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Summary

Lake Ida Anne is one of Langford's many parks. It is located in northern Langford and acts as a catchment for storm runoff from Bear Mountain. A large amount of nutrients are present in the influent to the lake due to fertilizers and soaps from washing cars making their way into the storm drain system. All these nutrients combined with sunny, warm weather and low flow rates have resulted in excessive algae growth in the lake. Algae growth is a problem since it creates both an unpleasant odour and sight, which deters the public from using the park.

Algae can be treated in multiple ways including aeration and bacteria. Aeration creates an oxygen rich environment that algae cannot survive in. Three aerations systems (fountains, surface bubblers and an oxygen concentrator) were tested over 11 weeks by measuring the DO concentration in the lake and by visual inspection of the amount of algae present. Fountains work by spraying water upwards which forces air to become mixed in, bringing oxygen into the water as it falls. Overall it was found that the fountains were not effective at increasing the DO level as they only aerate the surface of the water. Surface bubblers work by forcing air into the top of the water which creates tiny air bubbles that release oxygen when they burst. Since aeration is only occurring at the top of the water column the device proved to be ineffective at providing aeration to the entire lake. The oxygen concentrator is a device that takes in air and separates out the oxygen. Once the oxygen is concentrated it is pumped into the lake throughout the entire water column, allowing for a large increase in dissolved oxygen levels. [2] Bacteria work by transforming phosphorus into an unusable form, causing the algae to starve and die. The bacteria work immediately but are only temporarily effective.

It is recommended that the oxygen concentrator be used from April to September along with the addition of bacteria as needed.

Glossary

Aeration: The process of introducing air into a liquid.

Algae: Singled celled plant organisms that grow in groups

DO: Dissolved Oxygen is the amount free oxygen present in a liquid.

Photosynthesis: The process in which light energy is used to convert carbon dioxide and water into chemical energy in the form of glucose with oxygen as a by-product. This chemical energy is then used as fuel for activities.

Eutrophication: A form of water pollution that occurs when the water becomes enriched with nutrients.

1 Introduction

Ever since becoming a city in 1992 the City of Langford has taken great care to keep their parks beautiful. The City of Langford believes that public green spaces promote healthy living and create a sense of community as they reduce pollution and allow people engage with one another while being active. [1] One of the many parks in Langford containing a small lake and a walking trail is Lake Ida Anne.

Lake Ida Anne is located in North Langford. In recent years algae growth has become a growing problem in the lake. Figure 1 shows the extent of the algae coverage at the beginning of July 2015.

Figure 1: Algae Coverage July 2015

Algae growth is an issue the city is concerned about as it is unappealing to the eye and gives off unpleasant odours. This deters the public from making use of the park space and leads to complaints by the public which in turn create political issues. Algae can also harm marine life and have a negative impact to the surrounding ecosystem, which is a scenario the city would like to prevent.

The main cause of excessive algae growth is the right combination of nutrients in the form of phosphorous, nitrogen and potassium, along with a sufficient amount of sunlight. Lake Ida Anne acts as a catchment basin for the Bear Mountain development. Figure 2 shows how the overflow from the catchment on Bear Mountain follows a path outlined by the blue dashed line down to Lake Ida Anne.

