December 15, 2011

[redacted]
[redacted] Grey Road 12
Meaford, Ontario
[redacted]

Dear [redacted];

Re: Pond Consultation – for [redacted] Grey Road 12, Meaford,Ontario

Thank you for the opportunity to conduct an assessment of your recreational pond at the above noted property. The following report is intended to summarize our understanding of the current conditions of the pond and outline recommendations and possible solutions for some of the issues documented.

Company profile: C&M Aquatic Management Group Ltd

C&M Aquatic Management Group Ltd (C&M) is a Canadian owned firm, specializing in the sustainable management of aquatic systems. C&M provides a wide range of technologies and services to clients in the public, private and government sectors. Specific areas of expertise include:

- Nutrient management in aquatic systems;
- Fisheries management;
- aquatic inventories; and,
- Environmental permit facilitation

For additional information on C&M please visit our website at **www.cmaquatics.com**

Technician Background:

C&M was pleased to have one of its aquatic specialists (and company owners) **Josh Clark** complete a site visit to your location. Mr. Clark is an Aquatic Ecologist whose primary area of interest is in the management of aquatic ecosystems. He has participated in many aquatic habitat and fish community assessments and has also facilitated the obtaining of permits and approvals from various review agencies for numerous projects. Mr. Clark has managed numerous multidisciplinary Environmental Impact Studies and as a result is very familiar with environmental features and issues in various locations in Ontario.
Mr. Clark was previously employed by Aquafor Beach Limited, Gartner Lee Limited (now AECOM) as well as the Ontario Ministry of Natural Resources and continues to foster a positive working relationship

with his former employers. Mr. Clark is familiar with current environmental legislation including the Planning Act, Provincial Policy Statement, Conservation Authorities Act and Fisheries Act.
In addition to his professional experience, Mr. Clark has his Honours Bachelor of Science in Biology as well as his Masters of Science, in Aquatic Ecology, from the University of Guelph.

Existing Conditions& Observations:

A site inspection was conducted on October 5th, 2011 by Mr. Josh Clark of C&M Aquatics in order to assess the existing condition of the pond on your property and get a sense of your goals and objectives for the site. During the visit and a subsequent phone interview with you, numerous parameters were observed and/or recorded. These items include the following:

- Water level fluctuations
- Changes in aquatic plant growth
- Water quality
- Algae blooms
- Fish communities
- General history of the pond
- Structural aspects such as slopes
- Inflow and outflow areas
- Surrounding catchment areas
- Riparian Plant communities

Pond History:
Based on your understanding of the property, the pond under review was constructed sometime in the late 1960's or 1970s making it 40-50 years old. The pond was most likely originally built for agricultural purposes such as watering livestock. The surrounding land use is agricultural and has likely been so for quite some time. You also indicated that the edges of the pond where cleaned out approximately ten years ago.

Physical, Chemical & Biological Characteristics:
The pond is approximately 33,000 square feet (0.75 acres) in terms of surface area (See Figure 1). Based on its physical location (cut into the side of a hill) and your observations that the water level fluctuates very little throughout the year, the most likely water source for the pond is ground water seepage/upwelling. We also observed a 6-inch "Big O" tile drain situated uphill and northeast of the pond which was actively feeding water to the pond. It was unclear as to the exact source of the tile drain or the extent of the area which it drains. The amount of water entering the pond from the tile drain was clearly less than the amount leaving through the overflow pipe, again suggesting the infiltration of

groundwater into the pond. The area of the watershed which drains into the pond is very small (approximately 1.1-1.5 hectares) due to the nature of the surrounding terrain.

Water exits the pond through avertical corrugated steel culvert at the east end of the pond (Figure 2).This pipe discharges to another pipe which ultimately discharges the flow into a nearby watercourse. There also appears to be an emergency spillway situated on the west bank of the pond in the general vicinity of the dock. Based on visual observation, this area appears to be lower in elevation than the rest of the retaining berm such that in a severe flood event - flow would be directed over the berm in a small contained area as opposed to sheet flow over the entire berm. There was very little if any evidence of any erosion problems associated with the pond or the surrounding area.

Figure 1-Site Overview

Figure 2 – Overflow Pipe

Pond depths ranged up to a maximum of 5 metres (16.4 feet), with the average depth of the pond being approximately 3.76 metres (12.3 feet). A more shallow (1m) shelf of 10-15 feet width was observed around the majority of the perimeter of the pond with depths dropping off rapidly thereafter. Sediment sampling indicated that the predominant makeup of the pond bottom is clay which is overlain by a loosely consolidated black organic layer.

