The Heney Lake Rehabilitation 2007
Rebalancing Lake Chemistry to Reduce and Control Phosphorous Contamination

Introduction

The rehabilitation of Lake Heney, a lake with a surface area of 12 km^2, is without a doubt the most ambitious undertaking of its kind anywhere in the world. This ambitious project was undertaken for the Lake Heney Foundation, an organism that was founded to coordinate the rehabilitation project, and was accomplished through the application of more than 1,600 tonnes of ferric chloride to the lake. The project was spearheaded by WESA Envir-Eau, a member of WESA Group Inc., in association with the Lake Heney owners association and the scientific committee.

Lake Characteristics

Located 100 km north of Gatineau in the province of Quebec, Lake Heney was the site of a large scale fish farming operation during the 1990s. The discharge of the aquaculture's effluent into the lake, combined with other contributing factors, resulted in a steady increase of the lake's phosphorous concentrations. Since the fish farming business closure in 1999, phosphorous levels in the lake have averaged 25 μg/L without any sign of improvement.

Faced with deteriorating water quality conditions, the Lake Heney Foundation sought out a university panel to launch an intensive water quality study aimed at finding a viable water treatment solution. Extensive water quality monitoring events were carried out over a period of several years and established that the lake sediments were deficient in iron, an essential element in binding phosphorous to the lake bed. The lengthy lake retention time, determined to be seven years, was also a contributing factor in phosphorous accumulation. It was also established that the highest phosphorous concentrations appeared during the fall lake turnover event that occurs naturally when the lake's thermal stratification is broken.

Treatment Methodology

Experts determined that the best treatment option was the application of ferric chloride during the fall turnover event. Ferric chloride was selected for its capacity to precipitate phosphorous and to bind it to the lake sediments. Specifically, the ferric chloride injected into the lake reacts with the water to produce iron oxyhydroxide, a solid which binds the phosphorous during the precipitation process. $FeCl_3$ is commonly used in wastewater treatment systems to remove phosphorous from the treated effluent.

In order to determine the effectiveness of this treatment option and its safety when released into an aquatic environment, a pilot project was carried out in a small bay in the lake during the month of November 2004. The bay was isolated using an impermeable membrane and five tonnes of ferric chloride were distributed in the bay in order to obtain a lake concentration of 1.3 mg/L of Fe. The pilot allowed for the determination of product effectiveness in reducing the phosphorous concentration and its innocuousness on lacustrine organisms.

The pilot project demonstrated that the large scale application of $FeCl_3$ being proposed was a viable option. The environmental consulting firm, WESA Envir-Eau, was commissioned to design and implement the treatment throughout the entire body of the lake. The firm was commissioned with overseeing all administrative, engineering and logistical aspects of the project.

Logistical Constraints

WESA Envir-Eau faced major obstacles during the design and execution of this project. One of which was the daily application of 100 tonnes of a highly corrosive liquid into a 12 km^2 lake in a 25 day window without jeopardizing the aquatic life of the lake. Ferric chloride is corrosive to most metals and its use on a project of this scale presented many challenges. An injection system had to be designed that prevented contact of the chemical with any metal components. The chemical required heavy dilution prior to its introduction into the aquatic environment in order to prevent any adverse impacts. The product's corrosivity required a highly controlled and monitored work environment with extensive protective measures for worker health and safety and for the general environment.

The application had to be carried out during the fall lake turnover, a time period characterised by high winds, snow, fog and ice, presenting less than favourable navigation conditions. In addition, the short daylight hours during this period forced navigation beyond sunset.

A system of "just in time delivery" was coordinated with the chemical supplier to reduce the need for on site storage of large quantities of hazardous chemicals. A constant supply of $FeCl_3$ was then crucial to the success of the project and this had to be transported by tanker truck over rural roads not designed to handle the large scale heavy traffic.

