REPORT ON THE LAKE GEORGE

INSHORE CHEMICAL MONITORING PROGRAM

1993

Submitted to

The Lake George Association Fund

by

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EXECUTIVE SUMMARY

Initiated in 1986, the Lake George Inshore Chemical Monitoring Program is designed to provide information on the impacts of various types of shoreline usage on the nearshore water quality. This program's initial, and continuing purpose, is to compare terrestrial impacts on nearshore water quality from various types of land uses found within the Lake George Basin. Varying types of land uses common to the Lake George basin were identified with the basis for classification being: a) amount of development (impermeable surfaces) and b) degree of usage. Along these lines in the past, shorelines adjacent to marina operations, commercial and residential properties, and undeveloped areas were monitored. Water samples were collected in close proximity to the shoreline (shallow waters) in order to reduce the effects of dilution and to better quantify the terrestrial effects on water quality.

The main purpose of this project for 1993 was to compare results gathered from the previous years of the Inshore Program, conducted in the Huddle/Bolton Bay, to the findings in this years' study, with special attention paid to differences in degrees of shoreline development (impermeability). The question, "Will similar shoreline usages in different parts of the lake produce similar effects in their adjacent nearshore waters?" was addressed, and in many respects it was answered affirmatively.

Perhaps the most important aspect this study addressed was whether differences existed in inputs of phosphorus to the lake from one shoreline usage to another, since phosphorus is acknowledged to be the limiting nutrient to algal productivity in Lake George. Both data from this year and years previous, show that there are significantly greater levels of phosphorus found in waters adjacent to more developed shorelines than areas with little development, and that this is occurring at many sites within the basin.

Additionally, there were differences in the level of chlorophyll a(indicating increased algal productivity) in one of the more developed shoreline areas than in the more pristine shoreline. This may be a result of the strong correlation between chloride (sanding and salting activity) and nitrate since nitrate, as does phosphate, act as a fertilizer to increase algal growth in the water.

INTRODUCTION

Initiated in 1986, the Lake George Inshore Chemical Monitoring Program is designed to provide information on the impacts of various types of shoreline usage on the nearshore water quality. This program's initial, and continuing purpose, is to compare terrestrial impacts on nearshore water quality from various types of land uses found within the Lake George Basin. Varying types of land uses common to the Lake George basin were identified with the basis for classification being amount of development (impermeable surfaces) and degree of usage. Along these lines in the past, shorelines adjacent to marina operations, commercial and residential properties, and undeveloped areas were monitored. Water samples were collected in close proximity to the shoreline (shallow waters) in order to reduce the effects of dilution and to better quantify the terrestrial effects on water quality

Since the start of this program in 1986, nearshore waters have consistently shown higher concentrations of essential nutrients for algal and macrophyte growth (nitrogen and phosphorus) than found at open water sites (Eichler, Clear and Boylen; 1989; 1990). The established sites in the Bolton Bay area have shown that the unimpacted or largely undeveloped areas have the lowest concentration of nutrients and contaminants when compared to nearshore waters of developed shorelines (Eichler, Clear and Boylen; 1989a; 1990a). Elevated nutrient concentrations associated with certain shoreline types have been attributed to resuspension of shallow sediments due to heavy recreational usage, runoff of terrestrial soils and inputs from faulty or overloaded septic systems. Other possible inputs include terrestrial runoff of highway deicing materials and other pollutants associated with motor vehicles. Petroleum and corrosion products are deposited on road surfaces and become incorporated into stormwater runoff which, if not allowed to infiltrate the soil, eventually enter the lake.

