

# **Blue-Green Algae Report 2008**



**Water Resources Management Division  
Department of Environment and Conservation  
Government of Newfoundland and Labrador**

## Executive Summary

Blue-green algae are not true algae, but are photosynthetic bacteria called cyanobacteria. They can occur naturally in fresh and marine waters in low concentrations. Like plants, they live on light, carbon dioxide and nutrients such as nitrogen and phosphorus. They often occur in small numbers that are invisible to the casual observer and do not cause toxicity when present at low concentrations. When conditions are favorable for growth, their numbers can increase exponentially and they become easy to see. This condition is called a blue-green algae bloom.

Many species of blue-green algae are not harmful and serve as the energy producers at the base of the food web. Some species produce toxins within their cells, which are released into the surrounding environment when the cells rupture. If the toxins are present at significant concentrations, they have the potential to cause adverse health affects in humans, animals and waterfowl and can negatively impact aquatic life. Microcystins are the most common of the blue-green algae toxins found in water (Health Canada, 2008). Authorities are kept on alert for the toxicity of blue-green algae blooms in freshwaters that are used for drinking and recreational purposes. Health Canada recommends *a maximum acceptable concentration of 1.5 micrograms per liter ( $\mu\text{g/L}$ ) for total microcystins in drinking water*. The World Health Organization advises that *waters containing less than 20,000 blue-green algae cells per millilitre (cells/mL) are safe for recreational use; at 20,000 to 100,000 cells/mL of water some susceptible people can experience an adverse reaction from contact with the water; when concentrations are greater than 100,000 cells/mL nobody should be in contact with the water*.

The province of Newfoundland and Labrador experienced its first documented blue-green algae bloom in the late summer and early fall of 2007. In the spring of 2008 the Department of Environment and Conservation developed a multi-dimensional *Blue-Green Algae Monitoring Plan 2008* and a *Frequently Asked Questions and Answers* document and posted these on a public web page. Laboratory results from water samples collected as part of the monitoring plan were posted on the web page for public view. Additionally, key stakeholders were notified by email each time analysis results were updated. These stakeholders include officials from the Department of Natural Resources, the Department of Government Services, the Department of Fisheries and Oceans, Environment Canada, Eastern Health, and Northeast Avalon Atlantic Coastal Action Program (NAACAP). The intent of the public web page was to guide stakeholders and recreational users so that they could make informed decisions regarding the safe use of water bodies experiencing a blue-green algae bloom.

The ponds that were monitored for blue-green algae are not used as a source of public drinking water, but are used extensively for recreational purposes. All water samples collected as part of the 2008 Blue-Green Algae Monitoring Plan had concentrations of microcystin toxin and blue-green algae cell counts well below existing guidelines for recreational use. The Department of Environment and Conservation will continue to work with provincial and federal counterparts to monitor the presence of blue-green algae and microcystin in the province's surface water bodies as needed.

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### **List of Acronyms**

NAACAP	Northeast Avalon Atlantic Coastal Action Program
WHO	World Health Organization
ELISA	Enzyme Linked Immuno-Sorbant Assay
BGA	Blue Green Algae
TP	Total Phosphorus
USGS	United States Geological Survey
TKN	Total Kjeldahl Nitrogen
EPA	Environmental Protection Agency
STAR	Science to Achieve Results

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## 1.0 Introduction

This report provides an overview of blue-green algae blooms and the work the Department of Environment and Conservation has undertaken to monitor the presence of blue-green algae in provincial surface water bodies.

### 1.1 An Overview of Blue-Green Algae Blooms

Blue-green algae are single-celled bacteria that grow in both freshwater and marine environments. In low concentrations blue-green algae are not easily visible and are non-toxic (Jones & Orr, 2003). The abundance of blue-green algae is dependent on a number of environmental conditions including water temperature, wind conditions, water depth and flow, and the availability of nutrients such as nitrogen and phosphorus. Blue-green algae have the unique ability to trap gas, which enables them to change their depth to take advantage of more favorable growth conditions. Some species also have the ability to fix nitrogen directly from the atmosphere, which ensures a stable nitrogen supply. When blue-green algae become abundant, they can discolour the water, producing floating mats on the surface of the water that can be blue, green or red in colour. These floating mats of blue-green algae are called blooms. Blooms are most common in warm, calm, shallow bodies of water such as ponds, reservoirs, roadside ditches and other man-made impoundments, where the water is hard, alkaline and rich in nutrients, carbonates and organic matter (Government of British Columbia, Ministry of Environment, 2001). Blooms do not usually occur in flowing waters, rivers, streams, springs, irrigation canals or wells.

In a healthy and balanced aquatic ecosystem, many genera of non-toxic blue-green algae, such as *Spirulina* and *Tolypothrix*, form a small but important component of the natural plankton population (<http://www.env.gov.bc.ca/wat/wq/reference/cyanophytes.html#g1>). Other genera, such as *Anabaena*, *Nodularia*, and *Microcystis* contain species that produce toxins (<http://www.env.gov.bc.ca/wat/wq/reference/cyanophytes.html#g1>). The toxins are released into the surrounding water column when the blue-green algae cells rupture. The toxins are grouped into three categories: hepatotoxins, which affect the liver; neurotoxins, which affect the nervous system; and dermatotoxins, which irritate the skin. Symptoms are a function of the duration of contact, or quantity ingested, body weight and the type of toxin. Symptoms may last for several days and may range from skin itchiness and irritation to fever, dizziness, stomach cramps, vomiting, sore throat, and in sever cases, death.

Essentially, all warm-blooded animals are susceptible to blue-green algae toxins, including people, waterfowl, furbearers, livestock, poultry and household pets. Although humans are just as much at risk as animals from the toxic effects of certain strains of blue-green algae, most adverse health effects are reported to occur in cattle, horses, sheep, dogs and waterfowl since adult humans will rarely drink or swim in water with an obvious thick algae bloom. Water during a bloom looks and smells bad. Younger children may be unaware of the potential danger of drinking or swimming in water

experiencing a bloom.

(<http://www.env.gov.bc.ca/wat/wq/reference/cyanophytes.html#g1>).

Numerous animal deaths associated with blue-green algae were reported in Australia in the late 1800's when cattle, horses and sheep reportedly drank water from a lake that was experiencing a massive bloom. Since then, numerous reported animal and bird deaths caused by blue-green algae toxins have been published (Ressom et al., 1994; Kuiper-Goodman et al., 1999; WHO, 1999). Incidences of human illness have been linked to the recreational use of water contaminated by toxin-producing species of blue-green algae, such as *Anabaena* and *Microcystis*, in North America, the United Kingdom, the Netherlands and Australia (Health Canada, 2008). No fatalities associated with recreational use have been documented (Health Canada, 2008). To date, the most lethal outbreak attributed to exposure to blue-green algae toxins in drinking water occurred in Brazil in 1988. An immense blue-green algae bloom developed in a newly flooded dam, resulting in more than 2000 cases of gastroenteritis, with 88 deaths reported (mostly children) over a 42-day period. More recently, in February 1996, liver failure and death was reported in haemolysis patients of a Brazilian dialysis clinic where the dialysate was found to be contaminated with blue-green algae cells (Health Canada, 2008). Death was reported in approximately 50% of the dialysis patients exposed to the contaminated dialysate.

### **1.2 Blue-Green Algae Blooms in Newfoundland and Labrador**

The first documented blue-green algae bloom in Newfoundland and Labrador occurred in the late summer and early fall of 2007. Water bodies affected by the bloom include Cochrane Pond, Paddy's Pond, Three Arm Pond, and Three Island Pond. These ponds are not used for drinking water by humans, however all ponds are widely used for recreational purposes including swimming, wading, boating, water-skiing and fishing. The ponds are situated amongst a variety of land developments including commercial, agricultural, residential, cottage and a public camping ground. The Department of Environment and Conservation began monitoring this pond system in May 2008 for the recurrence of a blue-green algae bloom. Thomas Pond and Topsail Pond were monitored in addition to the four ponds monitored in 2007, as these water bodies are part of this pond system. Blue-green algae cells were frequently observed suspended in the water column and floating on the surface of the water in all six ponds during the course of the monitoring period, which ended in September 2008. The bloom observed in 2008 was sporadic and less intense than the bloom observed, particularly in Paddy's Pond, in 2007. The blue-green algae bloom observed in 2007 consisted of a thick dense mat of green material that floated and on the surface, and persisted for almost two months, from late August to mid-October.



Paddy's Pond, NL September 2008



Paddy's Pond, NL September 2007

### 1.3 Blue-Green Algae Blooms in Canada

Blue-green algae blooms have been documented in every province of Canada. Naturally occurring species of blue-green algae have also been identified in freshwater bodies in the Yukon (Benke, Colbert and Cushing, 2005) as well as in the Northwest Territories (Vézina and W. F. Vincent, 1996). The photos below depict blue-green algae blooms in Ontario and Prince Edward Island in 2005.



Unidentified Lake in Dorchester, Ontario 2005



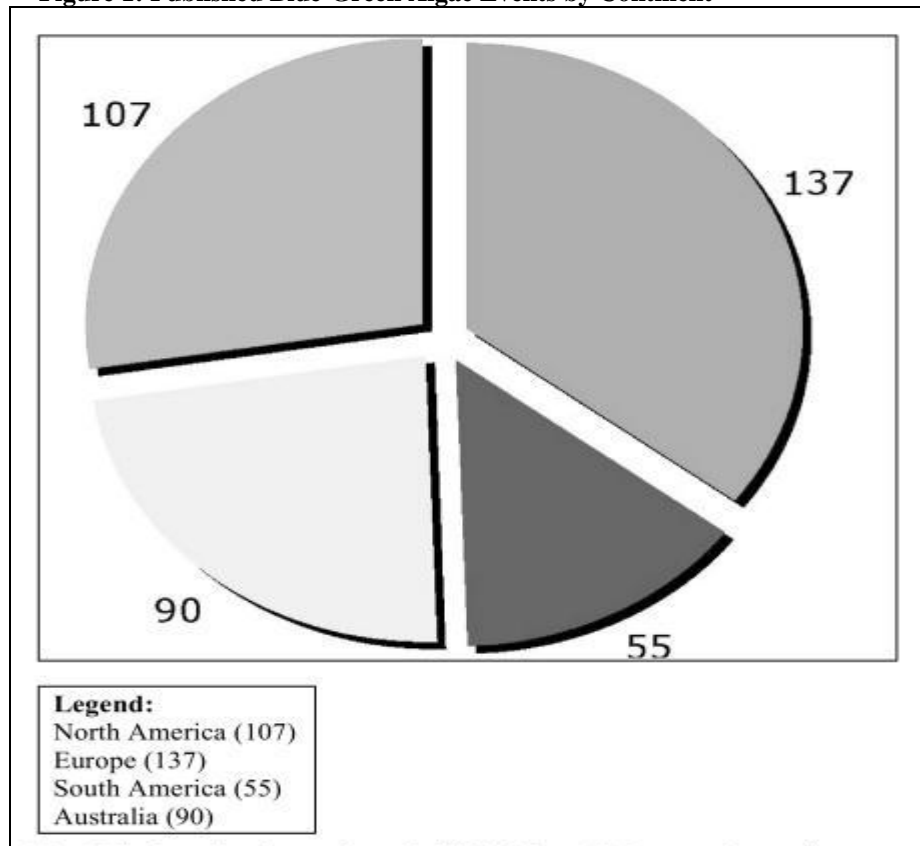
McClure's Pond, PEI 2005

### 1.4 Blue-Green Algae Blooms: a Global Issue

Blue-green algae blooms occur worldwide and are considered a worldwide problem (Carmichael, 2004). In 2004, Dr. Wayne Carmichael, Professor Emeritus at Wright State University in Dayton, Ohio, conducted a literature search of harmful blue-green algae blooms which included 3,063 references citing 705 journals written by 4,687 authors and editors. The pie chart in **Figure 1** outlines the number of published blue-green algae events by continent, based on this literature search:



**Figure 1: Published Blue-Green Algae Events by Continent**



### 1.5 Global Response to Blue-Green Algae Blooms

The worldwide response to blue-green algae blooms is varied and dependent upon the use of the water body and the intensity and toxicity of the bloom. Initial response typically involves a monitoring program consisting of laboratory identification and speciation of the blue-green algae cells and toxin analysis. If the water is used for human consumption, specialized filtration is commonly used to remove the blue-green algae cells, and follow-up treatment processes such as oxidation, activated carbon and membrane filtration has been shown to be effective in the removal of microcystin. Conventional water treatment, such as the addition of chlorine, is ineffective against microcystin (Ontario Ministry of Environment, 2005). The occurrence of blue-green algae blooms in recreationally used water bodies has solicited a variety of responses including public advisories regarding the safe use of water experiencing a bloom, closure of public beaches, the distribution of educational materials promoting the reduction of phosphorus and nitrogen based compounds, regulatory management of industrial wastes and mechanical and chemical removal of blue-green algae. Current global initiatives emphasize land and watershed management and education as the most effective means of reducing the occurrence of blue-green algae blooms.

## 2.0 Field Investigation of the 2008 Blue-Green Algae Bloom

In many cases, blue-green algae blooms tend to reoccur within the same bodies of water year after year (Health Canada, October 2008). As a follow-up to monitoring the blue-green algae bloom that affected Cochrane Pond, Paddy's Pond, Three Arm Pond and Three Island Pond in 2007, the Department of Environment and Conservation developed a multi-dimensional blue-green algae water quality monitoring plan that was implemented monthly from May to September 2008. The four ponds that were monitored in 2007 were included in the 2008 monitoring, and two additional ponds were monitored, Thomas Pond and Topsail Pond, as they are part of this pond system.