Water clarity was fairly turbid (unclear) with a measured Secchi depth of 1 metre. (A Secchi disk is a sampling device used to measure how deep a person can see into the water.) A shallow Secchi depth can be an indication of high amounts of phytoplankton (suspended algae) activity. Riparian (or shoreline) vegetation is well established around the entire perimeter of the pond and a species inventory was recorded and has been included as an attachment to this report (See Attachment 1). We also observed quite a few floating mats of filamentous algae around the periphery of the pond (see edges of the stand pipe in Figure 2). Once again this is a potential indicator of nutrient issues.

A temperature and dissolved oxygen profile was conducted over the deepest portion of the pond to look for evidence of nutrient loading problems (See Figure 3). Temperature was fairly consistent over the entire depth of the pond which is to be expected during the fall turnover period. Dissolved oxygen was consistent at near saturation levels until the last 0.5 metres of the water column. The low dissolved oxygen levels in this bottom portion of the pond are problematic in that they create ideal chemical conditions for leaching of phosphorous from the sediments (a phenomena known as internal nutrient loading). Phosphorous is the key nutrient in aquatic environments that limits the amount of growth of primary producers such as algae and aquatic plants. This topic is discussed further in the recommendations section. The result is that not only does the pond have to contend with the ongoing annual nutrient loading from sources like runoff and atmospheric deposition; it also has to accommodate a historical loading quotient. In a pond which is 40-50 years old there could be quite a large accumulation of phosphorous in the sediments(depending on historical land use practices).

This reduction of dissolved oxygen in the lower depths of the pond would be predicted to be even more pronounced in the height of summer or the depths of winter when atmospheric mixing is reduced or eliminated by either thermal stratification or ice cover respectively. The end result is that there is more nutrient available to fuel algae blooms.

The pond is used primarily for recreational purposes such as swimming and boating as well as general aesthetics and wildlife observation.

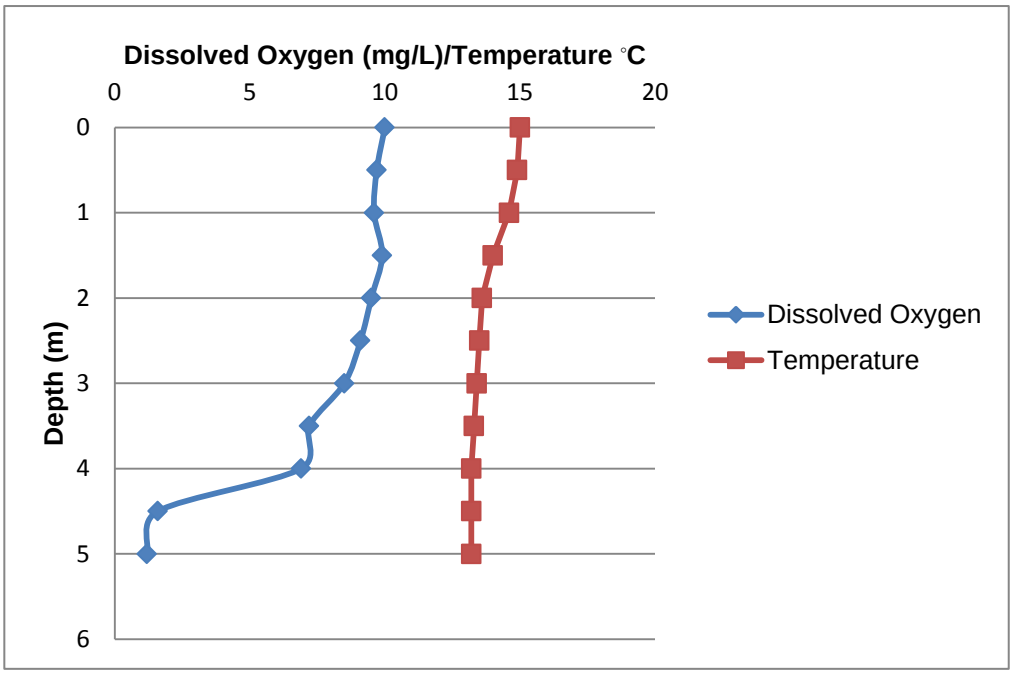

Figure 3 – Temperature & Dissolved Oxygen Profile, [redacted], October 5, 2011

Large numbers of minnows were observed around the shallow fringes of the pond. Although a definitive identification could not be obtained, it appears as though they are Fathead Minnows (*Pimephales promelas).*Fathead minnows are common residents in many ponds and small streams. They also represent an important forage species for many larger predatory fish and form the base of many fish communities.