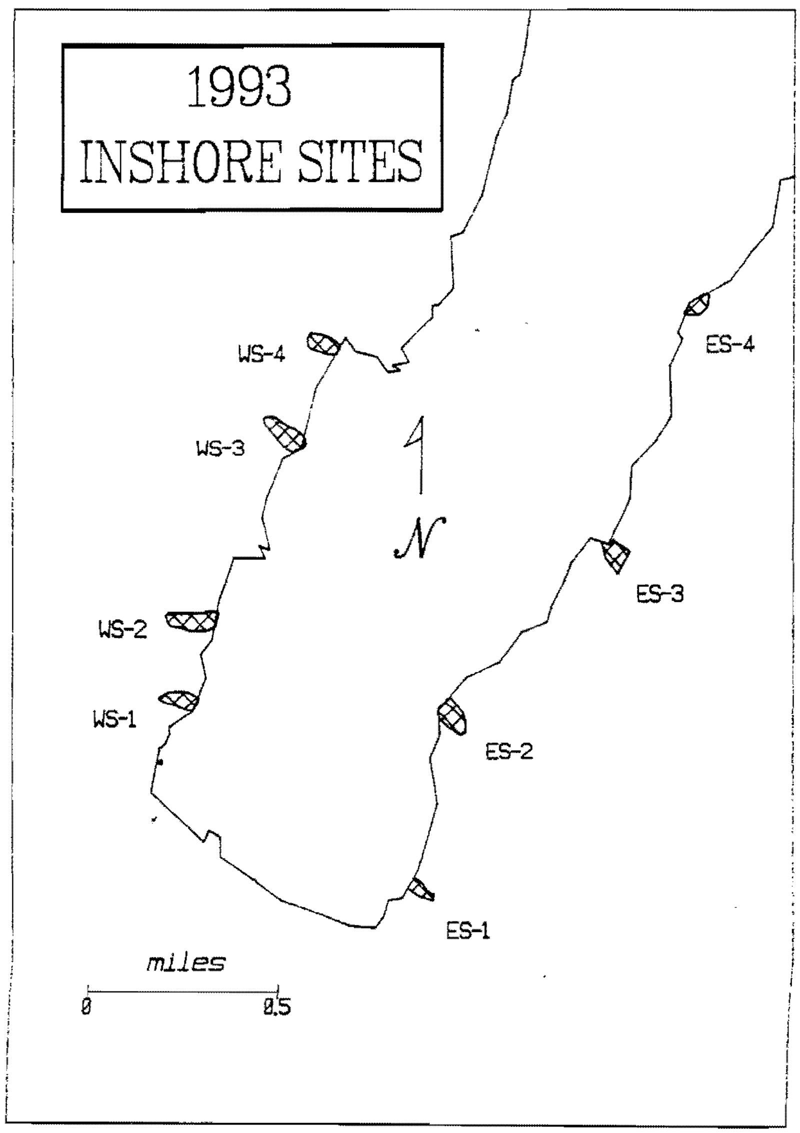
The 1993 Inshore Program changed its location of study while keeping intact the same overall concerns of previous years. New sites were selected to investigate whether or not they would behave as those studied previously in the Bolton/Huddle Bay area. That is to say, will the least developed areas show the lowest pollutant inputs in a different region of the lake. The newly selected sites were chosen from within the southernmost basin of the lake (south of Plum Point) in order to minimize chemical variability found among various parts of the lake. Once again, sites were chosen to represent the varying types of shoreline development common to Lake George. With the information provided from this study, the ability to extrapolate previously collected data to the entire lake may become possible. With the understanding of how similar types of shoreline land uses impact on the lake, a better understanding will be gained of to what degree future development will affect the lake's water quality.

STUDY SITE

The overall study site encompasses the east and west shorelines of the southernmost portion of Lake George, New York. Of the eight sampling sites selected for the program, four are located on the east shore and four on the west, and all are positioned south of Plum Point. The shoreline types within this area include forested land, single-family residences, hotels/motels, and marinas. This area of the lake holds a high degree of human activity on the water (boating, fishing, etc.) and can be quite heavy during the peak summer months (June-August), which corresponds to the sampling period for this project. Figure 1 details the location of each sampling site.

The southernmost basin of Lake George (Tea Island Basin), consistently shows the greatest productivity, nutrient content, and concentrations of other chemical parameters, than other regions of the lake. This has been attributed to the relatively high degree of shoreline development and its contributing runoff. Although, comparison among sites and possible chemical variations among them will be possible due to the close proximity of the sites to each other.

