RENR 8102 Restoration of Freshwater Aquatic Ecosystems
Aquatic Ecosystem Restoration Project

Stanley Park – Lost Lagoon water quality restoration

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Executive Summary

Lost Lagoon is the largest body of water in Stanley Park, used by 8 million people each year, it is important both socially and ecologically to the Lower Mainland of BC. Lost Lagoon was isolated from Coal Harbour and converted from an inter-tidal mudflat into a freshwater lake in 1916 by the construction of the Stanley Park Causeway. Lost Lagoon shares many similar ecological problems with lakes located in urban park areas such as eutrophication, pollution, sediment infilling, and invasive species. Organizations including Vancouver Board of Parks and Recreation and Stanley Park Ecological Society are actively looking for solutions to those problems as the water quality of Lost Lagoon continues to degrade. The main issue with putting together a restoration and management for Lost Lagoon is the lack of information. Currently there is a lack of information regarding the physics, chemistry, and biology that are scientifically measured and documented. In this report we will provide information about the depth and bottom topography of the lake. In addition, we will propose actions that will move things along to the eventual restoration of Lost Lagoon

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2 Introduction

2.1 Site History

Lost Lagoon is one of the major attractions of Stanley Park, where more than 8 million people visit each year (The Greater Vancouver Visitors and Convention Bureau, 2011). The area was originally an intertidal mud flat receiving tidal sea water from the Coal Harbour. The construction of the Causeway in 1916 has isolated the lake from Coal Harbour making it a lake supplied by runoff water. In 1929, a local fly fishing association raised funds to convert the lake into a freshwater lake for trout fishery (Worcester, 2010). Being the largest open body of water in the Stanley Park, Lost Lagoon is identified to be of high importance for people and wildlife in the recent state of the park report done by Stanley Park Ecological Society (Worcester, 2010).

2.2 Site Description

Stanley Park is on a peninsula located in the Lower Mainland region of BC right next to the downtown core of Vancouver. It is within the Costal Western Hemlock Biogeoclimatic zone with warm and moist climate (annual average temperature 10.3 ^{o}C and annual precipitation 1258 mm) the area is rich in biodiversity. The park is also important habitat for millions of migratory birds each year along the Pacific Flyway. Lost Lagoon is a shallow brackish water body with an area of 16ha and perimeter of 1.79 km (Worcester, 2010). The lake receives water from mainly from the creek from the west and Municipal water is streamed in to supply the lake. A one way flap gate was put underneath the Causeway to allow outflow while preventing saltwater intake into the lake. However, periodic intrusion of salt water still occurs and has kept the lake from being productive (Worcester, 2010). As a mitigation effort for the effect of widening the Stanley Park Causeway, a 3563 squared meter engineered wetlands was constructed to act as settling ponds and bio-filtration galleries in the northeast corner of the lake to filter out the road runoff that goes into the lake. More than 300000 cubic meters of chlorinated municipal water is being pumped into the lake per year in to maintain the water level of the lake and

improve the water quality. However, despite all the effort, the water in Lost Lagoon still appears to be eutrophic and algal blooms continue to happen.

2.3 Study objectives

After consulting with staffs at Vancouver Board of Parks and Recreation and Stanley Park Ecology Society, one of the main problems for the restoration of Lost Lagoon is the lack of information of the lake. Very little detailed scientific study has been done to document the limnology of the lake and the surrounding ecosystem. Understanding the many aspects of limnology for the lake including the average depth, bottom profile, water chemistry and nutrient content is vital for developing a successful and sustainable plan to restore the Lost Lagoon. After some discussion amongst ourselves and our course instructor Ken Ashley, we have decided to measure the average depth of the lake and create a topographic bottom profile of the lake. This information will be useful in the management of the lake and for designing restoration activates at the lake such as sediment removal, lake aeration and creating vegetated islands.