### 2.1 Field Sampling

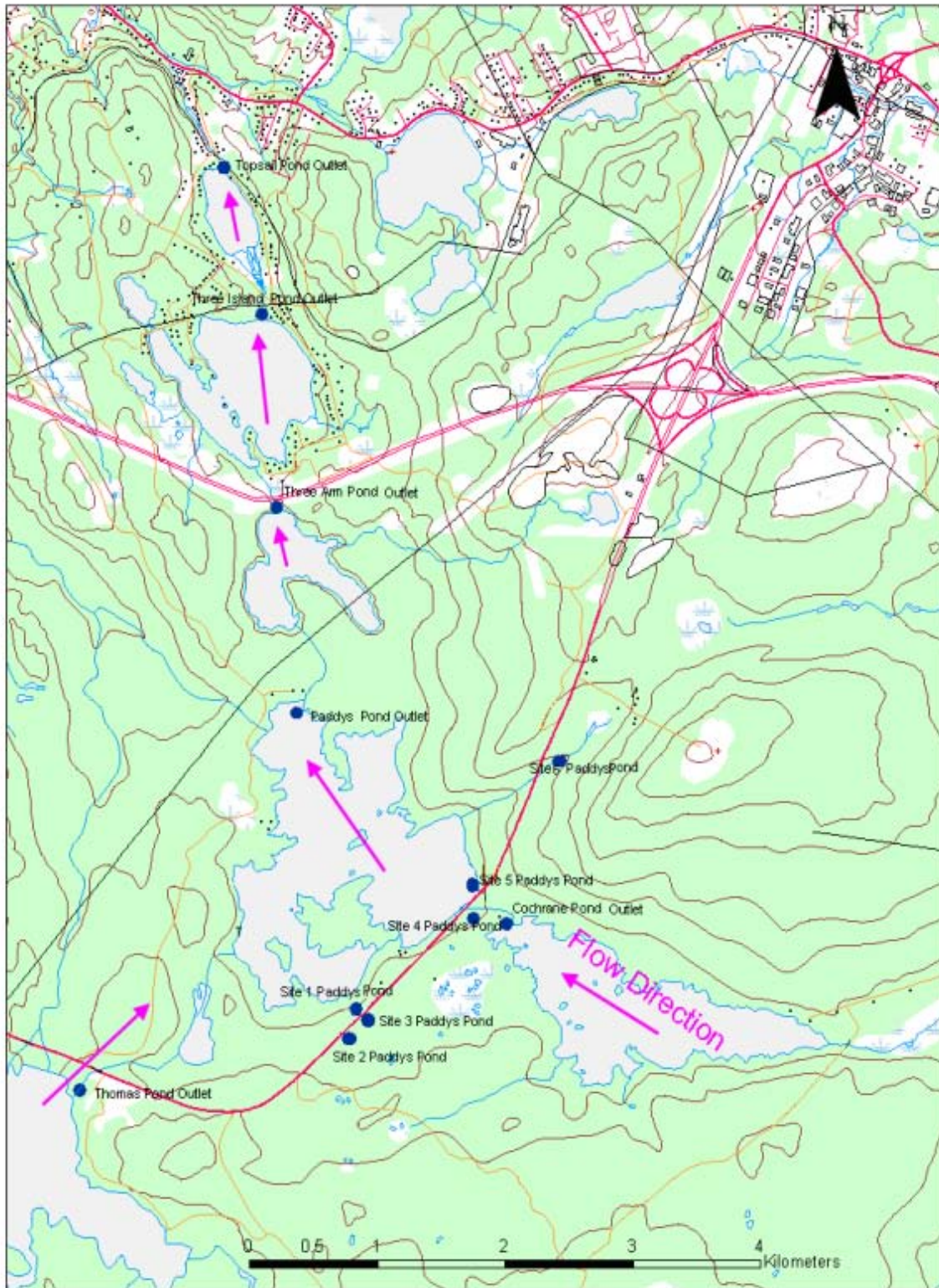
The 2008 Blue-Green Algae Monitoring Plan encompassed the following components:

- monthly collection of water samples from Thomas Pond, Cochrane Pond, Paddy's Pond, Three Arm Pond, Three Island Pond, Topsail Pond and from the inlets or outlets of six culverts that flow into Paddy's Pond
- monthly measurement of water quality at each sampling site using a multi parameter probe
- laboratory analysis of water samples for blue-green algae and the associated toxin, microcystin-LR
- laboratory analysis of water samples for inorganic, physical and biological parameters
- on-site field tests for the presence and semi-quantitative analysis of microcystin toxin
- documentation of field observations and climate conditions at the time of sampling
- sanitizing of all water quality monitoring equipment and personal field gear between sampling locations

Twelve monitoring locations were selected in an effort to obtain data that was highly representative of existing water quality conditions in Thomas Pond, Cochrane Pond, Paddy's Pond, Three Arm Pond, Three Island Pond and Topsail Pond, as well as from water flowing into or out of culverts that discharge into Paddy's Pond. Site #1 and #5 refer to the outlets of culverts discharging into Paddy's Pond, while Site #2, #3, #4 and #6 refer to sampling stations located at the inlet of culverts which discharge into Paddy's Pond.

A map identifying the twelve sampling locations is found in **Figure 2**:

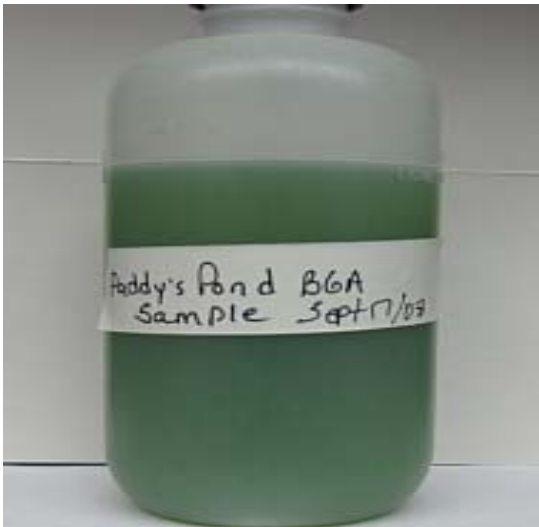
Figure 2: Map of Blue-Green Algae Sampling Sites 2008



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Water samples were collected from two additional locations in September 2008 based on an interest in determining nutrient concentrations in water near agricultural operations that border the shoreline of Cochrane Pond. The additional water samples were collected immediately downstream from a chicken farm and a sod farm.

The water sample collected from Site #5 on September 17, near the outfall of a culvert that flows into Paddy's Pond, was analyzed for blue-green algae, when a fairly thick blue-green algae bloom was observed along the southern shore of the pond. Water samples collected at the inflows and outflows of culverts typically were not analyzed for blue-green algae as part of this monitoring plan.



Water sample from Site#5, Paddy's Pond: Sept 17/08



Site #5, Paddy's Pond,; Sept 17/08

### 2.2 Sample Analysis

Analysis of water samples collected as part of the Blue-Green Algae Monitoring Plan was conducted at laboratories that are accredited by the Canadian Association for Environmental Analytical Laboratories for analysis of the specified parameter.

Identification of blue-green algae genera and microcystin analysis was conducted by HydroQual Laboratories in Calgary, Alberta.

Inorganic analysis of water samples was conducted by Maxxam Analytical, at labs located in St. John's, Newfoundland and Labrador and Bedford, Nova Scotia.

Bacteriological analysis of water samples was conducted at the Newfoundland and Labrador Public Health Laboratories in St. John's.

On-site field tests for the semi-quantitative screening of microcystin toxin were completed at all sampling sites in May, and the field tests were repeated for Thomas Pond, Cochrane Pond and Paddy's Pond in September. The field test was conducted

using an *Envirologix* Qualitube Kit for Microcystin, which is a competitive Enzyme Linked Immuno-Sorbant Assay (ELISA).

In-situ water quality was measured monthly at all sites using an YSI 6600 V2 multi-probe equipped with the following sensors: water temperature, specific conductivity, pH, dissolved oxygen, turbidity, blue-green algae and chlorophyll.

### **3.0 Interpretation of Analysis Results**

Analyses results from the Blue-Green Algae Monitoring Program 2008 are recorded in **Section 5.1, Appendix A**, at the end of this report.

One factor that should be considered when interpreting the results is that six sampling sites were located at the outlets of ponds, where there was substantial water flow, and where mixing with significant volumes of water had occurred upstream. The remaining six sampling sites were located at either the inlet or the outlet of culverts that discharge into Paddy's Pond. Samples near culverts were collected from very small volumes of water where flow was minimal and sometimes non-existent. It may not be good science to compare analysis results from samples collected at pond outlets to results from samples collected near culverts, since the water near culverts was often merely a standing pool providing an opportunity for some parameters to concentrate, while depleting other parameters, such as dissolved oxygen.

### **3.1 Blue-Green Algae Analysis**

#### ***3.1.1 Taxonomy of Blue-Green Algae***

Analysis results indicate that all blue-green algae cells detected in water samples from this study belong to the genus *Anabaena*. Several strains from this genus are known to contribute to the formation of toxic blooms in freshwater bodies through the production of a range of hepatotoxins or neurotoxins (Halinen et al, 2007). Although *Anabaena* cells were identified in several water samples collected in July, August and September no toxin was detected in these samples. These results support the findings of Huisman, Matthijs and Petra that "*some blooms dominated by potentially microcystin-producing genera are not toxic at all, whereas other blooms dominated by the same genera are highly toxic and can pose a serious health threat*" (Huisman, Matthijs and Petra, 2004).

#### ***3.1.2 Quantitative Analysis of Microcystin-LR***

Microcystins are the most common of the blue-green algae toxins found in water (Health Canada, January 2008). More than 80 microcystins have been identified to date, but only a few occur frequently and in high concentrations. Microcystin-LR is among the most frequently occurring and most toxic of the microcystin congeners (World Health Organization, 2003). The Blue-Green Algae Monitoring Plan 2008 included the



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quantitative analysis of microcystin-LR in water samples. **Table 1**, below, summarizes the results of the analysis:

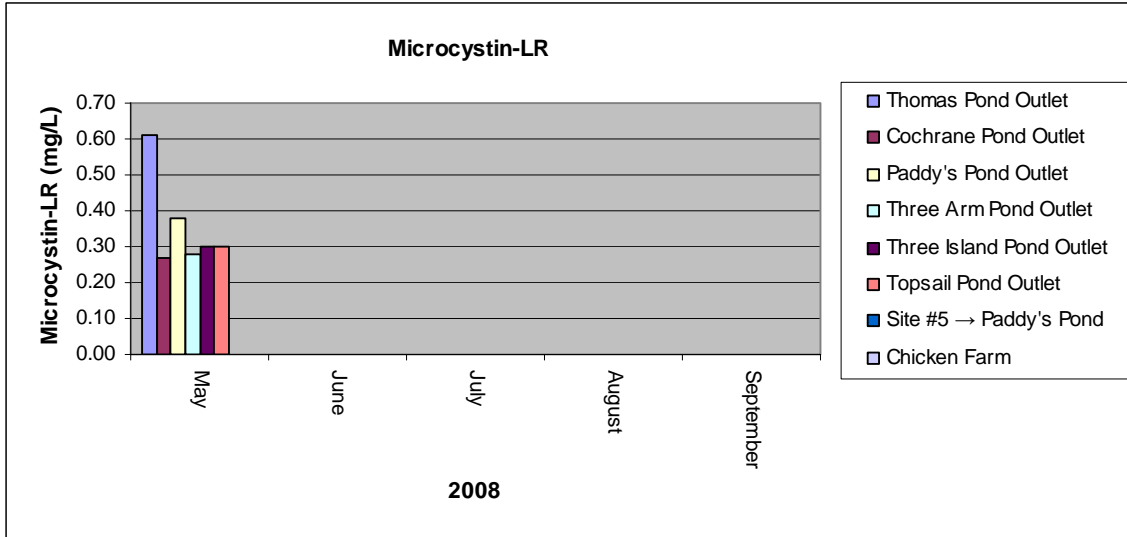
**Table 1: Laboratory Analysis of Blue-Green Algae in 2008**

<b>Location</b>	<b>Date 2008</b>	<b>* Blue-Green Algae (BGA) detected</b>	<b>Microcystin-LR (µg/L)</b>
<b>Thomas Pond</b>	May	No BGA cells detected	0.61
	June	No BGA cells detected	less than detect
	July	No BGA cells detected	less than detect
	August	One BGA cell detected	less than detect
	September	No BGA cells detected	less than detect
<b>Cochrane Pond</b>	May	No BGA cells detected	0.27
	June	No BGA cells detected	less than detect
	July	No BGA cells detected	less than detect
	August	No BGA cells detected	less than detect
	September	<i>Anabaena</i>	less than detect
<b>Paddy's Pond</b>	May	No BGA cells detected	0.30
	June	No BGA cells detected	less than detect
	July	<i>Anabaena</i>	less than detect
	August	No BGA cells detected	less than detect
	September	<i>Anabaena</i>	less than detect
<b>Three Arm Pond</b>	May	No BGA cells detected	0.30
	June	No BGA cells detected	less than detect
	July	<i>Anabaena</i>	less than detect
	August	No BGA cells detected	less than detect
	September	No BGA cells detected	less than detect
<b>Three Island Pond</b>	May	No BGA cells detected	0.38
	June	No BGA cells detected	less than detect
	July	<i>Anabaena</i>	less than detect
	August	<i>Anabaena</i>	less than detect
	September	<i>Anabaena</i>	less than detect
<b>Topsail Pond</b>	May	No BGA cells detected	0.28
	June	No BGA cells detected	less than detect
	July	<i>Anabaena</i>	less than detect
	August	<i>Anabaena</i>	less than detect
	September	No BGA cells detected	less than detect
<b>Chicken Farm</b>	September	Not analyzed	less than detect
<b>Site #5</b>	September	<i>Anabaena</i>	less than detect

Analysis results indicate the toxin microcystin-LR was detected in all ponds in May in concentrations that ranged from 0.27 to 0.61 micrograms per liter of sample (µg/L). While there is no existing guideline recommending a safe level of microcystin-LR in waters used for recreational purposes, the microcystin levels detected in the ponds were well below the Health Canada guideline for drinking water, which recommends a maximum concentration of 1.5 µg/L of microcystin-LR. The results also indicate that although microcystin-LR was detected in water samples from each pond in May, no blue-

green algae cells were detected. It can be hypothesized that the toxin was released into the water in late fall or early winter when colder water temperatures caused the cells to lyse and subsequently decompose, and the toxin persisted during low flow and ice conditions over the winter. Microcystin-LR was not detected in any samples collected in June, July, August or September. **Figure 3**, below, summarizes the levels of microcystin-LR detected during the 2008 Blue-Green Algae Monitoring Program:

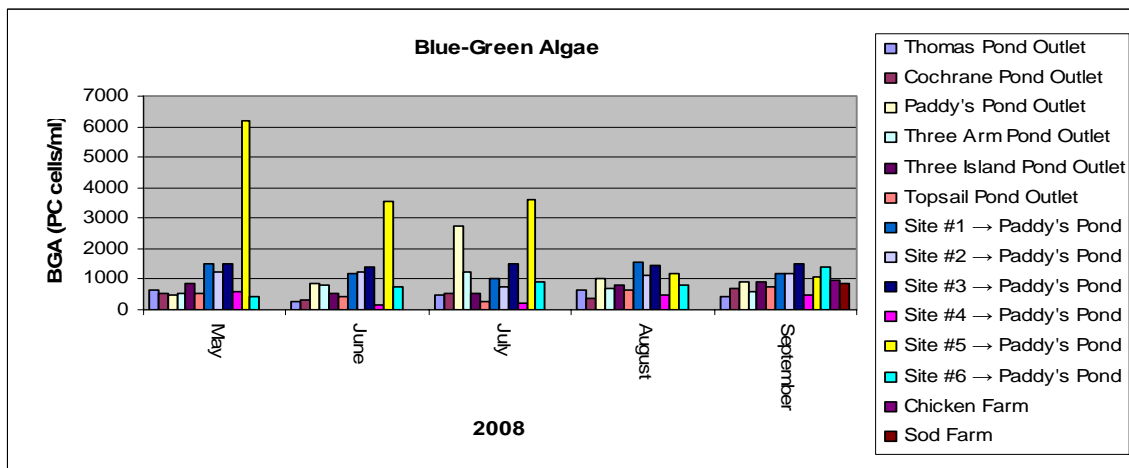
**Figure 3: Microcystin-LR Concentrations**



### 3.1.3 Quantitative Analysis of Blue-Green Algae Cells

Blue-green algae cell counts were less than 2000 cells per milliliter (cells/ml) of sample for 58 of the 62 water samples collected in 2008. Up to 2000 cells/ml is considered “background noise” by the manufacturer of the blue-green algae sensor. The remaining 4 samples had BGA cell levels between 2000 and 6000 cells/ml, which is considerably less than the maximum level of 20,000 BGA cells/ml recommended by the World Health Organization as causing no adverse health affects for recreational users. Quantitative analysis of blue-green algae cells from this study is shown in **Figure 4**:

**Figure 4: Quantitative Analysis of Blue-Green Algae Cells**



Site #5 had significantly higher levels of blue-green algae cells in May, June and July in comparison to all other sites; the outlet of Paddy's Pond also had elevated blue-green algae cell counts in July.

### **3.2 Other Parameters of Interest**

One of the most important factors influencing the development of a blue-green algae bloom is the availability of nutrients, particularly phosphorus and nitrogen. Some studies suggest the availability of the micronutrient iron, may also promote the growth of a bloom. Analysis results for these parameters are discussed in this section.

#### **3.2.1 Phosphorus**

Phosphorus is an essential element for all living organisms. It plays a major role in biological metabolism, and compared to other macronutrients required by biota, it is generally the least abundant and the first nutrient to limit biological productivity (Canadian Environmental Quality Guidelines, 2004).

Phosphorus exists naturally in rocks. Under normal weathering conditions, rocks release phosphorus into the environment as phosphate ions, which exist in three forms: orthophosphate, metaphosphate (or polyphosphate) and organic phosphate. Orthophosphate is readily available to the biological community and is typically found in very low concentrations in unpolluted waters. Poly forms are used for treating boiler waters and are found in detergents. In water, they are transformed into orthophosphate and become available for plant uptake. Organic phosphate is bound in plant tissue, waste solids, or other organic material. After decomposition, this phosphate can be converted to orthophosphate.

Apart from natural weathering of rocks and soils, phosphorus enters freshwater systems in four main ways: (i) atmospheric inputs, including rain and dust; (ii) point sources, including sewage treatment plants and industrial effluents; (iii) non-point sources, including storm water, agricultural, and land clearing runoff; and (iv) non-point sources from within the water system, including washout from riverbanks and re-suspension from sediments. The rate at which phosphorus loads enter freshwater systems varies with land use, geology, morphology of the drainage basin, soil productivity, human activities, and pollution (Canadian Environmental Quality Guidelines, 2007).

The best method to quantify phosphorus in aquatic systems is by measuring total phosphorus, because phosphorus is so rapidly transported between the biota and inorganic state (The Michigan Water Research Center, 2001). Total phosphorus (TP) levels vary widely in Canadian fresh waters. Some systems naturally have very low TP levels and may be described as oligotrophic. Other systems naturally have high TP levels and are described as eutrophic. Because of the wide variability of natural phosphorus levels in freshwater systems, it is not possible to establish a single meaningful guideline for phosphorus. Instead, a guidance framework has been developed to allow site-specific management of phosphorus (Canadian Environmental Quality Guidelines, 2007).



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The framework uses trigger ranges, which are ranges of phosphorus levels for a specific freshwater system. The appropriate trigger range is determined according to baseline data and management objectives or goals for the system. If phosphorus levels in the system exceed 50 percent of the baseline level or the upper limit of the trigger range, there may be an environmental problem and further investigation is triggered. The trigger ranges for Canadian lakes and rivers are summarized in **Table 2**, below:

**Table 2: Guidance Framework for Phosphorus**

<b>Trophic Status</b>	<b>Canadian Trigger Ranges TP (µg/L)</b>
Ultra-oligotrophic	<4
Oligotrophic	4-10
Mesotrophic	10-20
Meso-eutrophic	20-35
Eutrophic	35-100
Hyper-eutrophic	>100

The Department of Environment and Conservation had not conducted water quality analysis on Thomas Pond, Cochrane Pond, Paddy's Pond, Three Arm Pond, Three Island Pond and Topsail Pond prior to the blue-green algae bloom in 2007; therefore, baseline data for phosphorus concentrations has not been established. There maybe some benefit to placing the phosphorus data from 2008 into the appropriate trigger categories to compare phosphorus concentrations between the sampling sites. The 2007 data cannot be applied to the chart because a higher detection limit was used at the laboratory for phosphorus analysis in 2007, and most phosphorus levels were reported as "less than detect."

A total of 62 water samples were collected as part of the Blue-Green Algae Monitoring Plan 2008 and levels of TP ranged between 6 and 670µg/L, and are categorized according to Trophic Status in **Table 3**, below:

**Table 3: 2008 Phosphorus Data Applied to Guidance Framework**

<b>Trophic Status</b>	<b>Canadian Trigger Ranges TP (µg/L)</b>	<b># Samples from BGA Monitoring Plan 2008 with TP in Trigger Range</b>
Ultra-oligotrophic	<4	0
Oligotrophic	4-10	5
Mesotrophic	10-20	21
Meso-eutrophic	20-35	15
Eutrophic	35-100	10
Hyper-eutrophic	>100	11

When samples collected from inlets and outlets of culverts are excluded from the sample set and only the 32 water samples collected from the ponds are considered, levels of TP

ranged between 6 and 31µg/L and are categorized, according to trigger values, in **Table 4**, below:

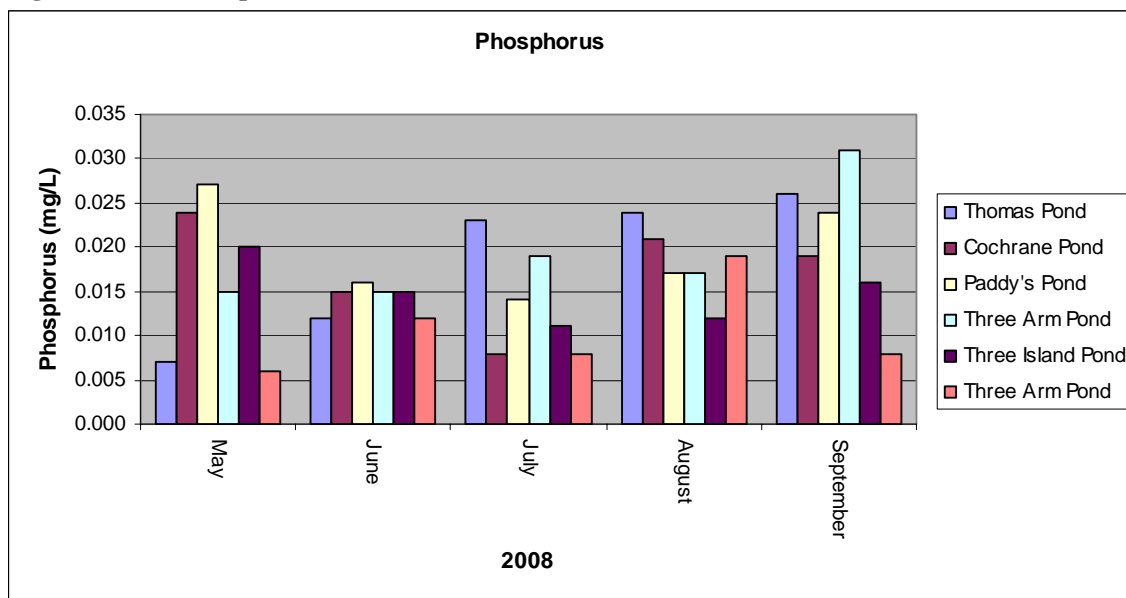
**Table 4: Phosphorus Data from Pond Outlets Applied to Guidance Framework**

Trophic Status	Canadian Trigger Ranges TP (µg/L)	# Samples from BGA Monitoring Plan 2008 with TP in Trigger Range
Ultra-oligotrophic	<4	0
Oligotrophic	4-10	5
Mesotrophic	10-20	17
Meso-eutrophic	20-35	10
Eutrophic	35-100	0
Hyper-eutrophic	>100	0

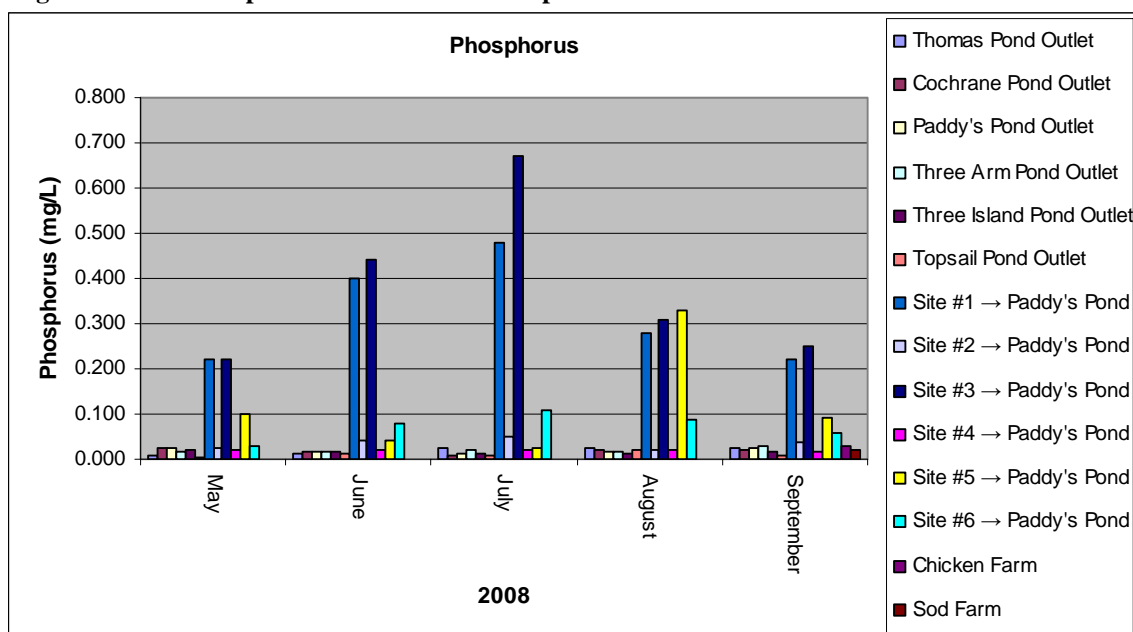
It may be reasonable to expect background phosphorus levels to fall within the oligotrophic to mesotrophic ranges for these ponds, since these categories define phosphorus levels as low to moderate, when compared to freshwaters bodies across the country.

A comparison of TP levels found in samples collected from the outlets of the six ponds is found in **Figure 5** below:

**Figure 5: Total Phosphorus Data from Six Pond Outlets**



A comparison of TP levels found in samples collected from the inlets and outlets of culverts, in addition to the six ponds is found in **Figure 6**:

**Figure 6: Total Phosphorus Data from all Samples**

The results indicate much higher levels of total phosphorus were detected at Sites #1 and #3, and to a lesser extent Sites #5 and #6 during each monthly sampling period. These sites are all located at the inlets or outlets of culverts that discharge surface drainage into Paddy's Pond. These results may be influenced by the very small volumes of water that served as the source for these samples.