Figure 1: Map of sampling sites for the 1993 Inshore sampling program.



METHODS

Six sample sets were collected between June 29th and September 8th, during the period of summer stratification. Data from the Tea Island 0-10 meter sampling site from the Offshore Chemical Monitoring Program of 1993 (Eichler, et al 1994) was used as a reference in order to compare the nearshore water chemistry to that of the open waters. Although samples were not collected at the same times, the lake was thoroughly stratified throughout the sampling period so overall measurements can be used for the purpose of comparison.

Dates of Inshore 1993 Sampling		Dates of Tea Is. 0-10 meter Sampling	
June 29	August 11	June 8	August 19
July 14	August 25	July 15	September 16
July 28	September 8		

Grab samples were collected in shallow water, approximately 0.5 meter depth, immediately in front of the designated site. Samples were immediately cooled and returned to the laboratory for appropriate analyses and preservation. The following chemical constituents were measured:

total phosphorus
orthophosphorus
nitrate
ammonia
silica
chloride
chlorophyll a

Initially, watershed areas encompassing each site were determined from a 7.5" U.S. Geologic Survey topographic map. On-site inspections were then carried out in order to identify more specific conditions that may affect water movements. These more specific inspections were vital due to the relatively small watersheds being considered, where small changes in water movement patterns can have a significant effect on watershed areas. After site areas were verified, the map information was digitized and entered into the MapInfo™ Geographic Information System (GIS) where specific areas were determined.

After watershed areas were determined, the composition of each site's cover was estimated. Types of cover were categorized either as permeable or impermeable. Permeable areas included tree, shrub, or grass cover and were determined by on-site inspection as a percentage of the total site area. Impermeable areas included covered structures and paved areas. Areas of all structures were verified from Town of Lake George tax maps. Paved areas along with all other cover types were determined as a percentage of site area and estimated from on-site inspection.

The composition of the watershed at each site, mainly its degree of permeability, is believed to be a major factor in the resulting water quality of the adjacent shallow waters in the lake. In order to observe the effects of varying types of subcatchments, the sites have been grouped according to the degree of impermeability observed. The table below gives the designations used throughout this report:

Impermeability Designation (ID):	Percent Impermeable:
High	> 90%
Moderate	10-25%
Low	< 10%

SITE DESCRIPTIONS

WS-1 Impermeability Designation: **High** Subcatchment Area: **2.18 ac**
This subcatchment area is entirely impermeable and its types of cover include paved roadways, parking areas, and covered buildings. The area adjacent to the north of the sampling site contains boat slips and a refueling area. A high degree of boat traffic occurs at this site throughout the period of sampling. Bottom sediments consist of sand and gravel.

WS-2 Impermeability Designation: **High** Subcatchment Area: **3.33 ac**
This subcatchment area is entirely impermeable and its types of cover include paved roadways, parking areas, and covered buildings. The sampling site is located within a marina area which receives a high degree of boat traffic. Bottom sediments consist of sand and gravel.

WS-3 Impermeability Designation: **Low** Subcatchment Area: **3.59 ac**
This site consists of a large sloping hillside covered mainly with grasses, shrubs and trees. The impermeable surfaces that are found consist of a single-family home, a small outbuilding and driveway. The bottom sediments consist of sand and cobbles. Shoreline usage and boat traffic at this site are very low.

WS-4 Impermeability Designation: **Moderate** Subcatchment Area: **2.12 ac**
The drainage area for this site consists of a diverse mixture of structures and ground cover types. Structures include large multiple-dwelling buildings and smaller rental cabins. Driveways and parking areas complete the impermeable areas. Permeable areas include maintained lawns, shrubs and trees. The bottom sediments consist of sand.

ES-1 Impermeability Designation: **High** Subcatchment Area: **1.19 ac**
This subcatchment consists mostly of impermeable structures and paved areas including a launch ramp that services a marina. The sampling site is located within a marina and receives a high degree of boat movements. The sediments at the sampling site consist of sand overlaid with detrital matter.