A large flock of approximately 40 Canada Geese (*Branta canadensis*) was flushed from the pond at the time of the pond inspection. It is worth noting that several studies have suggested that waterfowl such as geese can be significant sources of nutrient loading in small confined systems with limited dilution capacity such as ponds. The issue with geese is that they forage on nearby cash crop fields and then defecate nutrients into the pond. A rough calculation based on numbers provided by a study of

migratory geese in Michigan suggests that a population of 40 birds could contribute as much as1.2Kg of phosphorous and 3.8Kg of nitrogen to the pond over a 60 day period. Over time, this type of nutrient loading will contribute to the deterioration of water quality (or eutrophication) of your pond.

Pond Owner Goals& Objectives

Based on our discussion, there are a number of different objectives for the pond that have been identified. A summary of these objectives include:

- maintaining/improving water quality
- controlling algae growth
- aesthetic enjoyment of the pond on a long term basis

Recommendations

Nutrient management:

All ponds, regardless of their location undergo a natural aging process (eutrophication). This process is characterized by the gradual accumulation of organic sediments in the pond and an associated loss of depth as well as the dominance by a smaller and smaller number of species of aquatic vegetation. Unfortunately, this process can be rapidly accelerated in situations where the nutrient content of the water entering the pond is elevated due to human activities such as fertilizer use, septic bed leaching or agricultural runoff. These elevated levels of nutrients tend to stimulate primary production by suspended algae (phytoplankton), filamentous algae and submerged aquatic vegetation which leads to impairment of water quality and a reduced appeal for recreational use. All ponds have the potential to receive nutrient-laden runoff and it is important to be aware of some proactive management approaches to ensure accelerated situations do not occur and impact your pond. The fact that your pond has maintained excellent water quality for such a long period of time is largely a reflection that groundwater (which is generally relatively poor in nutrients) is the main water source for the pond. However, you indicated that recently you have noticed a decline in the clarity of the water and an increase in the appearance of filamentous algae.

These problems are most likely related to nutrient levels in the pond. Two potentially important sources of nutrients such as phosphorous and nitrogen for your pond are surface water runoff and the presence of large numbers of Canada Geese in the fall months. Surface water runoff should be reduced and/or eliminated from your pond because it has demonstrated a long term capacity to maintain its level based primarily on groundwater inputs. We would recommend you consider diverting as much surface water flow as possible around the pond to reduce nutrient loading on an ongoing basis.

The second recommendation to mitigate ongoing nutrient loading is to prevent seasonal accumulations of Canada Geese from using the pond as a roosting site. This is accomplished by harassing the geese repeatedly until they relocate to a different pond or lake. This would need to be repeated periodically

from September until first ice in early to mid November because new groups of geese will migrate through the area continuously during this time. The most effective course of action might be to permit or encourage neighbours to hunt geese periodically on the pond as an ongoing deterrent.

Algae Issues:

There are two groups or types of algae currently causing problems in your pond. The first are termedphytoplankton and are microscopic,mostly single-celled free floating algae which are the reason your water is no longer clear. The second are called metaphytonand are filamentous algae that typically start growing on the bottom before detaching and floating up to the surface (see figure 2 around the left side of the standpipe). Both metaphyton and phytoplankton are photosynthetic and depend on both sunlight and nutrients such as phosphorous and nitrogen for growth.

Limiting the amount of nutrient loading to your pond is a vital first step in achieving your goal of improvement of water quality. However, the algae problems your pond currently has would be likely to persist even with a drastic reduction in nutrient loading because very little phosphorous (the key nutrient controlling primary productivity) ever leaves the system. Therefore, in order to reduce the abundance of algae we need some additional strategies to tie up and/or remove phosphorous from the pond. Two strategies for phosphorous reduction that you should consider are:

1. Floating Treatment Wetlands plus Aeration
2. Phoslock

More information is provided for both solutions below. A third but likely less effective management measure which could be implemented next season would be to rake out and remove floating filamentous algae clumps (metaphyton) as they accumulate. It should be noted you need to take great care to ensurethe material is disposed of on the downstream side of the retaining berm to ensure the nutrients contained in the rotting algae don't simply wash back into the pond with the next rain. This method would be very gradual and labour intensive but would over a period of years, help to reduce to amount of phosphorous in the pond.

Floating Treatment Wetlands (also called floating islands)

Floating islands are a recently developed technology which consists of a floating mat, onto which native wetland plants (sedges rushes etc.) are established. The mat is porous enough to allow the roots of the plants to penetrate into the water column below which enables the plants to sequester nutrients such as phosphorous and/or nitrogen which would otherwise be available for non-desirable species such as algae.

Floating islands block out sunlight from penetrating into the pond and therefore reduce the heating of the water and the growth rates of algae which rely on the sun for photosynthesis.

The extensive root mass which develops below the mat provides an excellent refuge for small fish as it simultaneously offers both cover and food in the form of invertebrates such as insect larvae. This root mass also assists in tying up and removing tiny suspended particles in the water column, enhancing the water clarity of the pond.