2.4 Ecological concerns

Water quality of the lake continues to degrade over the years by different reasons. The most concerning one is the appearance of turquoise colored water in the summer of 2009 thought to be caused by blue-green algae, a type of cyanobacteria (CBC News, 2009). This particular event and repeated algal blooms during summer times is a sign of eutrophication (presence of excessive nutrient) of the lake (Braybn, Cochrane, Dura, & Malboeuf, 2000). Various efforts have been put in attempt to improve the situation. In 2001, a 1.1 million dollar project was done to install an 1170 cubic meters storm water treatment wetland to treat storm water runoff from the Stanley Park Causeway before it enters Lost Lagoon (Worcester, 2010). Even though the project was deemed successful for reducing polluted runoff to enter the lake directly, there are many other culprits in the system that is preventing it from become a clean and productive freshwater lake. Some possible problems that could have

contributed to the decrease of water quality in Lost Lagoon include:

- Polluted surface runoff into the lake
- Pollution from fecal matters of wildlife, especially water fowls that lives in and around the lake
- Internal nutrient load from lake bottom
- Intrusion of salt water from Coal Harbour causing stratification of the water body, resulting in low oxygen level near the bottom of the lake
- Thermal stratification of the lake
- Invasive species such as carp removing all submerged macrophytes while constantly disturbing the sediment to release nutrients and pollutants into the water column

Other major problems of the Lost Lagoon include the lack of natural water supply, intrusion of salt water from across the Causeway and infilling by sediment runoff and fecal material buildup from water fowls.

2.5 Rationale of restoration

Although Lost Lagoon is not a naturally occurred freshwater lake, it has been in place for decades and has since become one of the most recognized features of Stanley Park. The lake also serves as habitat for wildlife including a healthy population of water fowls as well as breeding and overwintering birds (Worcester, 2010). Some species that utilize the lake frequently include Canada geese, mallard ducks, great blue heron and introduced mute swan. Situated in a park within the downtown of a large city like Stanley Park, the restoration goals and objectives of Lost Lagoon can be very different from a lake in remote rural areas. Health and safety issues as well as social values such as aesthetic and recreational value have to be considered while addressing ecological concerns. With the Causeway in place it is not an option to have the Lost Lagoon return to the original state of intertidal mud flat. Therefore, it is in the best interest of the public and the ecosystem health of the park to have it restored

as a clean, self sustaining freshwater ecosystem which serves as a sightseeing attraction while providing valuable habitat for local wildlife.

3 Methods

3.1 Identifying information gaps

Restoration of fresh water lakes is a challenging task due to the combination of the physical characteristics, chemistry, and ecology that collectively led to the degradation of the water body; No two lakes are the same so are the restoration techniques. Therefore, it is very important to gather as much reliable information as possible about the lake to provide a sound scientific knowledge base to the managers of the park to put together restoration a plan that is best suited for the Lost Lagoon. After some discussions with Alan Duncan - Environmental Planner of Vancouver Board of Parks and Recreation; Robyn Worcester - Conservation Programs Manager of Stanley Park Ecology Society; and Ken Ashley - BCIT instructor of Restoration of Freshwater Aquatic Ecosystems. A list of current information gaps have been identified as follows:

- Average depth and topography of the bottom of the lake
- Dissolved Oxygen near the surface and near the bottom
- Nutrient content such as Nitrogen and Phosphorus
- Salinity of the water near the surface and near the bottom
- Wildlife and vegetation monitoring of the lake
- Chemical analysis of water
- Chemical analysis of sediment at the bottom
- Content of the runoff from the golf course west of the lake

3.2 Measuring the bottom of Lost Lagoon

All of the information above would be vital for developing restoration strategy of Lost Lagoon.

However, due to time constrain and the scope of this project, and to the fact that many of the information mentioned above varies seasonally and require long term measurements and data collections to be scientifically useful. In this project we have decided to measure the depth of the lake and generate a topographical profile of the lake bottom.

3.3 Measurements and data processing

62 waypoints are set up and laid out across Lost Lagoon in a handheld GPS device. Each waypoint is 50m apart from each other forming a 50 x 50m grid system covering the whole surface of the lake (see figure 1). Two students from BCIT approach each waypoint on a canoe guided by the handheld GPS. At each waypoint a metal pole with tape measure attached is lowered to the bottom of the lake and vertical distance between the bottom and the water surface is measured and recorded into a data sheet (see figure 2).