ES-2 Impermeability Designation: **Moderate** Subcatchment Area: **2.75 ac**
The shoreline consists of an abrupt, rocky outcrop and the sediments are composed of sand and cobbles. The subcatchment contains a few large structures and paved areas, and remaining areas consist of maintained lawns and trees.

ES-3 Impermeability Designation: **Moderate** Subcatchment Area: **1.99 ac**
The drainage area for this sight consists mainly of forest with a single-family residence located at the shoreline. The sample site bottom sediments consist of sand and cobbles. Shoreline usage and boat traffic is low.

ES-4 Impermeability Designation: **Low** Subcatchment Area: **1.45 ac**
The shoreline consists of a rocky outcrop and the sediments are composed of sand and cobbles. The entire subcatchment is forested and shoreline usage and boat traffic immediately adjacent is low.

RESULTS and DISCUSSION

<u>Total Phosphorus</u>

The average Total Phosphorus (TP) values for all the Inshore sites is shown in Figure 2. The values fall into two distinct groupings where higher values (> 5 ug P/l) belong to sites with a high degree of impermeability along with one moderate site (WS-4). TP values less than 4.5 ug P/l are found at sites with low to moderate amounts of impermeability. Of the sites designated moderately impermeable, WS-4 is the most developed with 25% impermeable surfaces within the subcatchment. The midlake reference site had a mean TP value of 3.7 ug P/l (SE=0.3), less than any of the Inshore sampling sites.

When grouped according to impermeability designation (ID), Figure 3, the High was significantly greater, 5.7 ug P/l, than either of the Low (4.2 ug P/l) or Moderate(4.4 ug P/l), where the t-test $P<0.01$ for both comparisons. This point corresponds with results from previous Inshore reports where waters adjacent to the most undeveloped shorelines showed a consistently lower TP value than more developed shorelines (Eichler, Clear, & Boylen, 1993)

Figure 2. Average total phosphorus for all Inshore sites. Error bars = 1SE (n=6).

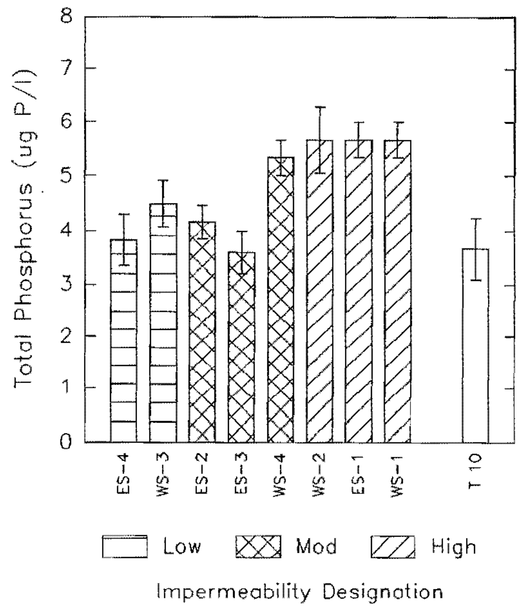
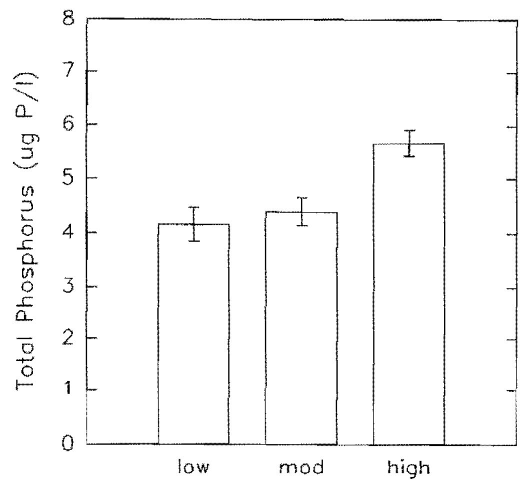


Figure 3. Average total phosphorus for Impermeability Designations. Error bars = 1 SE (n=12,17,18 respectively).