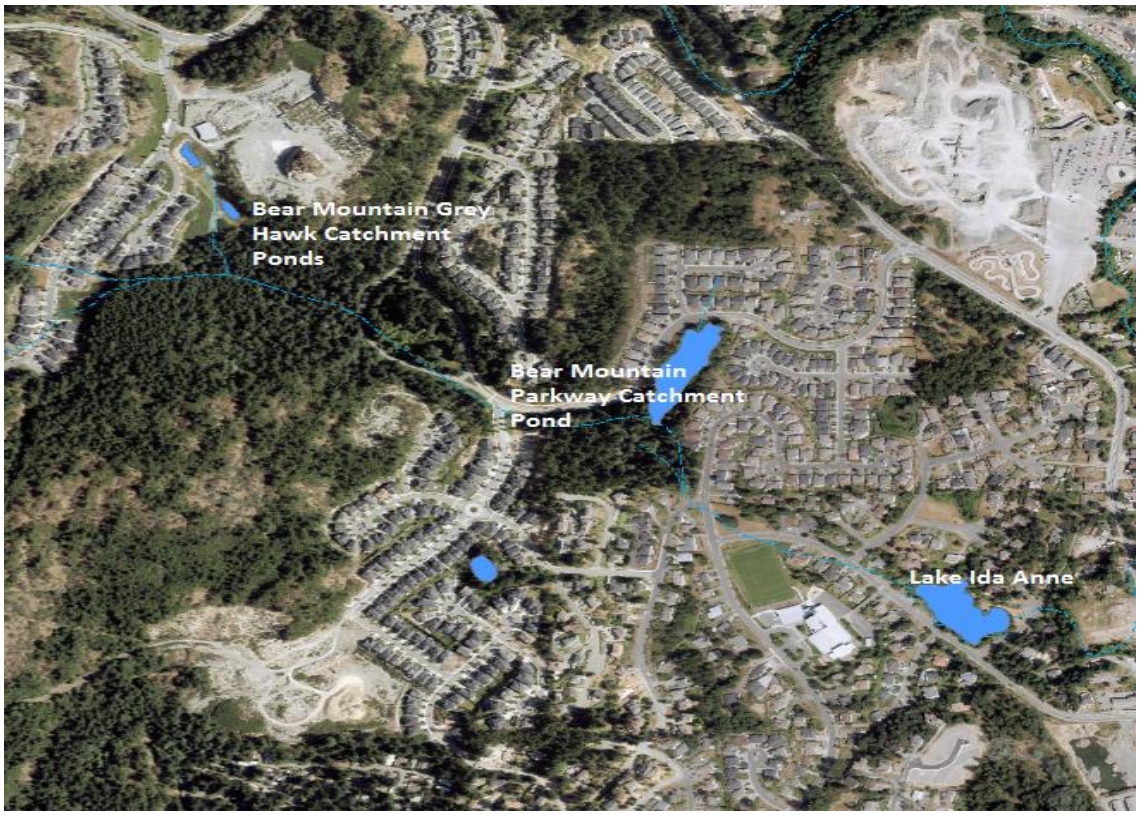


Figure 2: Flow Path from Bear Mountain to Lake Ida Anne

The result of Lake Ida Anne acting as a catchment basin is that large amounts of nutrients have made their way into the lake. These nutrients are derived from household activities such as car washing and lawn fertilization combined with household waste water containing phosphorus rich detergents and organic waste. While waste water should have never entered the system, cross connections between the sewer and storm system were found on Bear Mountain. Eutrophication combined with sunny weather in Langford created optimal conditions for algae growth in Lake Ida Anne.

This report outlines the various ways algae can be controlled. Three aerator options were tested by measuring the dissolved oxygen (DO) content of the water and the results are presented. Bacteria were also introduced and the results via visual inspection are noted. Conclusions and recommendations for the optimal solution are given as well.

2 Discussion

The following sections outline various methods to control algae growth such as aeration systems and the addition of bacteria. The benefits and disadvantages of each option will be discussed and test results will be presented.

2.1 Options to Control Algae Growth

2.1.1 Aeration

Aeration involves forcing oxygen into water. Since algae rely on photosynthesis for survival they take in carbon dioxide and produce oxygen. When there is a large amount of oxygen present algae cannot survive. Once an algae bloom begins it is hard to control because as the algae die and decompose they produce carbon dioxide and nutrients for the surviving algae to feed off of.

Thus aeration is most effective at preventing algae blooms and can be performed in a variety of ways including fountains, diffusers and oxygen concentrators.

Fountains such as the one shown in Figure 3 provide aeration by spraying water upwards and allowing the naturally oxygen rich air to become mixed in through the effects of gravity. Mixing and movement also occur in the water as contact is made between the water droplets and the pond surface, providing further aeration. The main benefit of fountains are that they are visually appealing, making them a method that is supported by the public. However fountains are not very effective at increasing DO concentrations as the oxygen concentration in the air is low and gravity is not strong enough to force much air into the water. Another disadvantage is that they only provide aeration at the top of the water column. The final disadvantage is that fountains are expensive at $5000.00 each and involve a $500.00 installation cost each. A significant amount of maintenance is also required for fountains as it was found that they break regularly as discussed in the sections to follow, resulting in additional costs.

Figure 3: Fountain

Surface bubblers are a less expensive alternative to fountains costing $2500.00 each and have an installation cost of $1000.00 each. Surface bubblers provide aeration by taking in the atmospheric air and forcing it into the water near the surface through diffusers. This causes bubbles to form and oxygen to become mixed into the water as they burst. Benefits to surface bubblers are that they are not very expensive compared to other options, they are moderately effective and they do not require much maintenance as discussed further in the sections to follow. By forcing air into the water in the form of tiny bubbles much more oxygen is able to become mixed rather than relying on the force of gravity alone like the fountains do. Disadvantages are that surface bubblers only provide aeration to the top of the water column and they are not as pleasing to look at as shown by Figure 4 below.