The collected data are then entered into a spreadsheet according to the waypoint number and the GPS coordinates. Simple averaging of the depth data using the spreadsheet program produced the average depth of the lake which is 1.46 meters. A topographic profile of the bottom of the lake is generated by putting the depth data and the coordinates into GIS program (see figure 3)

Figure 1: Sampling points lay across Lost Lagoon

Figure 2: Measuring depth of the lake

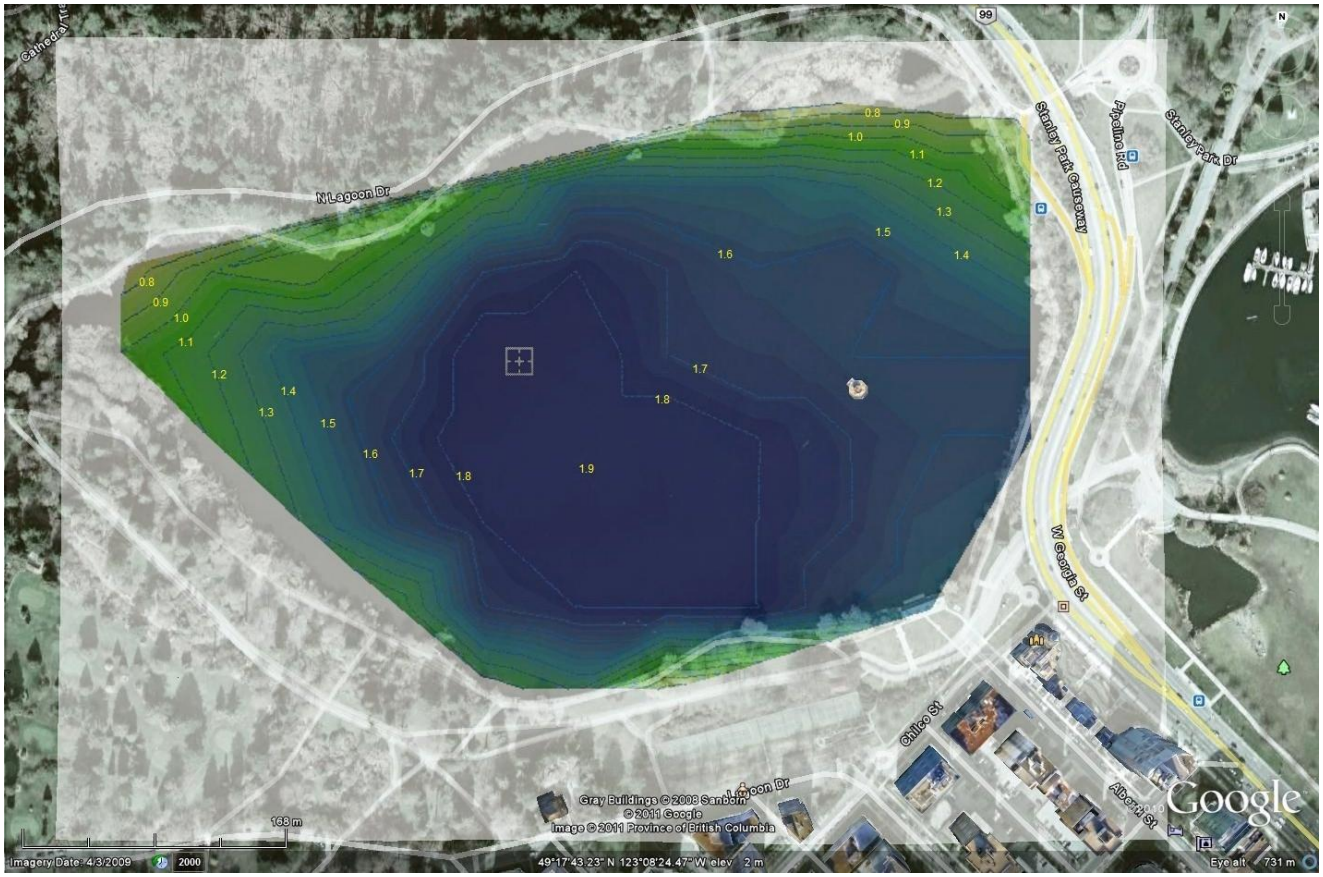

Figure 3: Topographic profile of the lake bottom, showing depth in meters

4 Results and discussions

The average depth of Lost Lagoon is 1.46 meters with a very flat bottom throughout the lake. Although the lake is measured to be deeper than the estimated 1.0 – 1.2 meters from previous reports (Worcester, 2010) (Braybn, Cochrane, Dura, & Malboeuf, 2000), it is still a very shallow body of water with low surface area (16.7 ha) to depth ratio. This makes the lake more prone to eutrophication and algal blooms with the following reasons:

- The lake holds a low volume of water compared to deeper lakes, intensifies any input of nutrients and pollutants as the dilution ability is lower
- With small surface area to depth ratio, the lake warms up more easily by solar radiation and ambient temperature, providing an environment more suitable for algae growth
- High evaporation ratio due to large surface area, concentrates pollutants especially during summer times

- Small surface area to depth ratio allow sunlight to reach a higher percentage of the water column, favoring algae growth

The problems associated with being a shallow water lake is combined with other factors such as low natural water supply, polluted runoff, defecating water fowls and invasive carps. The result is a lake with greenish turbid water which is not only unappealing to the users of the area, but also unproductive for native wildlife species. Although it is evident that work is needed to be done to improve the water quality of Lost Lagoon; it is necessary to understand the limnology of the lake and the surrounding ecosystem in detail before any changes are made to the lake. Some studies have been done on the lake by mostly students, volunteers and consultants who provided valuable information. However, to better develop restoration strategy and management practices, more baseline studies of the physical, chemical and biological conditions of Lost Lagoon would be necessary. In this report we have came up with a list of suggested studies to be done in Lost Lagoon.

- Annual measurement of depth and topographic profile of the lake bottom to understand the infilling situation