<u>Orthophosphorus</u>

Four of the sites sampled recorded average orthophosphorus (OP) levels at or above the limit of detection of 1.0 ug P/l (Figure 4). These sites included all the highly impermeable sites and one moderate site, WS-4. This follows closely with observations from the TP measurements where these same sites also had the greatest average values. When considering both P measurements, WS-4 tends to behave more like a site designated highly impermeable than moderate even though its total impermeable area is 25%. This may in part be due to the fact that its shoreline usage is much greater (beaches, boating, etc.) than that of the other moderately impermeable areas sampled, which can account for a larger amount of suspended sediment. These suspended sediments can carry substantial amounts of phosphorus. Also, the septic systems for this area support a large number of people during peak usage and the greater phosphorus measurements may simply be due to the leaching of P containing compounds from the adjacent soils. Atmospheric deposition (rainfall and dryfall) are also major sources of phosphorus. Most impermeable surfaces within a watershed allow a greater percentage of phosphorus from these sources to reach the lake.

The open water site, T10, showed average OP levels below the limit of detection, comparable to the remaining Moderate and Low impermeable sites.

Figure 4. Average orthophosphate for all Inshore sites. Error bars = 1SE (n=6).

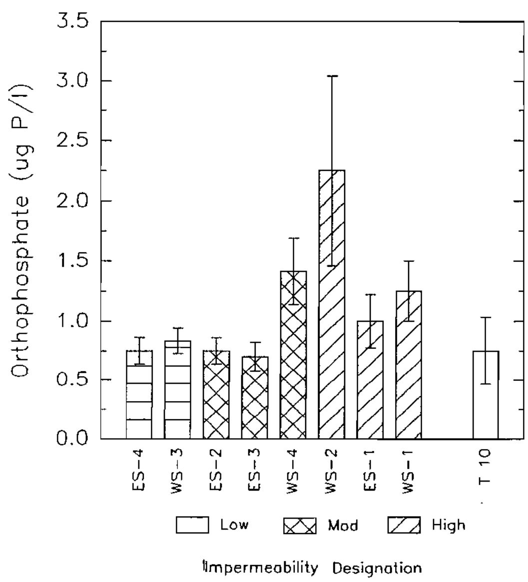
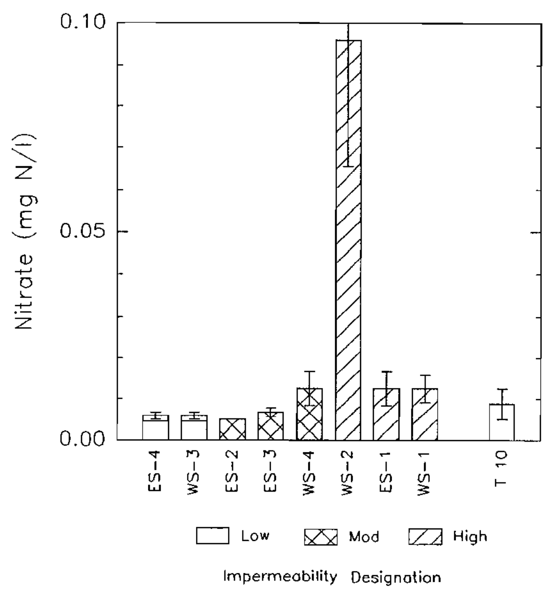


Figure 5. Average Nitrate for all Inshore sites. Error bars = 1 SE (n=6).



Nitrate

Only one site, WS-2 (High impermeable designation), recorded average Nitrate (NO_3) levels greater than the limit of detection (0.01 mg N/l) with an average of 0.09 mg N/l (Figure 5). The input of NO_3 at this site appeared continuous over most of the sampling period (June - September) and was not the result of a single large NO_3 measurement. This would indicate a rather large NO_3 input from this area as this average ambient measurement is nearly ten times the average for the open waters in this region of the lake (Eichler, et al 1994). Sources for nitrate to Lake George atmospheric deposition, wastewaters and terrestrially derived materials such as fertilizers, corrosion products, etc.