Figure 4: Surface Bubbler

The final method of aeration used was unconventional. An oxygen concentrator designed for use in a hospital as pictured in Figure 5 was connected to a pump system in the lake pictured in Figure 6. The oxygen concentrator takes in atmospheric air and separates out the oxygen, allowing it to concentrate. This concentrated oxygen is then pumped into the water. The main benefit of this method is that it is very effective at increasing the DO concentration as it delivers bubbles of high oxygen content to the entire water column. This allows a large amount of oxygen to be dispersed evenly throughout the pond. The main disadvantage to the oxygen concentrator is that it is very expensive. The oxygen concentrator only costs $1500.00 but the land shark pump that is needed costs $5000.00 and they have a combined installation costs of $7500.00. Maintenance is also needed regularly as discussed further in the following section which increases the costs even further.

Figure 5: Oxygen Concentrator [3]

Figure 6: Land Shark Pump [2]

2.1.2 Bacteria

An alternative method to fight algae blooms is to add bacteria such as Microbe-Lift/Sa Sludge Away to the pond. Bacteria break down organic solids, thus removing the nutrient source for the algae and also eliminate the dead algae that otherwise would break down and be recycled back to the living algae as nutrients. The bacteria also bind the phosphates so they are in a form that cannot be used by the algae. The benefits of bacteria are that it works fast, it works at any temperature, and it is a bio-degradable product that will not harm fish and other aquatic life. However while using a bio-degradable product ensures the safety of the downstream environment, it also means that the bacteria only survive for at most a month in the lake, causing a frequent need for re-treatment.

2.1.3 Other Notes

It should be noted that a camera program in underway to find all of the cross connections on Bear Mountain to eliminate sewage contamination. This will reduce the nutrient source. Further source reduction can be attempted through policy requiring phosphate free car soaps and restricted fertilization, however such policy cannot be enforce in a realistic manner so this option will not be discussed any further in this report.

2.2 Test Results

The amount of dissolved oxygen in Lake Ida Anne was measured weekly at seven locations shown in Figure 7 below. The readings were taken at a depth of 1m, which is approximately the middle of the water column. Figure 7 also shows the locations of the aeration systems and the main inlet and outlet.