### 3.2.2 Nitrogen, Nitrate, Nitrite, and Total Kjeldahl Nitrogen

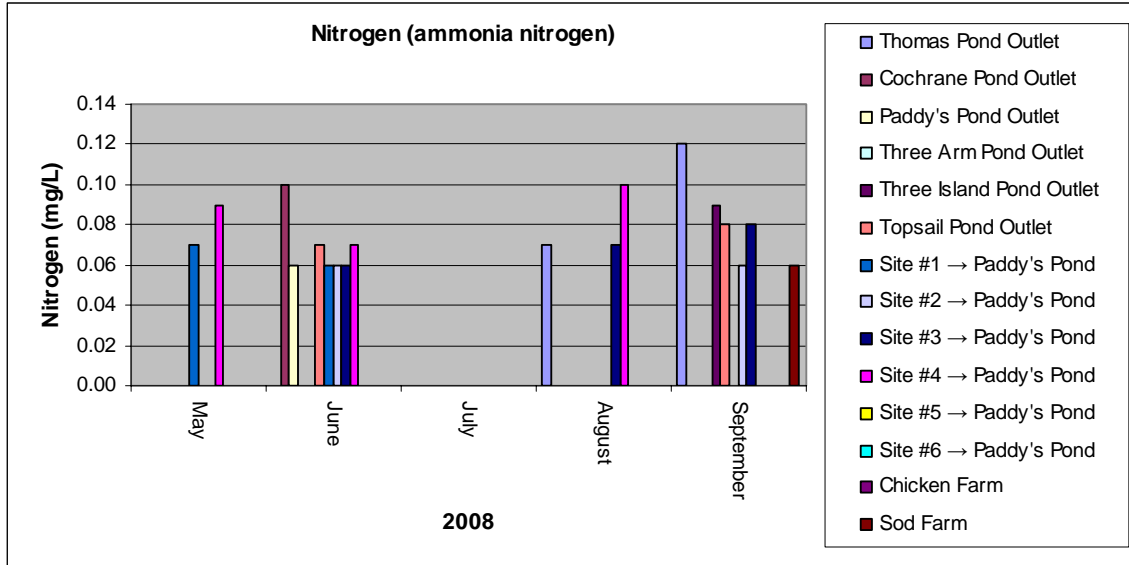
Many forms of nitrogen exist in nature, including atmospheric, organic and inorganic. In its atmospheric form, nitrogen gas makes up 78 percent of our atmosphere. Most plants cannot use nitrogen gas, but in the presence of certain bacteria, it can be transformed into other compounds, such as nitrite, nitrate and ammonia that plants can use. Blue-green algae have the ability to transform or "fix" nitrogen directly from the atmosphere, thus converting it to a usable form. Organic nitrogen refers to a nitrogen compound that had its origin in living material, and exists in materials formed from animal, human, and plant activities that produce manures, sewage waste, compost, and decomposing roots or leaves. Organic nitrogen cannot be used by plants until it is transformed by microbes into inorganic forms, which include nitrate, nitrite and ammonia.

#### 3.2.2.1 Nitrogen (ammonia nitrogen)

The United States Geological Survey (USGS) defines ammonia nitrogen as the concentration of ionized ammonia ( $\text{NH}_4^+$ ) and un-ionized ammonia ( $\text{NH}_3$ ) in water, that are formed as products of the decomposition of organic matter (Watershed Monitoring and Assessment, The IOWA Department of Natural Resources, Iowa City, IA). Ammonia exists as the less toxic ammonium in freshwater that has a pH less than 9. Almost all naturally occurring freshwater in Newfoundland and Labrador has a pH less than 9.0. Low-level ammonia nitrogen may be present in water naturally as a result of the biological decay of plant and animal matter. High concentrations in surface waters can

indicate contamination from waste water treatment facilities, industrial effluents or fertilizer run off (APHA Standard Methods, 1992). **Figure 7**, below, displays concentrations of nitrogen (ammonia nitrogen) detected in water samples collected for this study:

**Figure 7: Nitrogen (ammonia nitrogen) Concentrations from all Samples**

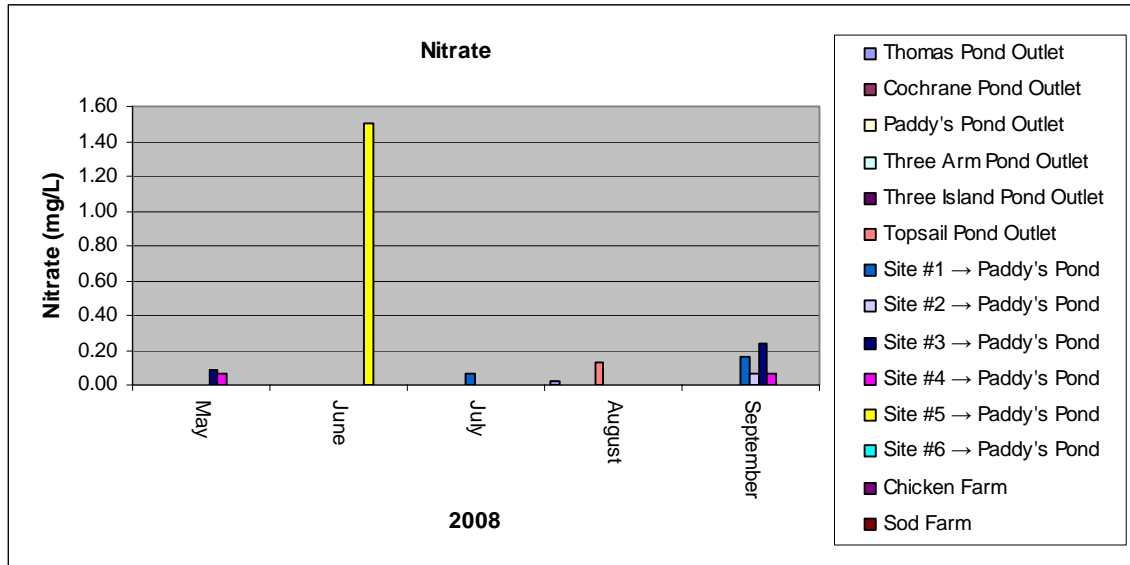


There are no Canadian Recreational Water Quality Guidelines and no Guidelines for the Protection of Aquatic Life for ammonia nitrogen in fresh water. Ammonia nitrogen was detected in 7 of the 32 (22%) water samples collected from the six pond outlets, at concentrations ranging from 0.06 to 0.12mg/L. One notable observation from the data is that the ammonia nitrogen level in Thomas Pond increased from less than the detectable limit in May, June and July to 0.07mg/L in August, and then to almost double that concentration in September, when its concentration was 0.12mg/L. Ammonium nitrogen was detected in 10 of the 30 (33%) water samples collected from the culvert inlets and outlets during this study, at concentrations ranging from 0.06 to 0.10mg/L. Ammonia nitrogen was not detected in the water sample collected near the chicken farm, and was detected at 0.06mg/L in the sample collected near the sod farm.

**3.2.2.2 Nitrate**

Nitrate tends to be the dominant form of nitrogen in waters with normal levels of dissolved oxygen. It can be converted naturally in soils and waters from other forms of nitrogen with the help of bacteria, or it can be released directly to surface waters from industrial, residential, and agricultural sources (Canadian Environmental Quality Guidelines, 2007). **Figure 8**, below, displays the concentrations of nitrate detected in all samples analyzed as part of the Blue-Green Algae Monitoring Plan 2008:

Figure 8: Nitrate Concentrations from all Samples



The Canadian Water Quality Guidelines for the Protection of Aquatic Life recommend, as an interim guideline, a maximum concentration of 13mg/L for nitrate in freshwater (Canadian Council of Ministers of the Environment, 2003). Most samples (52 of 62 samples) in this study had nitrate concentrations below the laboratory detection limit of 0.06 mg/L. The remaining 10 samples had nitrate concentrations that ranged between 0.02 and 1.5 mg/L. Only one water sample, which was collected from Site #5 in June, had a nitrate concentration (1.5mg/L) above the maximum level for Canadian oligotrophic lakes, of 0.4mg/L. Site #5 refers to the outlet of a culvert that drains directly into Paddy’s Pond. The high concentration of nitrate reported in this sample may be an indication of a land-based input; however 1.5mg/L is well below the maximum guideline recommended by the Canadian Water Quality Guidelines for the Protection of Aquatic Life. Nitrate was not detected in samples collected near the sod farm and chicken farm.

**3.2.2.3 Nitrite**

In water, nitrites are generally formed by the action of bacteria on ammonia and organic nitrogen. As they are quickly air-oxidized to nitrates, they are seldom present in surface waters in significant concentrations. The presence of nitrite does not always signify pollution, although, in conjunction with ammonia and nitrate, the presence of nitrite is a pollution indicator.

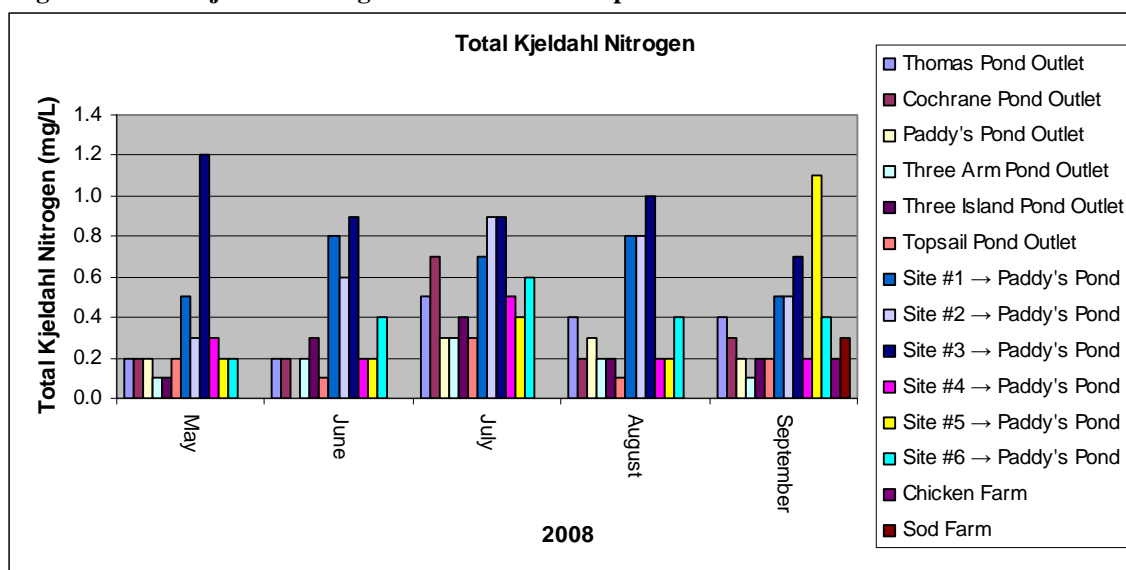
Laboratory analysis indicates that nitrite concentrations for all 62 samples collected during this study were below the laboratory detection limit of 0.06mg/L.

**3.2.2.4 Total Kjeldahl Nitrogen (TKN)**

The USGS defines total kjeldahl nitrogen (TKN) as the sum of organic nitrogen, ammonia and ammonium (Watershed Monitoring and Assessment, The IOWA Department of Natural Resources, Iowa City, IA). Analysis of TKN differs from the analysis of ammonia nitrogen in that TKN includes the concentration of organic nitrogen.

**Figure 9**, below, displays the concentrations of total kjeldahl nitrogen detected in all samples analyzed as part of the Blue-Green Algae Monitoring Plan 2008:

**Figure 9: Total Kjeldahl Nitrogen Data from all Samples**



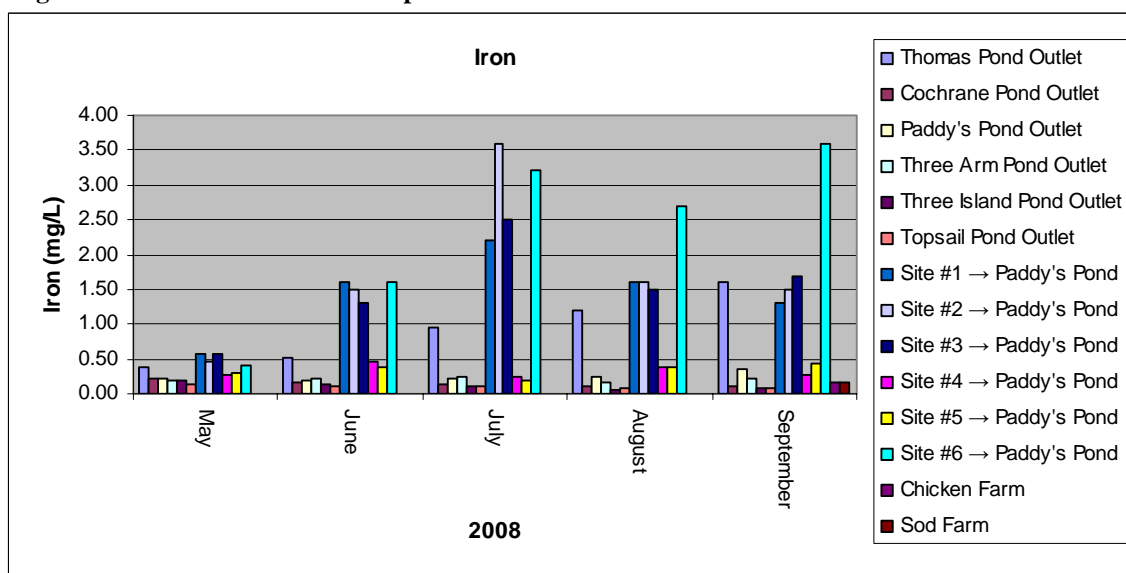
For each sample analyzed, the TKN concentration was higher than ammonia nitrogen concentration, indicating the presence of organic nitrogen at each sampling site. Organic nitrogen is not biologically available to plants, but can be converted to nitrate, nitrite and ammonia which can readily be utilized by plants. The analysis results indicate higher levels of TKN at Sites # 1, 2 and 3 than at any other sampling site for each round of sampling, with the exception of Site #5, which had the highest concentration of TKN in September.

### 3.2.3 Iron

The presence of iron in natural waters can be attributed to the weathering of rocks and minerals, acidic mine water drainage, landfill leachates, sewage effluents and iron-related industries (Government of the Northwest Territories). Iron can occur in two forms: the soluble ferrous iron, or insoluble ferric iron. The concentrations of iron in Canadian surface waters are generally below 10 mg/L (Government of the Northwest Territories).