The addition of a water circulation is vital to enhancing the nutrient removal capacity of the floating islands as scientific research has demonstrated circulating water past the islands increases the efficiency of nutrient uptake by the plants. In addition, aeration of the pond will reduce or eliminate the anoxic (low-no dissolved oxygen) areas limiting the remobilization of phosphorous currently stored in the sediments (internal nutrient loading). Aeration systems can be electric, solar or wind powered and come in a variety of different options. C&M has extensive experience designing and installing aeration systems for recreational ponds such as yours.

Islands can be built in any shape or size and anchored in any location within the pond. Additional information on this technology is provided in Attachment 2.

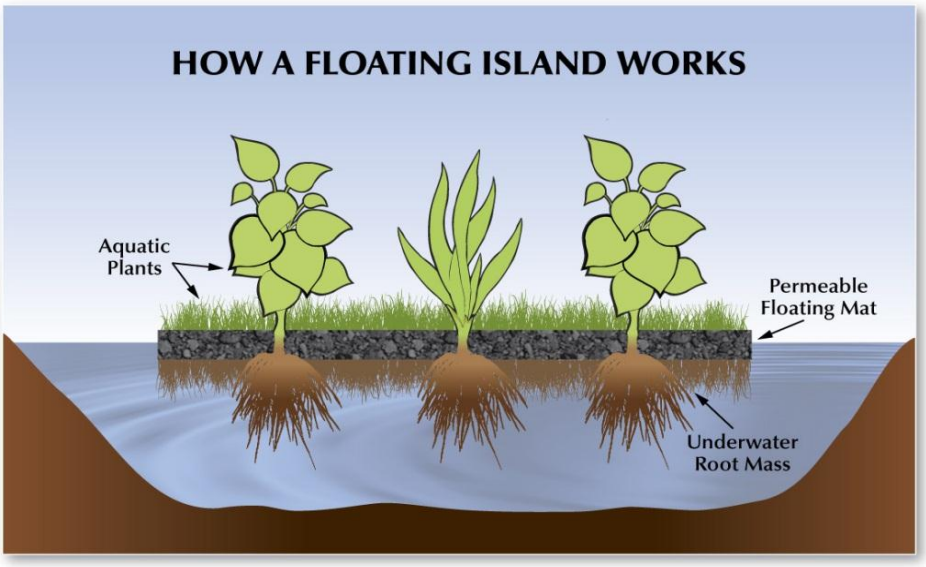

Figure 4- Floating Island Schematic

Figure 5-A module of PhytoLinks™ Floating Treatment Wetland System

C&M has conducted extensive research on floating islands technology and have developed our own proprietary version called PhytoLinks™ (See Figure 5). We are also currently researching the notion of harvesting plants from our islands as a means of physically removing nutrients like phosphorous and nitrogen from aquatic environments.

Ponds with nutrient issues such as algae blooms etc. require coverage of up to 5% of the surface area of the pond. The shape and location of the islands would ultimately be determined through collaboration between you and C&M.

Phoslock®

Phoslock® is a non-toxic modified bentonite clay product which is applied to permanently chemically bind and remove phosphorous from aquatic environments. It is typically applied from a boat as slurry, which gradually settles through the water column before settling on the surface of the bottom sediments. The layer it forms on the sediment surface acts as a cap against the re-release of phosphorous ensuring that phosphorous concentrations remain low until the binding capacity of the product is reached. We have included some additional reading material on this product for your review (See Attachment 3). C&M has not yet applied Phoslock® as it has only recently become available to North American markets (the product was developed in Australia). The advantage of this product is that its effects are immediate.The disadvantages are that it is relatively expensive and will need to be reapplied if phosphorous loading issues are not mitigated.

Long Term Water Quality Monitoring

It is important to note that the measurements we have used are merely a 'snapshot' view of the conditions in your pond. It is strongly recommended that you consider implementing your own long term water quality monitoring program to better understand the status of your pond. We would be happy to provide assistance and advice with regards to required equipment as well as which parameters to measure.

Summary Recommendations

As discussed above, the following items and concerns should be addressed.

- **Divert surface water inputs around the pond**
- **Eliminate fall roosting on the pond by Canada Geese**
- **Install aeration system to reduce the occurrence of internal nutrient loading**
- **Implement a phosphorous removal strategy using either Floating Treatment Wetlands or Phoslock®**

You will find an invoice attached for the pond consultation. We would be happy to discuss more about the next steps in forming and implementing a management plan for your pond – so please call us at your convenience.

It was a pleasure to talk with you and visit your pond. We are confident you will find our report and recommendations to be valuable in improving your pond. We thank you for your business and look forward to speaking with you soon.

Kind regards;
Per:

Josh Clark, M.Sc.
C&M Aquatic Management Group Ltd.