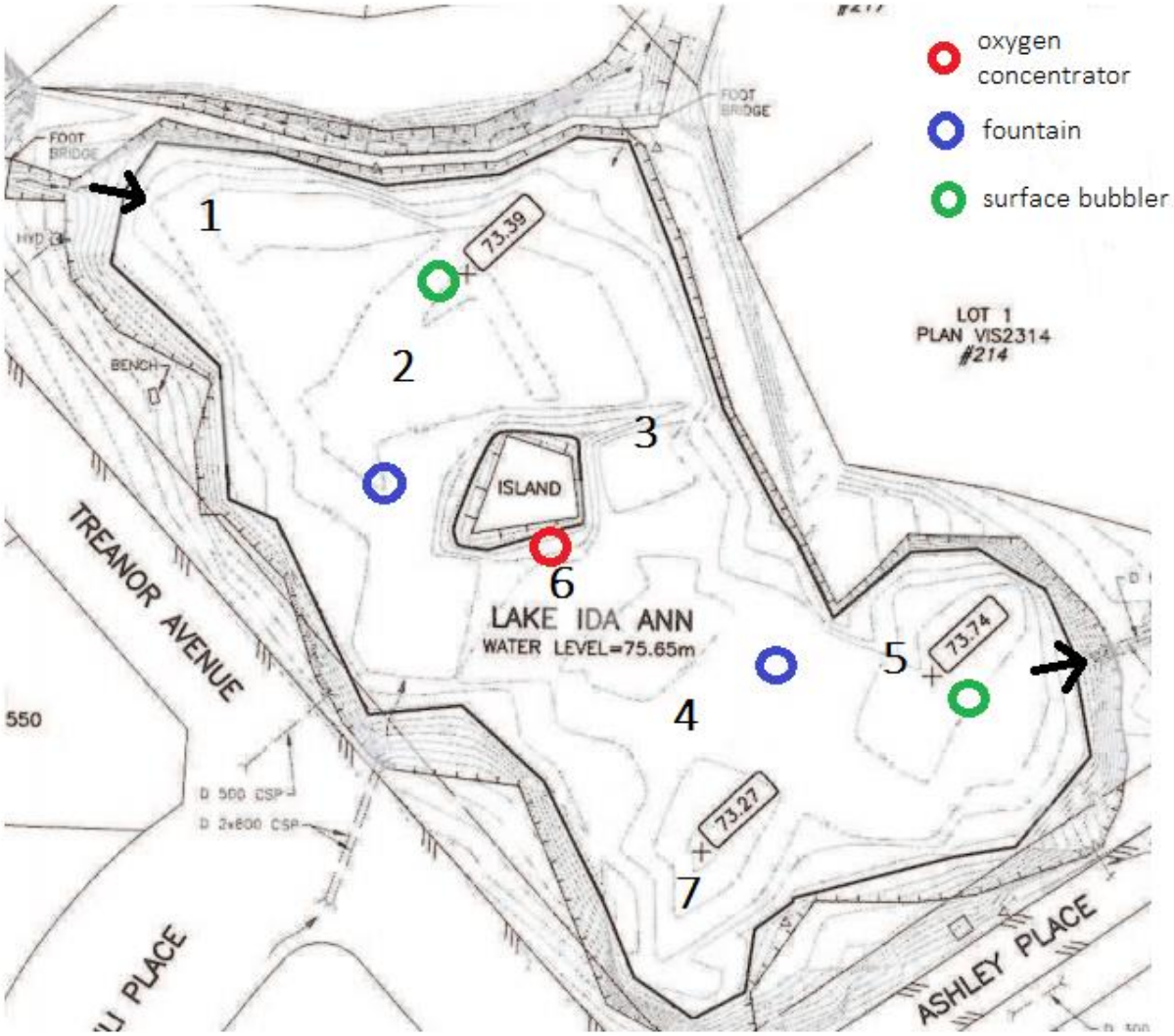


Figure 7: Lake Ida Anne Map

The graph in Figure 8 below shows the results from 11 weeks of testing at a depth of 1m. The dissolved oxygen concentration was measured using a YSI dissolved oxygen meter. The original data can be found in Appendix A.

