jun-00	15.2	-	8.1	1.2	0.024
T(6.2)	Lower Schofield Brook	21-Jun-00	17.0	-	12.2	6.9	0.042
L(0)	Black River Lake	1-Aug-00	22.0	12.4	16.2	0.0	0.068
R(0.5)	Mill Pond Inflow	1-Aug-00	16.1	12.1	145.4	94.7	0.185
R(0.7)	Mill Pond Outflow	1-Aug-00	17.0	7.5	133.3	55.2	0.249
R(2.0)	Black River	1-Aug-00	17.0	12.1	114.3	61.8	0.207
R(2.5)	Black River	1-Aug-00	16.5	14.9	103.1	58.8	0.406
T(2.9)	Unnamed Brook	1-Aug-00	17.0	16.0	8.1	1.2	0.024
R(3.0	Hollow Bridge	1-Aug-00	16.5	14.9	112.5	57.9	0.388
T(4.2)	Porcupine Brook	1-Aug-00	16.5	16.8	0.2	6.0	0.112
L(4.4)	Davidson Bridge	1-Aug-00	22.5	12.4	15.9	0.0	0.019
L(6.6)	Lumsden Outflow	1-Aug-00	22.5	12.0	17.1	1.8	0.022
T(-)	Upper Schofoield B	1-Aug-00	16.0	16.8	14.7	9.9	-
L(0)	Black River Lake	3-Aug-00	22.3	13.4	7.8	3.6	0.000
R(0.5)	Mill Pond Inflow	3-Aug-00	15.6	10.6	178.0	95.9	0.011
R(0.7)	Mill Pond Outflow	3-Aug-00	16.6	7.4	144.2	64.5	0.000
R(2.0)	Black River	3-Aug-00	17.0	10.8	125.8	77.2	0.160
R(2.5)	Black River	3-Aug-00	17.5	14.2	116.7	69.9	0.344
C(2.9)	Upper Hollow Canal	3-Aug-00	22.3	12.8	8.4	4.5	0.000
R(3.0)	Hollow Bridge	3-Aug-00	17.5	14.5	108.9	76.0	0.419
C(3.4)	Lower Hollow Canal	3-Aug-00	22.5	12.2	9.3	3.9	0.000
R(3.5)	Black River	3-Aug-00	22.5	14.5	41.0	7.8	0.006
L(4.4)	Davidson Bridge	3-Aug-00	23.0	13.0	15.3	4.2	0.004
L(6.6)	Lumsden Outflow	3-Aug-00	22.0	13.2	25.0	9.3	0.047
L(0)	Black River Lake	28-Aug-00	21.0	12.5	11.4	2.4	0.003
R(0.5)	Mill Pond Inflow	28-Aug-00	19.0	8.5	98.3	61.8	0.022
R(0.7)	Mill Pond Outflow	28-Aug-00	19.2	5.6	119.4	61.5	0.020
R(1.0)	Black River	28-Aug-00	19.1	7.8	121.8	68.7	0.139
R(2.0)	Black River	28-Aug-00	19.1	10.3	111.9	68.7	0.225
R(2.3)	Black River	28-Aug-00	19.0	12.0	118.2	72.7	0.269
R(2.5)	Black River	28-Aug-00	18.9	14.2	99.2	74.5	0.308
C(2.9)	Upper Hollow Canal	28-Aug-00	-	-	12.0	3.6	0.012
R(3.0)	Hollow Bridge	28-Aug-00	18.9	13.8	112.5	67.8	0.301
R(3.5)	Lumsden Inflow	28-Aug-00	18.9	14.2	94.1	61.2	0.289
L(4.4)	Davidson Bridge	28-Aug-00	22.5	13.3	20.5	1.5	0.020
L(6.6)	Lumsden Outflow	28-Aug-00	22.3	14.0	35.5	5.4	0.022