Water samples collected as part of this study were analyzed for total iron concentration because iron is recognized as a micronutrient required for plant productivity. The US Environmental Protection Agency (EPA) reports that based on research conducted under its STAR Research Program, the growth of blue-green algae maybe stimulated by nutrients and micronutrients, principally nitrogen, phosphorus and iron (US EPA Office of Research and Developmental Science, 1997). In a document entitled *Cyanobacterial Toxins-Microcystin-LR*, Health Canada reports that iron and molybdenum are particularly important micronutrients for blue-green algae growth because of their direct involvement in nitrogen fixation and photosynthesis (iron) as well as carbon fixation and nitrogen uptake (molybdenum) (Health Canada, 2008). **Figure 10**, below, displays iron concentrations in samples collected from all sites:

**Figure 10: Iron Data from all Samples**

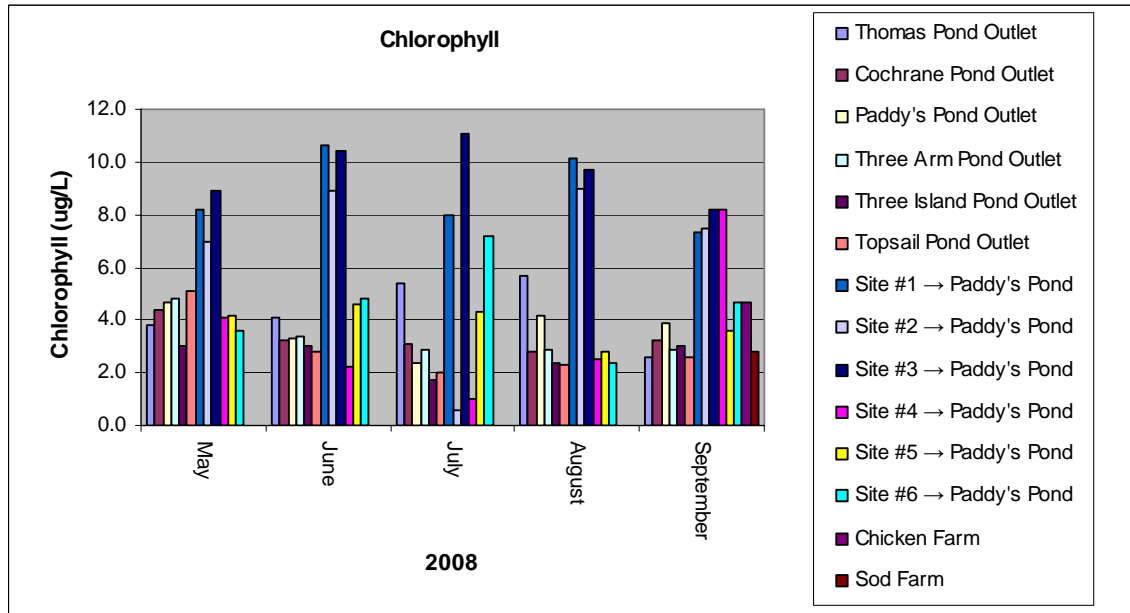


Iron was detected in all samples that were collected as part of this study, in concentrations that ranged from 0.05 to 3.6 mg/L. The results indicate that iron was consistently detected at higher concentrations in water samples from Thomas Pond, Site#1, #2, #3, and #6 for each sampling period. It is reasonable to expect iron concentrations to be higher near the inlets and outlets of iron culverts, such as Site #'s 1, 2, 3, and 6.

### 3.2.4 Chlorophyll

Chlorophyll, in various forms, is bound within the living cells of algae and other phytoplankton found in surface water. The measurement of chlorophyll in surface water is therefore an indication of the level of algae growth. Surface waters that have high chlorophyll conditions are typically high in nutrients, generally phosphorus and nitrogen. These nutrients promote the growth of algae and the potential development of blooms. Chlorophyll analysis results are shown in **Figure 11**:

**Figure 11: Chlorophyll Data from all Samples**



Sites #1, #2 and #3 had higher chlorophyll levels in comparison to all other sites during all monthly sampling periods; Site #4 also had elevated chlorophyll levels in September. **Figures 6 and 9** above indicate that Sites #1 and #3 also had the highest concentrations of phosphorus and total kjeldahl nitrogen of all sampling sites for each monthly sampling period, with the exception of Site #5, which had the highest phosphorus concentration in August and the highest total kjeldahl nitrogen concentration in September.

Water quality data, graphed by sampling site, are found in **Appendix 2** at the end of this report.

#### 4.0 Conclusions

- **Microcystin-LR and blue-green algae cells were detected in this pond system during the 2008 study, at levels much lower than the maximum safe levels recommended by the Canadian Drinking Water Quality Guidelines and the World Health Organization Guidelines for recreational use of water.** The presence of blue-green algae and microcystin-LR indicate a need for further monitoring of this pond system to detect recurring blooms and to monitor toxicity levels.
- **The culvert Sites #1 - #6 had the highest concentrations of nitrogen and phosphorus during each monthly sampling period when compared to samples collected at the outlets of ponds.** These results indicate the need for monitoring water quality along the drainage ditches that follow upstream from these culverts in an effort to identify possible point source inputs of nutrients. Water quality in a drainage ditch located in a relatively pristine environment, outside this pond watershed should also be monitored as a reference condition.



- **Water samples collected from Thomas Pond Outlet in May had more than twice the concentration of microcystin-LR than water samples from any other site.** Ammonia nitrogen levels also increased significantly at this site between May and September. These results indicate the need for a reconnaissance survey of Thomas Pond during the spring of 2009 to identify land-based activities that may potentially input nutrients into Thomas Pond.

The water quality data collected from the Cochrane Pond system in 2007 and 2008 is generating useful information for the Department of Environment and Conservation to understand water quality conditions that may lead to the formation of blue-green algae blooms, and to identify land based activities that may be contributing to these conditions. Continued monitoring of this pond system is recommended to assess emerging trends in nutrient concentrations, blue-green algae bloom developments and toxicity levels in water impacted by the blooms.

## 5.0 Recommendations

The Department of Environment and Conservation collected monthly water quality data from the Cochrane Pond watershed from May to September in 2007 and 2008 to monitor a blue-green algae bloom. Based on scientific research which indicates that blue-green algae blooms are likely to reoccur in water bodies, and have the potential to produce toxins, the following is recommended for blue-green algae monitoring in 2009:

1. Monthly inorganic analysis of water samples collected from the outlets of Thomas Pond, Cochrane Pond, Paddy's Pond, Three Arm Pond, Three Island Pond and Topsail Pond, as well as at the six culverts identified for sampling in 2007 and 2008.
2. The addition of the following five sampling sites for monthly inorganic water analysis: Cochrane Pond Goulds Outlet, Cochrane Pond Chicken Farm, Cochrane Pond Sod Farm, Round Pond Outlet, and a non-impacted drainage ditch outside this pond system (exact location yet to be decided).
3. Collection of water samples from this pond system whenever a blue-green algae bloom is observed for blue-green algae genus identification, cellular enumeration and quantitative total microcystin-LR analysis.
4. Monthly samples collected from all seventeen sites for bacteriological analysis.
5. Reconnaissance survey of drainage ditches that flow to culvert sites #1-#6.
6. Reconnaissance survey of Thomas Pond watershed to identify land-based activities that may potentially input nutrients into Thomas Pond.
7. Monthly recording of water levels at the dams located on each of the pond outlets.
8. Monthly recording of physical water quality parameters at each sampling site, including water temperature, pH, dissolved oxygen, specific conductivity,

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- turbidity, blue-green algae cells and chlorophyll. Physical parameters should be measured using a freshly calibrated multi-parameter probe.
9. Monthly recording of weather observations including precipitation, daily average wind speed and wind direction data 48 and 24 hours prior to sampling, and at the time of sampling. This information can be obtained from the Department of Environment and Conservation's weather station located at Pippy Park.

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## **7.0 Appendices**

### **7.1 Appendix A: Laboratory Analysis Results**

Microcystin –LR Analysis Results

Inorganic Laboratory Analysis Results

Physical Parameters from Multi-Sensor Field Probe



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**Table 1: Microcystin-LR Analysis Results**

Date/Time (dd/mm/yyyy hrs)	Site Identification	TOTAL MICROCYSTIN LR LABORATORY RESULTS (µg LR equiv/L)	TOTAL MICROCYSTIN LR FIELD TEST RESULTS (ppb)
05/21/2008 12:35	Thomas Pond Outlet	0.61	<0.5
05/21/2008 15:30	Cochrane Pond Outlet	0.27	<0.5
05/22/2008 11:00	Paddy's Pond Outlet	0.38	<0.5
05/22/2008 12:00	Three Arm Pond Outlet	0.28	<0.5
05/22/2008 07:30	Three Island Pond Outlet	0.30	<0.5
05/22/2008 06:50	Topsail Pond Outlet	0.30	<0.5
05/22/2008 14:40	Site #1 → Paddy's Pond	not analyzed	not analyzed
05/22/2008 14:45	Site #2 → Paddy's Pond	not analyzed	not analyzed
05/22/2008 14:50	Site #3 → Paddy's Pond	not analyzed	not analyzed
05/22/2008 15:00	Site #4 → Paddy's Pond	not analyzed	not analyzed
05/22/2008 14:35	Site #5 → Paddy's Pond	not analyzed	not analyzed
05/22/2008 15:05	Site #6 → Paddy's Pond	not analyzed	not analyzed
6/25/08 14:10	Thomas Pond Outlet	<0.22	not analyzed
6/25/08 15:00	Cochrane Pond Outlet	<0.22	not analyzed
6/26/08 8:40	Paddy's Pond Outlet	<0.22	not analyzed
6/26/08 9:40	Three Arm Pond Outlet	<0.22	not analyzed
6/26/08 7:10	Three Island Pond Outlet	<0.22	not analyzed
6/26/08 7:50	Topsail Pond Outlet	<0.22	not analyzed
6/26/08 10:05	Site #1 → Paddy's Pond	not analyzed	not analyzed
6/26/08 11:10	Site #2 → Paddy's Pond	not analyzed	not analyzed
6/26/08 11:40	Site #3 → Paddy's Pond	not analyzed	not analyzed
6/26/08 12:10	Site #4 → Paddy's Pond	not analyzed	not analyzed
6/26/08 10:30	Site #5 → Paddy's Pond	not analyzed	not analyzed
6/26/08 12:30	Site #6 → Paddy's Pond	not analyzed	not analyzed
7/15/08 13:20	Thomas Pond Outlet	<0.22	not analyzed
7/15/08 14:10	Cochrane Pond Outlet	<0.22	not analyzed
7/15/08 13:00	Paddy's Pond Outlet	<0.22	not analyzed
7/15/08 13:37	Three Arm Pond Outlet	<0.22	not analyzed
7/15/08 11:30	Three Island Pond Outlet	<0.22	not analyzed
7/15/08 11:50	Topsail Pond Outlet	<0.22	not analyzed
7/15/08 9:00	Site #1 → Paddy's Pond	not analyzed	not analyzed
7/15/08 14:35	Site #2 → Paddy's Pond	not analyzed	not analyzed
7/15/08 14:50	Site #3 → Paddy's Pond	not analyzed	not analyzed
7/15/08 10:15	Site #4 → Paddy's Pond	not analyzed	not analyzed
7/15/08 9:30	Site #5 → Paddy's Pond	not analyzed	not analyzed
7/15/08 10:40	Site #6 → Paddy's Pond	not analyzed	not analyzed
8/20/08 & 8/21/08 11:00	Thomas Pond Outlet	<0.22	not analyzed
8/20/08 & 8/21/08 11:30	Cochrane Pond Outlet	<0.22	not analyzed
8/20/08 & 8/21/08 15:45	Paddy's Pond Outlet	<0.22	not analyzed
8/20/08 & 8/21/08 16:30	Three Arm Pond Outlet	<0.22	not analyzed
8/20/08 & 8/21/08 14:15	Three Island Pond Outlet	<0.22	not analyzed
8/20/08 & 8/21/08 14:40	Topsail Pond Outlet	<0.22	not analyzed
8/20/08 & 8/21/08 13:15	Site #1 → Paddy's Pond	not analyzed	not analyzed
8/20/08 & 8/21/08 11:50	Site #2 → Paddy's Pond	not analyzed	not analyzed
8/20/08 & 8/21/08 12:10	Site #3 → Paddy's Pond	not analyzed	not analyzed
8/20/08 & 8/21/08 12:30	Site #4 → Paddy's Pond	not analyzed	not analyzed
8/20/08 & 8/21/08 12:50	Site #5 → Paddy's Pond	not analyzed	not analyzed
8/20/08 & 8/21/08 13:40	Site #6 → Paddy's Pond	not analyzed	not analyzed
09/16/08 & 09/17/08 10:30	Thomas Pond Outlet	<0.22	<0.5
09/16/08 & 09/17/08 11:00	Cochrane Pond Outlet	<0.22	<0.5
09/16/08 & 09/17/08 09:30	Paddy's Pond Outlet	<0.22	<0.5
09/16/08 & 09/17/08 10:00	Three Arm Pond Outlet	<0.22	<0.5
09/16/08 & 09/17/08 08:00	Three Island Pond Outlet	<0.22	<0.5
09/16/08 & 09/17/08 08:30	Topsail Pond Outlet	<0.22	<0.5
09/16/08 & 09/17/08 14:00	Site #1 → Paddy's Pond	not analyzed	not analyzed
09/16/08 & 09/17/08 14:20	Site #2 → Paddy's Pond	not analyzed	not analyzed
09/16/08 & 09/17/08 14:40	Site #3 → Paddy's Pond	not analyzed	not analyzed
09/16/08 & 09/17/08 15:00	Site #4 → Paddy's Pond	not analyzed	not analyzed
09/16/08 & 09/17/08 13:30	Site #5 → Paddy's Pond	<0.22	not analyzed
09/16/08 & 09/17/08 15:30	Site #6 → Paddy's Pond	not analyzed	not analyzed
9/16/08 12:00	Chicken Farm	<0.22	not analyzed
9/17/08 11:30	Sod Farm	not analyzed	not analyzed



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**Table 2: Inorganic Laboratory Results**