Ammonia

There were no significant differences among sites concerning average ammonia (NH_4) measurements. While there were some single sporadic elevated ammonia measurements, 0.06 at WS-3 and 0.07 mg N/l at ES-3, there were no continuous NH_4 inputs observed at any specific sites or corresponding to Impermeability Designation.

Chlorophyll a

There was large variability seen among sites concerning average chlorophyll a (Chla) measurements (Figure 6). The lowest average chlorophyll a value was recorded at ES-3 (Low) 0.84 ug/l and the highest at WS-2 (High) 2.17 ug/l. The high Chla levels measured at WS-2 are most likely the result of greater nutrient availability (OP, NO_3) for the phytoplankton populations than at other sites. The inputs of nutrients appeared continuous at WS-2 causing consistently elevated chlorophyll a concentrations whereas other sites showed only sporadic nutrient inputs. With fluctuating nutrient levels, phytoplankton populations will respond accordingly, thus showing lower average chlorophyll a concentration and a larger standard error term (SE). When sites are divided into their respective Impermeability Designations, there are no significant differences among groups.

Chlorophyll a values provide a direct measurement of primary (algal) productivity in lake systems. Algal productivity is controlled by many factors including soluble nutrient (OP, NO_3, Si) concentrations, and environmental factors such as water temperature and available sunlight. Grazing from zooplanktors can also significantly reduce standing phytoplankton biomass. Sampling locations were chosen in close proximity to each other to reduce the effects of environmental factors.

Figure 6. Average Chlorophyll a for all Inshore sites. Error bars = 1SE (n=6).

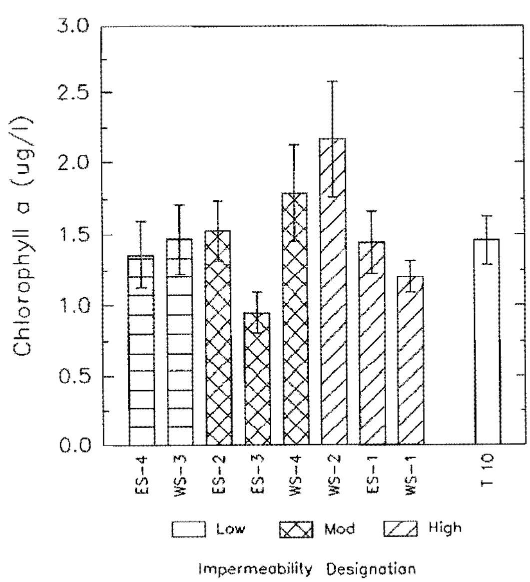
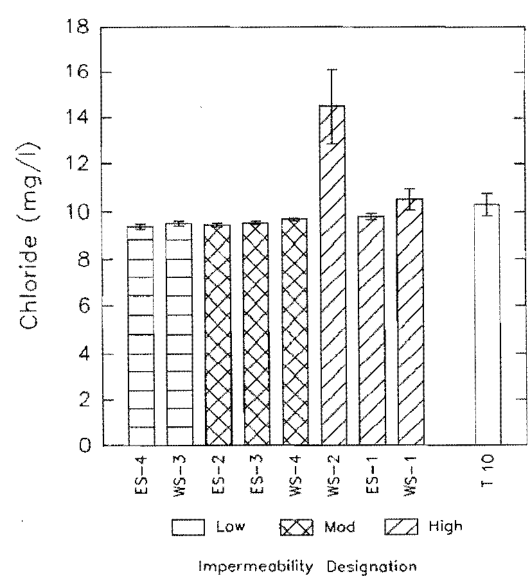


Figure 7. Average Chloride for all Inshore sites. Error bars = 1 SE (n=6).



Chloride

The site WS-2 stands alone as having the greatest average Chloride (Cl) measurement among all sites with a mean concentration of 14.5 mg/l (Figure 7). All other sites range from 9.4 mg/l (ES-4) to 10.3 mg/l (WS-1) across all Impermeability Designations (IDs). The reference site (T10) had a mean concentration of 10.3 mg/l. Clearly, a significant source of Cl is appearing at site WS-2 to create a much higher average ambient level of Cl than at all other sites, including the open water site (T10). When comparing average Cl levels by ID groupings, the High is significantly greater than either of the Low or Moderate, although this is due mainly to the high concentrations of Cl at WS-2. The levels of chloride at all sites except WS-2 fall within normal concentrations seen during mid-summer in the southernmost sub-basin of Lake George (Eichler, et al 1994).