Marine Equipment

Based on the logistical constraints, WESA Envir-Eau opted for the use of a single large barge towed by a tug-boat (see Figure 1). The barge, which was constructed of six (6) individual compartments assembled together on site, provided a working area of 560 m^2. One of the compartments had an integrated fuel storage component which provided the capability for fuelling the tug-boat, power generating equipment and the mechanical pump. The barge operations were self contained and the barge itself was fitted with a heated office serving as shelter for the employees and electronic equipment. The navigation relied on a DGPS system and a depth sounder both feeding a computer in the office. The navigational data was relayed to a computer in the tug-boat by means of a Local Area Network (LAN).

Chemical Delivery System

The delivery mechanism is detailed in Figures 2 and 3. The product was stored in three tanks that held the daily application volume of liquid ferric chloride eliminating the need to return to the base for refilling and thereby optimising the schedule. Lake water was used to dilute the $FeCl_3$ prior to injection and was collected from the front of the barge using a high power diesel pump. The concentrated ferric chloride was injected into the pump's discharge line through a venturi device. Once introduced into the system, the mixture was not in contact with metal components. The dilution rate was 150 litres of ferric chloride to 4,000 litres of water. The diluted chemical stream was then routed to a submerged diffusion boom mounted at the stern of the barge. Flow meters were incorporated into the system at strategic points throughout the assembly to provide operators with the means to control the concentration of the chemical solution through a system of flow valves. The diffuser boom was designed in conjunction with McGill University engineers. The system was designed to allow for a predetermined dilution of the chemical. The storage tanks were fitted with sensors to monitor the level of liquid to sequence the delivery of the chemical solution while maintaining a balanced load distribution on the barge. All components of the system were equipped with electronic memories and the data was downloaded daily to the main computer.

Project Operation

In order to ensure a steady supply of ferric chloride, several tanker cars of ferric chloride were warehoused at the Ottawa rail yard, more than 125 km from the lake. It was decided that the balance of the stock would be delivered directly from the supplier in Varennes, Quebec.

The spreading operation could not be initiated until the fall lake turnover event. The thermal stratification break was reached on November 14, 2007 in the north section of the lake and November 19, 2007 in the southern half. In total, approximately 1,600 metric tonnes of ferric chloride were distributed throughout the lake over a period of 18 days, from November 20th to December 6th, 2007 inclusively. The supplier delivered a total of 46 tanker loads by mean of three tankers a day carrying a combined weight of 100 tonnes of ferric chloride. The lake distribution route, shown on Figure 4, was selected to allow for maximum dispersal of the product through the natural currents of the lake. The delivery system was designed to distribute three times more chloride in the south basin in order to compensate for the differing volume ratios between the north and south portions of the lake. The dispersion results met the objective of 1.3 mg/L of Fe in the lake as specified by the Foundation's scientific consultant. Members of the scientific team were tasked with the monitoring of pH and other parameters throughout the distribution process to prevent any adverse effects on water quality.

Conclusions

It was necessary to overcome critical logistical, environmental and technical challenges throughout the operation. The schedule was short, the weather and visibility poor for the most part and the magnitude of the operation large in the context of a small lake in Western Quebec. Due to the short project schedule, many tasks occurred concurrently such as equipment final design and testing, environmental approvals and ultimately execution. This project was both unique and innovative since the technology and methodology had never before been applied on such a large scale. Everything had to be designed and implemented in a time frame that allowed little room for error. Continuous adjustments were applied throughout the duration of the project.

Close collaboration between WESA Envir-Eau and all parties involved was crucial to the success of this project. Despite the inclement climactic conditions, the project met all predetermined objectives. Data available on the Foundation's website indicate that after the first year of post monitoring, the phosphorous concentrations have decreased to 10 µg/L. The success of this undertaking and the positive impact on lake water quality demonstrates the feasibility of this type of project elsewhere. Large bodies of water may be effectively rehabilitated in limited time frames.