Date/Time (dd/mm/yyyy hrs)	Site Identification	INORGANIC LABORATORY RESULTS						
		Total Phosphorus (mg/L)	Nitrogen (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Iron (mg/L)	Hardness (CaCO <sub>3</sub> ) (mg/L)
05/21/2008 12:35	Thomas Pond Outlet	0.007	<0.05	<0.06	<0.06	0.2	0.38	3.00
05/21/2008 15:30	Cochrane Pond Outlet	0.024	<0.05	<0.06	<0.06	0.2	0.22	4.00
05/22/2008 11:00	Paddy's Pond Outlet	0.027	<0.05	<0.06	<0.06	0.2	0.22	6.00
05/22/2008 12:00	Three Arm Pond Outlet	0.015	<0.05	<0.06	<0.06	0.1	0.19	6.00
05/22/2008 07:30	Three Island Pond Outlet	0.020	<0.05	<0.06	<0.06	0.1	0.20	8.00
05/22/2008 06:50	Topsail Pond Outlet	0.006	<0.05	<0.06	<0.06	0.2	0.13	8.00
05/22/2008 14:40	Site #1 → Paddy's Pond	0.220	0.07	<0.06	<0.06	0.5	0.57	8.00
05/22/2008 14:45	Site #2 → Paddy's Pond	0.023	<0.05	<0.06	<0.06	0.3	0.45	5.00
05/22/2008 14:50	Site #3 → Paddy's Pond	0.220	<0.05	0.09	<0.06	1.2	0.56	8.00
05/22/2008 15:00	Site #4 → Paddy's Pond	0.022	0.09	0.07	<0.06	0.3	0.28	4.00
05/22/2008 14:35	Site #5 → Paddy's Pond	0.100	<0.05	<0.06	<0.06	0.2	0.31	7.00
05/22/2008 15:05	Site #6 → Paddy's Pond	0.029	<0.05	<0.06	<0.06	0.2	0.40	6.00
6/25/08 14:10	Thomas Pond Outlet	0.012	<0.05	<0.06	<0.06	0.2	0.51	4.00
6/25/08 15:00	Cochrane Pond Outlet	0.015	0.10	<0.06	<0.06	0.2	0.16	4.00
6/26/08 8:40	Paddy's Pond Outlet	0.016	0.06	<0.06	<0.06	<0.1	0.20	5.00
6/26/08 9:40	Three Arm Pond Outlet	0.015	<0.05	<0.06	<0.06	0.2	0.23	6.00
6/26/08 7:10	Three Island Pond Outlet	0.015	<0.05	<0.06	<0.06	0.3	0.14	7.00
6/26/08 7:50	Topsail Pond Outlet	0.012	0.07	<0.06	<0.06	0.1	0.12	11.00
6/26/08 10:05	Site #1 → Paddy's Pond	0.400	0.06	<0.06	<0.6*	0.8	1.60	18.00
6/26/08 11:10	Site #2 → Paddy's Pond	0.040	0.06	<0.06	<0.06	0.6	1.50	10.00
6/26/08 11:40	Site #3 → Paddy's Pond	0.440	0.06	<0.06	<0.06	0.9	1.30	13.00
6/26/08 12:10	Site #4 → Paddy's Pond	0.020	0.07	<0.06	<0.06	0.2	0.45	5.00
6/26/08 10:30	Site #5 → Paddy's Pond	0.042	<0.05	1.50	<0.06	0.2	0.38	9.00
6/26/08 12:30	Site #6 → Paddy's Pond	0.081	<0.05	<0.06	<0.3*	0.4	1.60	11.00
7/15/08 13:20	Thomas Pond Outlet	0.023	<0.05	<0.06	<0.06	0.5	0.96	4.00
7/15/08 14:10	Cochrane Pond Outlet	0.008	<0.05	<0.06	<0.06	0.7	0.13	4.00
7/15/08 13:00	Paddy's Pond Outlet	0.014	<0.05	<0.06	<0.06	0.3	0.21	5.00
7/15/08 13:37	Three Arm Pond Outlet	0.019	<0.05	<0.06	<0.06	0.3	0.24	6.00
7/15/08 11:30	Three Island Pond Outlet	0.011	<0.05	<0.06	<0.06	0.4	0.11	7.00
7/15/08 11:50	Topsail Pond Outlet	0.008	<0.05	<0.06	<0.06	0.3	0.11	7.00
7/15/08 9:00	Site #1 → Paddy's Pond	0.480	<0.05	0.06	<0.06	0.7	2.20	24.00
7/15/08 14:35	Site #2 → Paddy's Pond	0.052	<0.05	<0.06	<0.06	0.9	3.60	20.00
7/15/08 14:50	Site #3 → Paddy's Pond	0.670	<0.05	<0.06	<0.06	0.9	2.50	17.00
7/15/08 10:15	Site #4 → Paddy's Pond	0.019	<0.05	<0.06	<0.06	0.5	0.25	5.00
7/15/08 9:30	Site #5 → Paddy's Pond	0.026	<0.05	<0.06	<0.06	0.4	0.20	5.00
7/15/08 10:40	Site #6 → Paddy's Pond	0.110	<0.05	<0.06	<0.06	0.6	3.20	14.00
8/20/08 & 8/21/08 11:00	Thomas Pond Outlet	0.024	0.07	0.02	<0.06	0.4	1.20	5.00
8/20/08 & 8/21/08 11:30	Cochrane Pond Outlet	0.021	<0.05	<0.06	<0.06	0.2	0.10	4.00
8/20/08 & 8/21/08 15:45	Paddy's Pond Outlet	0.017	<0.05	<0.06	<0.06	0.3	0.25	5.00
8/20/08 & 8/21/08 16:30	Three Arm Pond Outlet	0.017	<0.05	<0.06	<0.06	0.2	0.15	6.00
8/20/08 & 8/21/08 14:15	Three Island Pond Outlet	0.012	<0.05	<0.06	<0.06	0.2	0.05	8.00
8/20/08 & 8/21/08 14:40	Topsail Pond Outlet	0.019	<0.05	0.13	<0.06	0.1	0.09	8.00
8/20/08 & 8/21/08 13:15	Site #1 → Paddy's Pond	0.280	<0.05	<0.06	<0.06	0.8	1.60	15.00
8/20/08 & 8/21/08 11:50	Site #2 → Paddy's Pond	0.022	<0.05	<0.06	<0.06	0.8	1.60	10.00
8/20/08 & 8/21/08 12:10	Site #3 → Paddy's Pond	0.310	0.07	<0.06	<0.06	1.0	1.50	12.00
8/20/08 & 8/21/08 12:30	Site #4 → Paddy's Pond	0.020	0.10	<0.06	<0.06	0.2	0.39	5.00
8/20/08 & 8/21/08 12:50	Site #5 → Paddy's Pond	0.330	<0.05	<0.06	<0.06	0.2	0.38	6.00
8/20/08 & 8/21/08 13:40	Site #6 → Paddy's Pond	0.088	<0.05	<0.06	<0.06	0.4	2.70	11.00
09/16/08 & 09/17/08 10:30	Thomas Pond Outlet	0.026	0.12	<0.06	<0.06	0.4	1.60	6.00
09/16/08 & 09/17/08 11:00	Cochrane Pond Outlet	0.019	<0.05	<0.06	<0.06	0.3	0.11	4.00
09/16/08 & 09/17/08 09:30	Paddy's Pond Outlet	0.024	<0.05	<0.06	<0.06	0.2	0.36	5.00
09/16/08 & 09/17/08 10:00	Three Arm Pond Outlet	0.031	<0.05	<0.06	<0.06	0.1	0.21	5.00
09/16/08 & 09/17/08 08:00	Three Island Pond Outlet	0.016	0.09	<0.06	<0.06	0.2	0.08	7.00
09/16/08 & 09/17/08 08:30	Topsail Pond Outlet	0.008	0.08	<0.06	<0.06	0.2	0.07	7.00
09/16/08 & 09/17/08 14:00	Site #1 → Paddy's Pond	0.220	<0.05	0.16	*<0.3	0.5	1.30	16.00
09/16/08 & 09/17/08 14:20	Site #2 → Paddy's Pond	0.038	0.06	0.06	<0.06	0.5	1.50	10.00
09/16/08 & 09/17/08 14:40	Site #3 → Paddy's Pond	0.250	0.08	0.24	<0.06	0.7	1.70	14.00
09/16/08 & 09/17/08 15:00	Site #4 → Paddy's Pond	0.016	<0.05	0.07	<0.06	0.2	0.26	5.00
09/16/08 & 09/17/08 13:30	Site #5 → Paddy's Pond	0.092	<0.05	<0.06	<0.06	1.1	0.44	7.00
09/16/08 & 09/17/08 15:30	Site #6 → Paddy's Pond	0.058	<0.05	<0.06	*<0.3	0.4	3.60	18.00
9/16/08 12:00	Chicken Farm	0.029	<0.05	<0.06	<0.06	0.2	0.17	5.00
9/17/08 11:30	Sod Farm	0.021	0.06	<0.06	<0.06	0.3	0.17	5.00

\*reporting limit for nitrite elevated to 0.3mg/L due to chloride interference



## Blue-Green Algae Report 2008

**Table 3: Physical Parameters from Multi-Sensor Field Probe**

Date/Time (dd/mm/yyyy hrs)	Site Identification	YSI MULTI PROBE FIELD DATA						
		BGA PC (cells/mL)	Water Temp (°C)	pH (pH units)	Sp Conductivity (mS/cm)	Diss Oxygen (mg/L)	Turbidity	Chlorophyll (µg/L)
05/21/2008 12:35	Thomas Pond Outlet	638	9.43	5.95	0.023	10.88	0.5	3.8
05/21/2008 15:30	Cochrane Pond Outlet	537	10.92	6.59	0.024	12.90	0.5	4.4
05/22/2008 11:00	Paddy's Pond Outlet	511	9.98	6.52	0.073	12.70	0.6	4.7
05/22/2008 12:00	Three Arm Pond Outlet	523	10.24	6.79	0.075	12.70	0.7	4.8
05/22/2008 07:30	Three Island Pond Outlet	859	9.00	6.67	0.098	11.10	0.6	3.0
05/22/2008 06:50	Topsail Pond Outlet	530	9.85	6.77	0.102	12.80	0.6	5.1
05/22/2008 14:40	Site #1 → Paddy's Pond	1517	9.47	6.10	0.075	12.80	1.4	8.2
05/22/2008 14:45	Site #2 → Paddy's Pond	1228	10.42	5.54	0.073	12.80	1.6	7.0
05/22/2008 14:50	Site #3 → Paddy's Pond	1499	9.61	5.91	0.046	12.80	1.5	8.9
05/22/2008 15:00	Site #4 → Paddy's Pond	588	10.29	6.32	0.026	12.70	5.9	4.1
05/22/2008 14:35	Site #5 → Paddy's Pond	6192	9.94	6.44	0.116	12.80	0.5	4.2
05/22/2008 15:05	Site #6 → Paddy's Pond	427	9.14	6.21	0.152	12.70	0.2	3.6
6/25/08 14:10	Thomas Pond Outlet	259	19.32	6.08	0.025	9.24	0.4	4.1
6/25/08 15:00	Cochrane Pond Outlet	320	21.37	6.60	0.026	9.45	0.1	3.2
6/26/08 8:40	Paddy's Pond Outlet	868	16.96	6.32	0.446	9.40	0.2	3.3
6/26/08 9:40	Three Arm Pond Outlet	820	18.44	6.51	0.058	9.22	0.6	3.4
6/26/08 7:10	Three Island Pond Outlet	526	17.72	6.61	0.077	9.38	0.2	3.0
6/26/08 7:50	Topsail Pond Outlet	422	17.89	6.57	0.084	9.40	0.1	2.8
6/26/08 10:05	Site #1 → Paddy's Pond	1193	13.38	6.03	0.271	7.33	1.1	10.6
6/26/08 11:10	Site #2 → Paddy's Pond	1219	16.88	6.06	0.150	7.56	0.5	8.9
6/26/08 11:40	Site #3 → Paddy's Pond	1418	16.55	5.88	0.091	9.63	0.9	10.4
6/26/08 12:10	Site #4 → Paddy's Pond	187	18.70	6.28	0.029	8.60	0.4	2.2
6/26/08 10:30	Site #5 → Paddy's Pond	3573	17.68	6.49	0.074	9.56	3.4	4.6
6/26/08 12:30	Site #6 → Paddy's Pond	729	17.34	6.44	0.194	9.30	0.8	4.8
7/15/08 13:20	Thomas Pond Outlet	500	20.38	6.26	0.027	8.76	2.4	5.4
7/15/08 14:10	Cochrane Pond Outlet	541	20.47	6.59	0.027	8.68	0.4	3.1
7/15/08 13:00	Paddy's Pond Outlet	2755	23.90	7.56	0.057	9.18	1.3	2.4
7/15/08 13:37	Three Arm Pond Outlet	1243	23.88	6.79	0.060	9.04	1.8	2.9
7/15/08 11:30	Three Island Pond Outlet	532	21.68	6.79	0.078	8.68	0.2	1.7
7/15/08 11:50	Topsail Pond Outlet	254	22.04	6.99	0.082	8.75	0.2	2.0
7/15/08 9:00	Site #1 → Paddy's Pond	1042	14.98	5.96	0.308	6.27	1.5	8.0
7/15/08 14:35	Site #2 → Paddy's Pond	761	16.88	5.45	0.296	4.35	2.8	0.6
7/15/08 14:50	Site #3 → Paddy's Pond	1533	16.31	5.84	0.131	5.84	5.8	11.1
7/15/08 10:15	Site #4 → Paddy's Pond	206	20.55	6.31	0.029	8.17	0.6	1.0
7/15/08 9:30	Site #5 → Paddy's Pond	3607	21.49	7.55	0.061	9.42	1.3	4.3
7/15/08 10:40	Site #6 → Paddy's Pond	909	18.04	6.57	0.102	8.65	13.8**	7.2
**Upstream section of brook was disturbed prior to sampling-very silty bottom								
8/20/08 & 8/21/08 11:00	Thomas Pond Outlet	666	18.36	6.08	0.300	8.84	1.5	5.7
8/20/08 & 8/21/08 11:30	Cochrane Pond Outlet	392	19.38	6.37	0.028	8.53	0.6	2.8
8/20/08 & 8/21/08 15:45	Paddy's Pond Outlet	1020	19.20	6.62	0.059	9.04	0.9	4.2
8/20/08 & 8/21/08 16:30	Three Arm Pond Outlet	691	19.33	6.56	0.058	8.83	0.7	2.9
8/20/08 & 8/21/08 14:15	Three Island Pond Outlet	824	19.17	6.78	0.081	9.03	0.8	2.4
8/20/08 & 8/21/08 14:40	Topsail Pond Outlet	645	19.38	6.79	0.085	9.15	0.6	2.3
8/20/08 & 8/21/08 13:15	Site #1 → Paddy's Pond	1550	15.07	5.73	0.141	6.57	1.7	10.1
8/20/08 & 8/21/08 11:50	Site #2 → Paddy's Pond	1150	16.12	5.20	0.121	5.83	1.3	9.0
8/20/08 & 8/21/08 12:10	Site #3 → Paddy's Pond	1430	15.36	5.56	0.058	6.14	1.3	9.7
8/20/08 & 8/21/08 12:30	Site #4 → Paddy's Pond	466	18.78	6.27	0.031	8.33	0.9	2.5
8/20/08 & 8/21/08 12:50	Site #5 → Paddy's Pond	1206	19.07	6.43	0.079	9.16	1.7	2.8
8/20/08 & 8/21/08 13:40	Site #6 → Paddy's Pond	824	16.33	6.41	0.130	9.21	2.1	2.4
09/16/08 & 09/17/08 10:30	Thomas Pond Outlet	455	16.39	6.36	0.021	8.99	0.3	2.6
09/16/08 & 09/17/08 11:00	Cochrane Pond Outlet	680	15.86	6.66	0.028	9.10	0.5	3.2
09/16/08 & 09/17/08 09:30	Paddy's Pond Outlet	930	16.54	6.62	0.057	8.92	0.5	3.9
09/16/08 & 09/17/08 10:00	Three Arm Pond Outlet	573	16.46	6.70	0.059	9.04	0.3	2.9
09/16/08 & 09/17/08 08:00	Three Island Pond Outlet	915	16.87	7.30	0.076	9.26	0.4	3.0
09/16/08 & 09/17/08 08:30	Topsail Pond Outlet	763	16.89	6.94	0.079	9.03	0.5	2.6
09/16/08 & 09/17/08 14:00	Site #1 → Paddy's Pond	1168	13.02	6.06	0.229	7.97	2.4	7.3
09/16/08 & 09/17/08 14:20	Site #2 → Paddy's Pond	1184	13.60	5.69	0.172	5.19	1.4	7.5
09/16/08 & 09/17/08 14:40	Site #3 → Paddy's Pond	1485	13.17	5.89	0.096	7.47	2.0	8.2
09/16/08 & 09/17/08 15:00	Site #4 → Paddy's Pond	486	16.06	6.55	0.030	9.26	0.5	8.2
09/16/08 & 09/17/08 13:30	Site #5 → Paddy's Pond	1065	17.01	6.73	0.063	9.45	0.2	3.6
09/16/08 & 09/17/08 15:30	Site #6 → Paddy's Pond	1422	14.27	6.66	0.207	9.80	3.2	4.7
9/16/08 12:00	Chicken Farm	953	17.23	6.44	0.03	9.05	0.8	4.70
9/17/08 11:30	Sod Farm	875	15.79	6.74	0.03	9.60	0.6	2.80