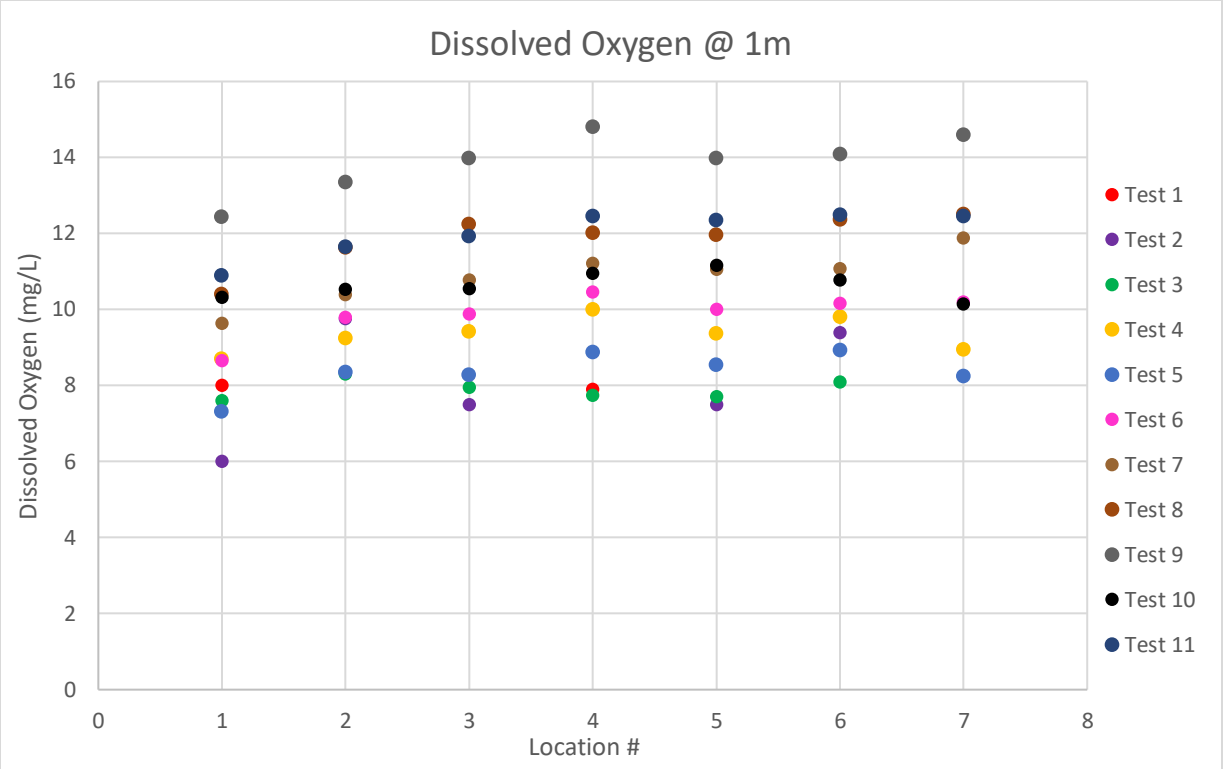


Figure 8: Dissolved Oxygen Concentration Test Results

Overall the oxygen levels increased at a rate of approximately 1mg/L/week throughout the entire lake. The oxygen levels at the inlet are consistently the lowest and the dissolved oxygen concentration rises as the readings approach the south end of the lake. The DO concentration dropped throughout the entire lake at Test 5. At this time it was found that the oxygen concentrator was not working as it had overheated and shut off. A cover that included a fan was built to house the equipment, preventing this problem from repeating. At Test 7 it was found that the fountain near test location 4 was off. As seen in Figure 8 the loss of the fountain did not affect the oxygen concentration. After Test 7 had commenced bacteria were added to the lake. The pictures in Figures 9, 10 and 11 show the algae coverage at Test 7, 8 and 9. Through these images it is apparent that the algae decreases after the bacteria is added, however weeds then begin to grow.

Figure 9: Algae Coverage at Test 7

Figure 10: Algae Coverage at Test 8

Figure 11: Algae Coverage at Test 9

The fountain near test location 2 was found to be off during Test 8 and the one near test location 5 was back on. Again no significant effect on the DO concentration was found at these locations. In the days leading up to Test 9 there was some rainfall which produced flow which in turn created mixing, allowing oxygen levels increased significantly. Unfortunately the oxygen concentrator was discovered to be off during Test 10 and the DO concentration was found to have dropped significantly throughout the entire lake. Test 11 showed that once the oxygen concentrator was on again the DO concentration began to increase. A complete set of pictures taken during Tests 6 through 11 can be found in Appendix A. From these pictures it is clear that the amount of oxygen present does have an impact on the amount of algae able to grow.

2.3 Comparison Table

Table 1 below compares the cost of the discussed treatment options as well as their overall effectiveness and the estimated amount of maintenance they will require. It should be noted that the costs for the aeration systems are initial costs that will not occur again over the lifetime of the equipment, however the bacteria cost is on an annual basis as the bacteria are not reusable year to year.

Table 1: Algae Solutions Comparison

System	Product Cost ($)	Installation Cost ($)	Total Cost	Estimated Maintenance Frequency Over 6 Months	Effectiveness Rating (1= good, 3 = poor)
Fountain	5,000	500	11,000	6	3
Surface Bubbler	2,500	1,000	7,000	1	2
Oxygen Concentrator & Land Shark Pump	6,500	7,500	14,000	3	1
Bacteria	400	25	2,550	6	1

3 Conclusions

Overall the DO concentration increased at a rate of approximately 1mg/L/week throughout the lake. None of the aeration systems caused a significant change to the amount of DO present in the immediately surrounding water. The fountains did not cause a noticeable change in DO levels when they were turned off, however a large drop in DO was found during tests where the oxygen concentrator had been off. The DO content would then rise in the week following the repair of the oxygen concentrator, proving that it is effective.

There were several sources of errors that may have affected test results. It was impossible to take readings at identical locations each time, therefore the locations are only approximate. The depth of water varied each week due weather and influent to the lake meaning that the aerators would be oxygenating a varying volume of water and thus the overall effectiveness of the aeration would also vary. The pumps for the fountains and oxygen concentrator also broke regularly resulting in inconsistent operating times between tests.

In conclusion oxygen concentrator had a significant impact on DO levels, while the other aeration systems did not. Even though it is an expensive option, the oxygen concentrator is much more effective than other aeration systems and the bulk of the cost is a one-time expense. For these reasons the oxygen concentrator aeration system is the best aeration option. The bacteria were also effective at clearing the algae, however they only works as a temporary fix and have a monthly cost if used alone, which will add up to be quite expensive. It is because of this high cost if used on their own that the bacteria are best implemented as a supplement to oxygen as needed.