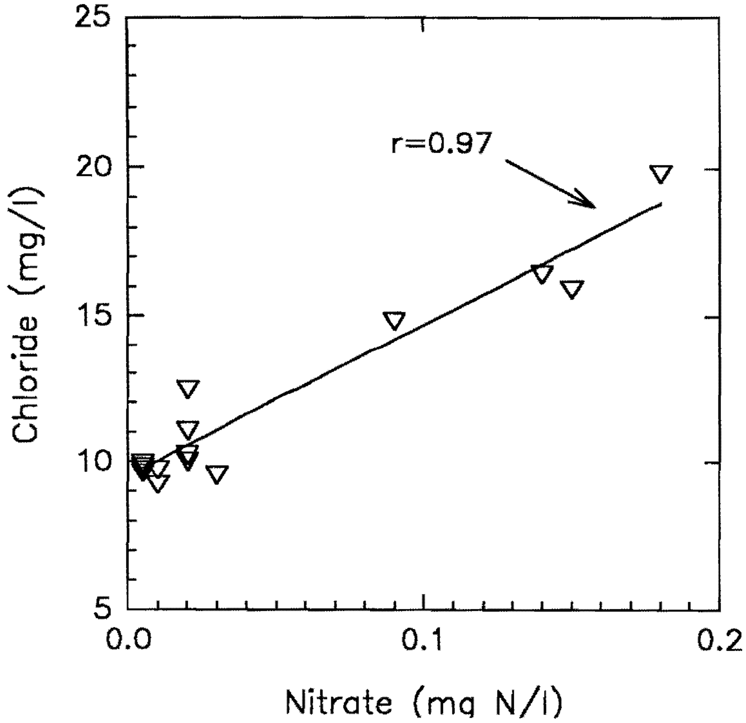
The identified sources of chloride to Lake George have previously been associated with the winter application and subsequent runoff of road deicing materials, i.e., road salt. Although these inputs do not normally continue throughout the summer months as they do at the WS-2 site. An alternate source of Cl is causing the elevated levels at this site. The Cl input at WS-2 apparently is not common to all the sites with High impermeability as the remaining sites do not show comparably elevated Cl values (Figure 7).

Figure 8 shows the strong correlation that develops between chloride and nitrate at the highly impermeable sites. Samples with elevated levels of nitrate are associated with elevated chloride levels suggesting that inputs of the two materials may be connected or from the same source.

Silica

No significant differences were observed in average Silica (Si) concentrations among the Inshore sampling sites or the impermeability designations. The levels found throughout the sampling program were comparable to those found in the open waters (T10), and ranged between 0.8 and 0.9 mg/l. Silica can often be an important nutrient to fresh water systems as it is needed by diatoms (an algae classification) to produce a silicate frustule or exoskeleton. A significant portion of the Lake George phytoplankton community is, at times, composed of diatoms.

Figure 8. Nitrate data plotted against Chloride data for High Impermeable Designations. n=18.



CONCLUSIONS

The main purpose of this project was to compare results gathered from the previous years of the Inshore Program, conducted in the Huddle/Bolton Bay, to the findings in this years' study, with special attention paid to differences in degrees of shoreline development (impermeability). The question, "Will similar shoreline usages in different parts of the lake produce similar effects in their adjacent nearshore waters?" was addressed, and in many respects it was answered affirmatively.

Perhaps the most important aspect this study addressed was whether differences existed in inputs of phosphorus to the lake from one shoreline usage to another, since phosphorus is acknowledged to be the limiting nutrient to algal productivity in Lake George. Both data from this year and years previous, show that there are significantly greater levels of phosphorus found in waters adjacent to more developed shorelines than areas with little development, and that this is occurring at many sites within the basin.

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