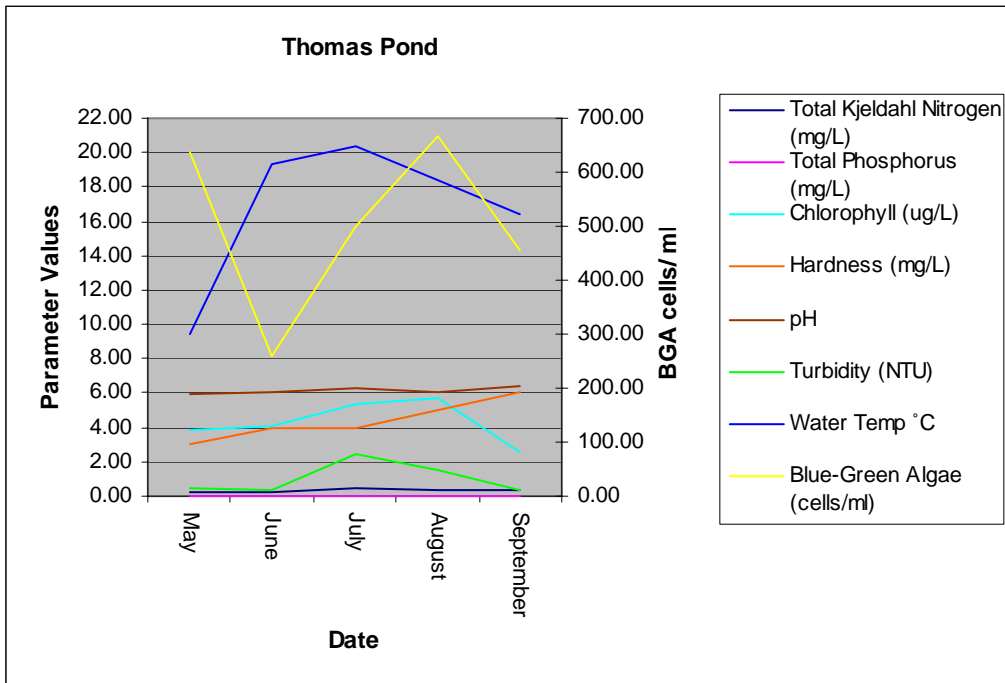
**7.2 Appendix B: Water Quality Graphs by Sampling Site**

- Graph 1: Thomas Pond Outlet
- Graph 2: Cochrane Pond Outlet
- Graph 3: Paddy's Pond Outlet
- Graph 4: Three Arm Pond Outlet
- Graph 5: Three Island Pond Outlet
- Graph 6: Topsail Outlet
- Graph 7: Site #1 (Culvert Outlet)
- Graph 8: Site #2 (Culvert Inlet)
- Graph 9: Site #3 (Culvert Inlet)
- Graph 10: Site #4 (Culvert Inlet)
- Graph 11: Site #5 (Culvert Outlet)
- Graph 12: Site #6 (Culvert Inlet)

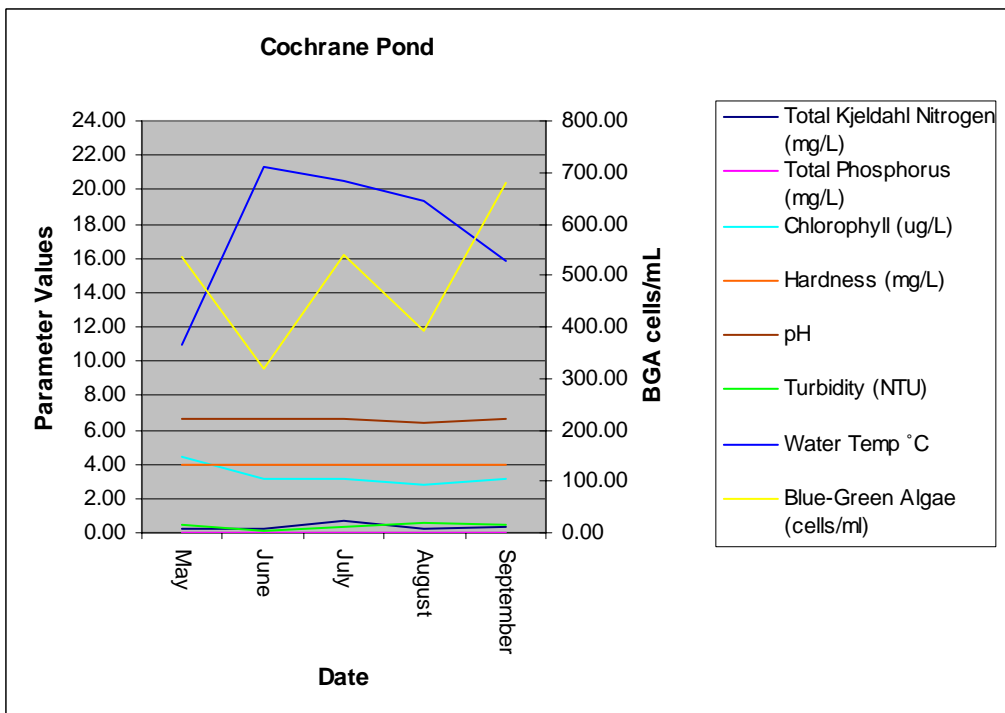


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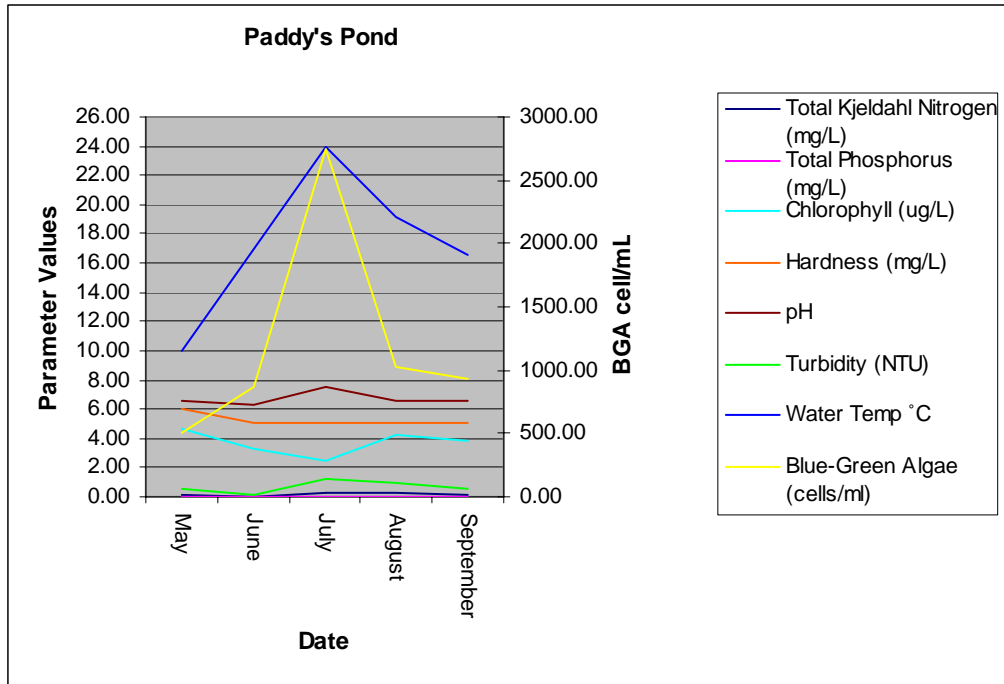
## Graph 1: Thomas Pond Outlet