4 Recommendations

It is recommended that the use of the oxygen concentrator should begin in April with a placement on the North West side of the island. This will allow the lake to become oxygenated before optimal algae conditions occur in May and, will also allow for more oxygen to reach the inlet. The use of the oxygen concentrator should continue until the end of September when algae blooming conditions end. It is also recommended that the lake be checked bi-weekly for algae and that bacteria be added as needed to supplement the oxygen concentrator in fighting the algae.

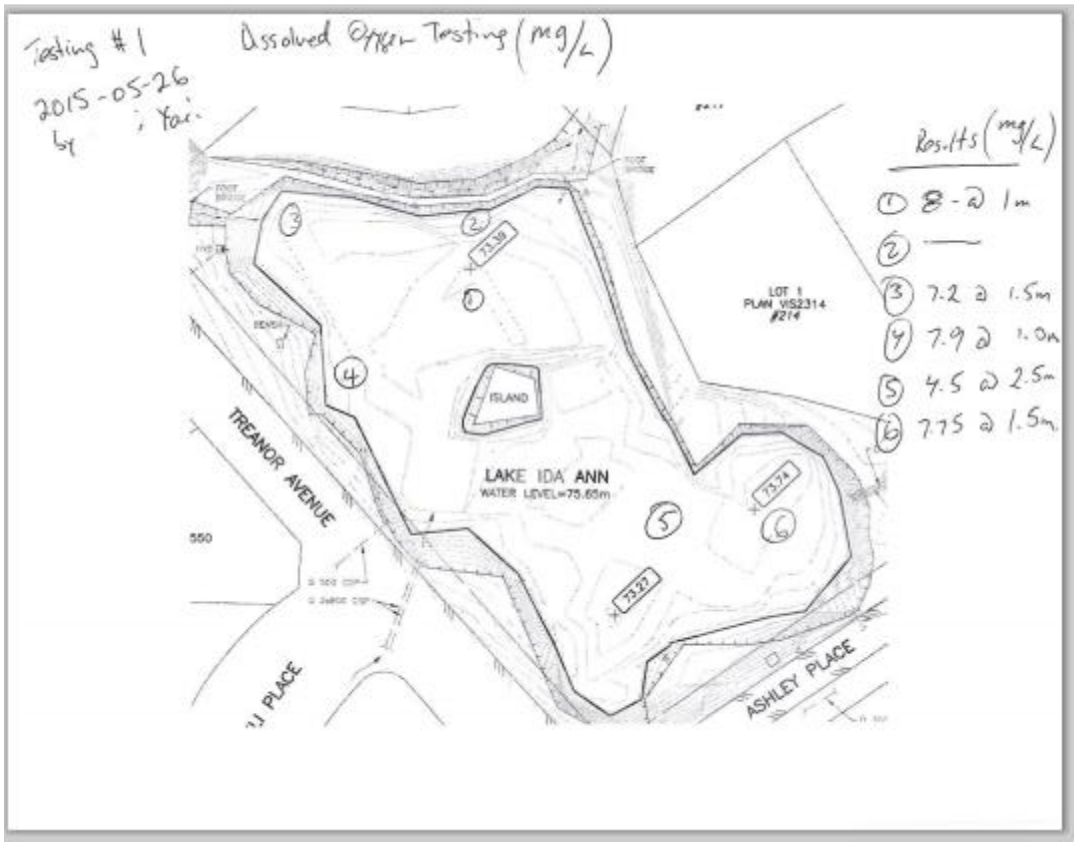
References

[1] City of Langford. (2015). Parks [online]. Available: http://www.cityoflangford.ca/EN/main/lifestyle/things-to-do/parks-trails/parks.html