- Conduct a 3 year, bi-weekly measurement of water temperature and chemistry including salinity, total phosphorus and total nitrogen level. Samples should be taken from different depths of the lake to obtain information about the stratification status of the lake
- Conduct a 2 year, quarterly monitoring of vertebrate species inside the lake to identify the number of native species versus introduced species. If the lake contains mostly introduced species, it is more justifiable socially and scientifically to implement more dramatic restoration work such as fish extermination by introducing sterile piscivorous fish, dredging and draining the lake to build vegetated islands in the middle to create more habitats.
- Perform sediment analysis in various locations of the lake bottom to find out if the sediment is a major source of pollution and if the substrate is suitable for macrophyte growth.

- Identify locations of salt water intrusion and identify possible prevention solutions

5 Potential Solutions

With the complexity of environmental issues surrounding the Lost Lagoon, it will be a challenge to identify the key problems and then to make restoration actions. Depending on results of future research and monitoring programs, some possible actions can be implemented to improve the water quality of Lost Lagoon and increase the overall social and ecological value of the area. Some possible solutions include:

- Dredging to increase depth and volume of the lake and to remove contaminated sediment. Reducing the need of municipal water input and reducing source of pollution
- Install an impermeable barrier to prevent salt water intrusion and put in an emergency outflow mechanism to allow flowing of water from the lake into Coal Harbour during raining season
- Encourage fishing activities for carp in Lost Lagoon while banning re-release back into the lake. (may encourage illegal release of more carp)
- Extirpate invasive carp by draining the lake outside of breeding season to avoid eggs remaining in the substrate and manually remove all fish
- Draining the lake and build 2 – 3 vegetated islands around the lake with both canopy and understory vegetations to provide habitats for wildlife while increasing cover on the lake, lowering the amount of sunlight on the water
- Deploy potted submerged macrophytes into the lake bottom to increase nutrient uptake and reduce damage done by carps.

This list of solutions is by no means exhaustive and as more research is done on the lake, more restoration strategies and techniques can be developed to suit the conditions.

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