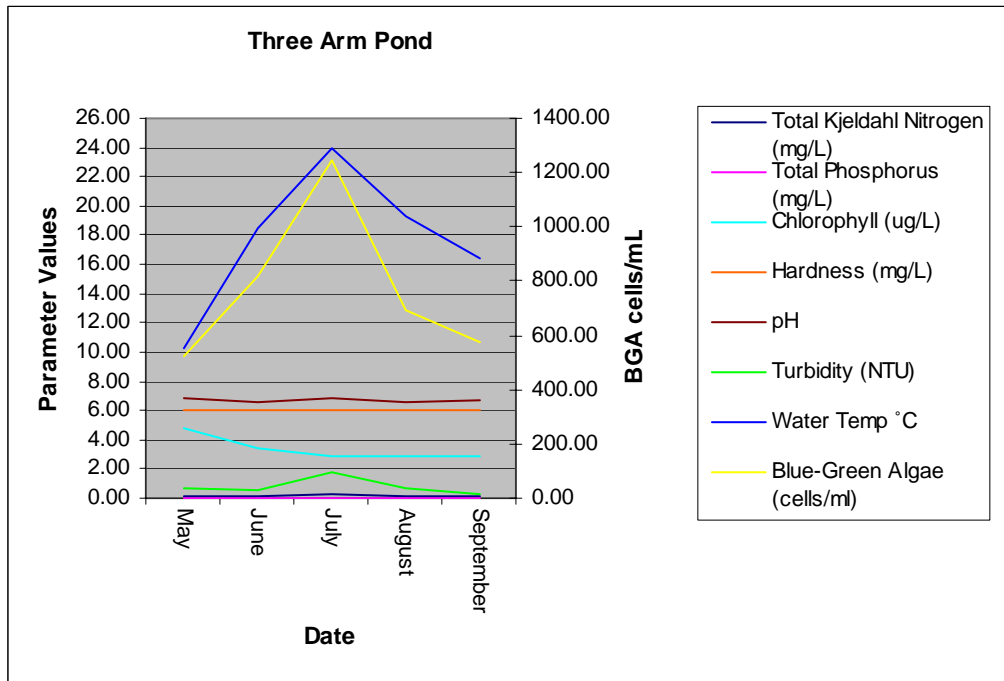
## Graph 2: Cochrane Pond Outlet



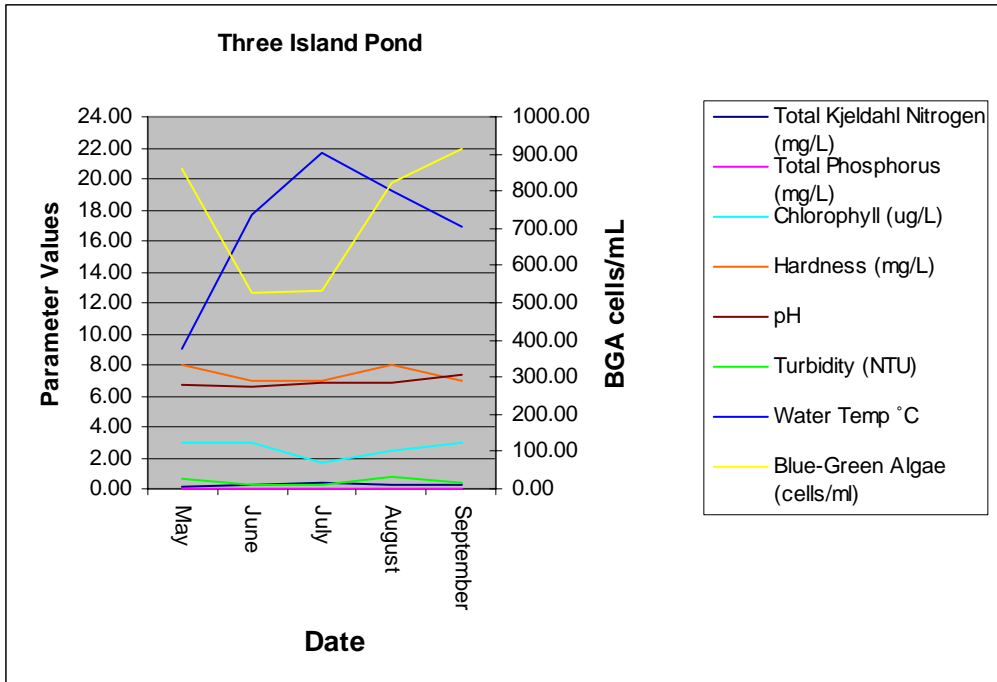
**Graph 3: Paddy's Pond Outlet**



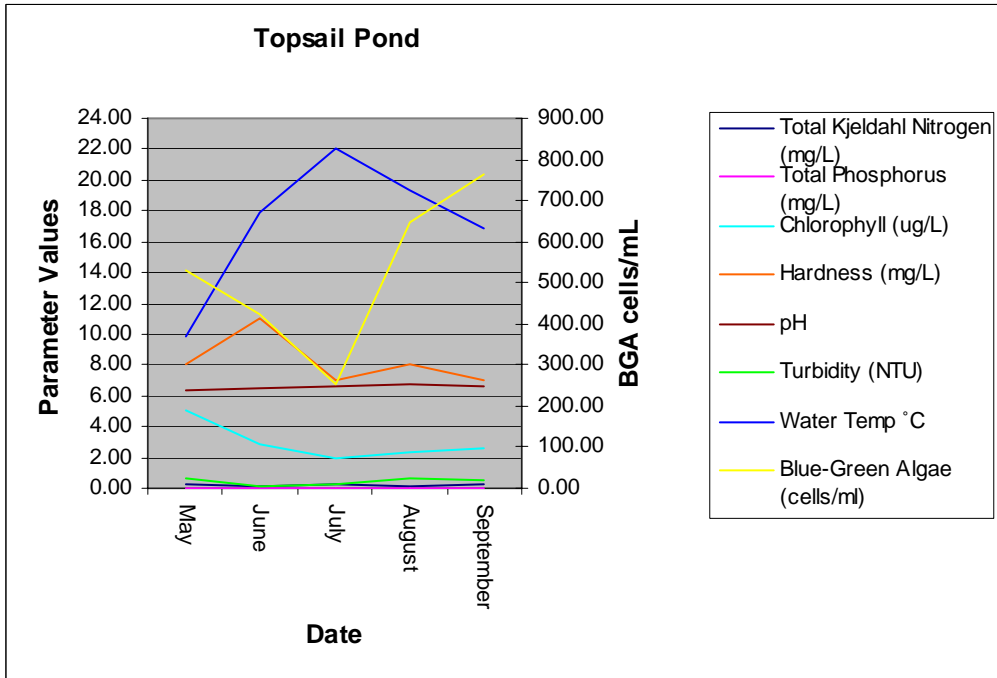
**Graph 4: Three Arm Pond Outlet**



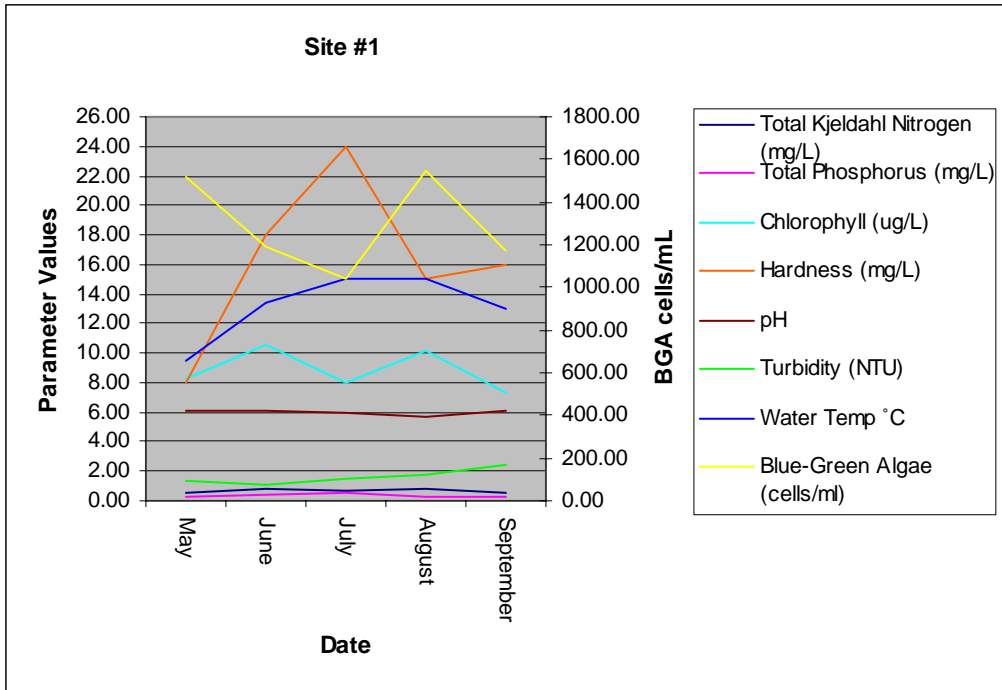
Graph 5: Three Island Pond Outlet



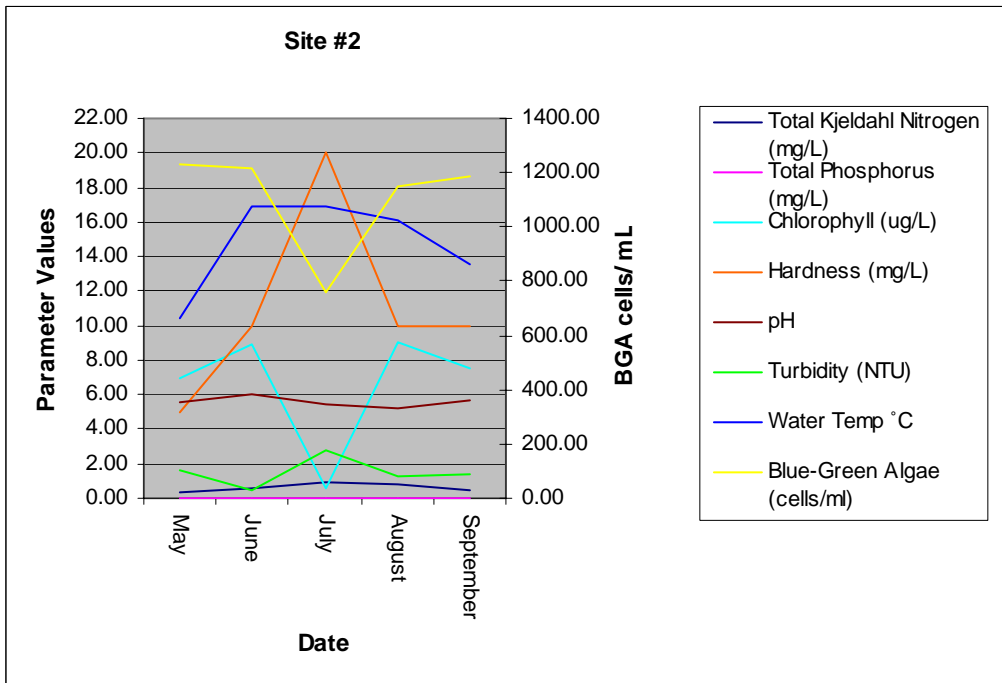
Graph 6: Topsail Pond Outlet



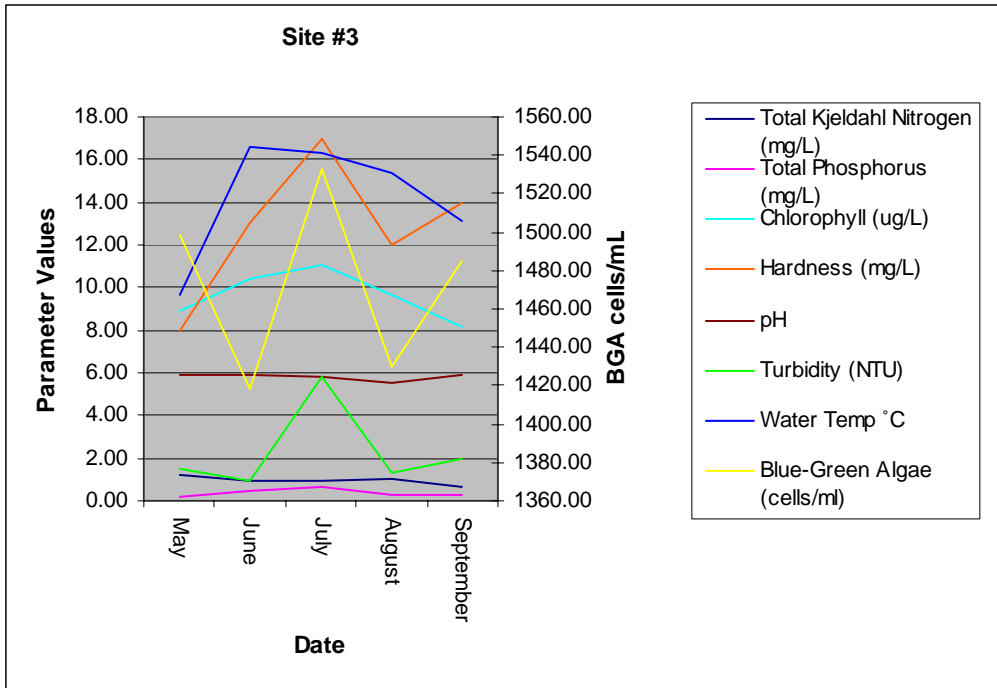
**Graph 7: Site #1 (Culvert Outlet)**



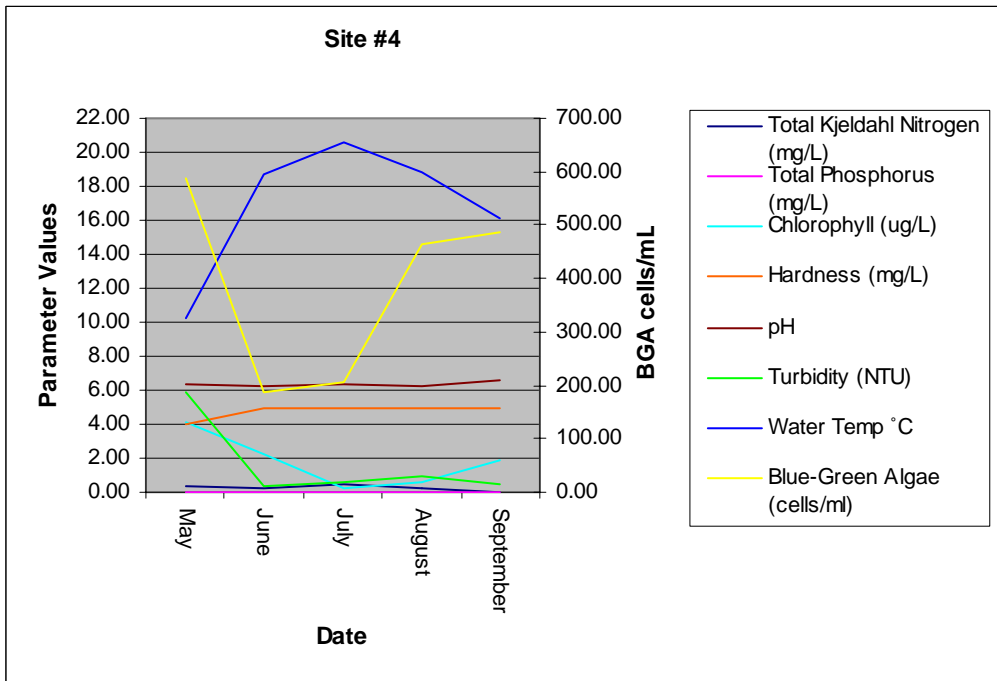
**Graph 8: Site #2 (Culvert Inlet)**



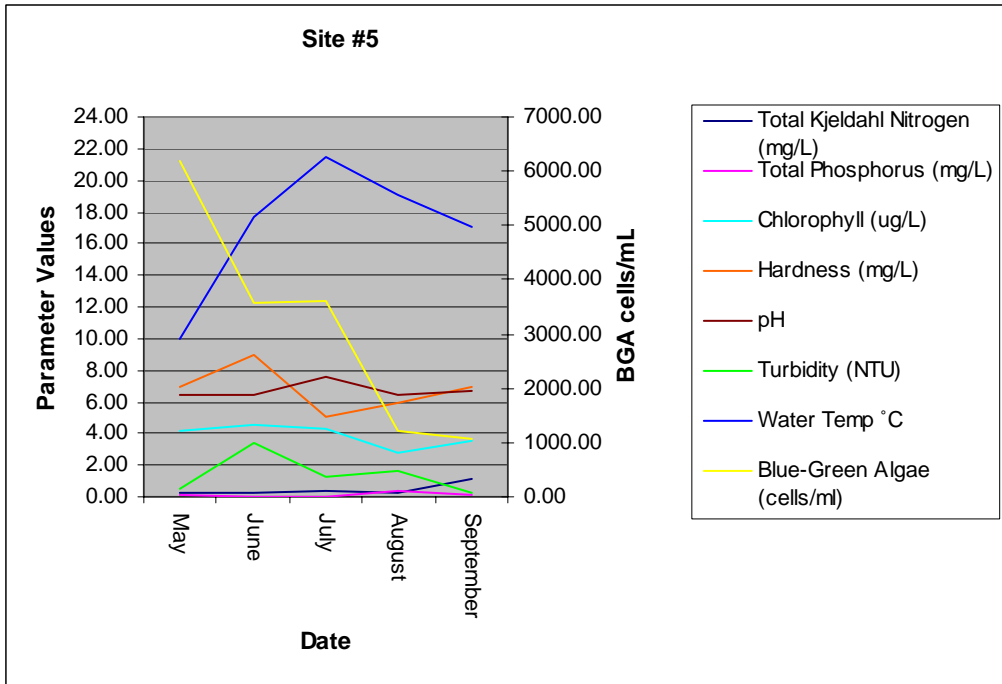
**Graph 9: Site #3 (Culvert Inlet)**



**Graph 10: Site #4 (Culvert Inlet)**



**Graph 11: Site #5 (Culvert Outlet)**



**Graph 12: Site #6 (Culvert Inlet)**