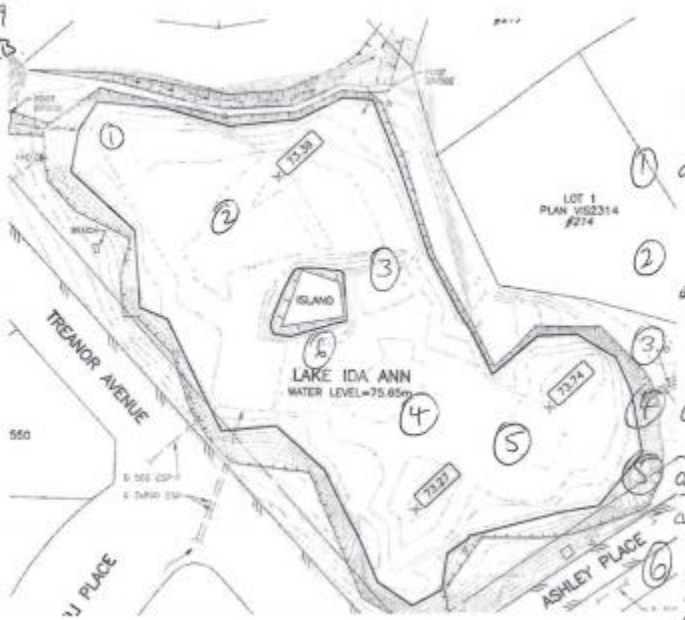
[2] K. Bowbyes, "Algae Removal at Lake Ida Anne," unpublished

[3] Farla Medical Supplies Limited. (2001-2015). DeVilbiss® Compact 525 Oxygen Concentrator [online]. Available: http://www.farlamedical.co.uk/category_Oxygen-Concentrators-5044/DeVilbiss-Compact-525-Oxygen-Concentrator/

Appendix A


Testing #1
2015-05-26
Dissolved Oxygen Testing (mg/L)
Results (mg/L)
1 8-2 1m
2
3 7.2 @ 1.5m
4 7.9 @ 1.0m
5 4.5 @ 2.5m
6 7.75 @ 1.5m
LOT 1
PLAN VIS2314
#214
ISLAND
LAKE IDA ANN
WATER LEVEL=75.65m
TREANOR AVENUE
550
ASHLEY PLACE

Test #2
Dissolved oxygen
2015-06-09
Tested by KB



Results (mg/L)

1 @ 1m, 5-7
2m 1-3

2 @ 1m 9.76
@ 2m 3↓

3 @ 1m 7-8

4 @ 2m 1↓

5 @ 1m 7-8
@ 1.5m 8.5

6 @ 1m 9.4
@ 2m 7.3

Test #3 June 18 @ 10am
sunny/cloudy
19°C

1 @ 1m 7.5
1.5m 6.5

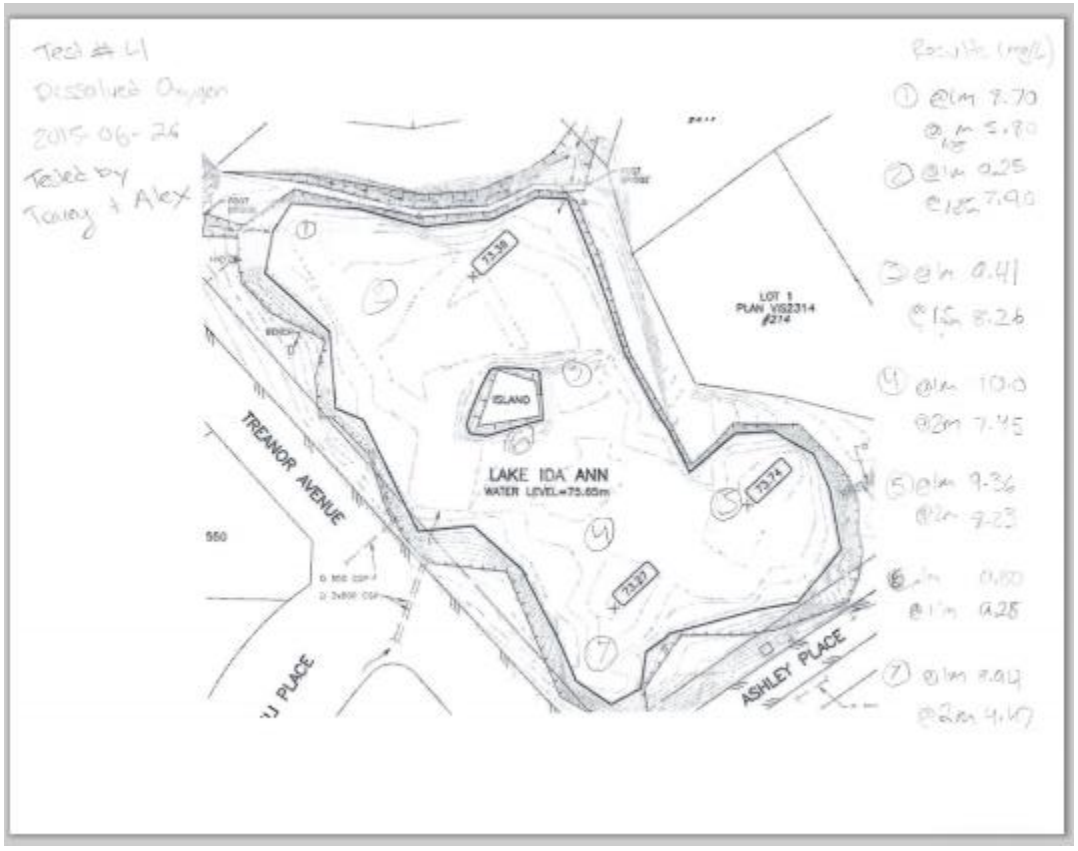
2 @ 1m 8.3
1.75
@ 2m 4.75

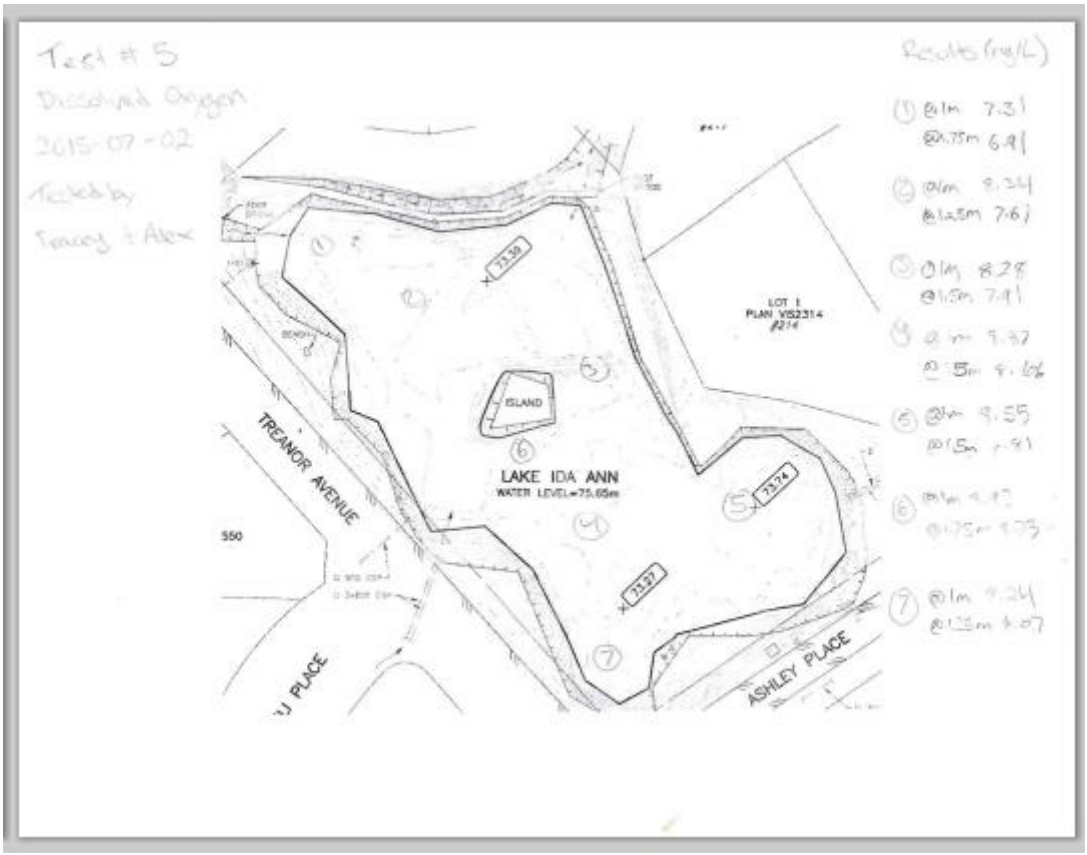
3 @ 1m 7.95

4 @ 1m 7.75
@ 1.5m 7.70

5 @ 1m 7.70
@ 1.5 7.5

6 @ 1m 8.1
@ 2m 7.3


Test # 4
Dissolved Oxygen
2015-06-26
Tested by
Tracey + Alex
Results (mg/L)
LOT 1
PLAN VIS2314
#214
ISLAND
LAKE IDA ANN
WATER LEVEL=75.65m
TREANOR AVENUE
ASHLEY PLACE
550


Test # 5
Dissolved Oxygen
2015-07-02
Tested by
Tracey + Alex
Results (mg/L)
LOT 1
PLAN VIS2314
#214
ISLAND
LAKE IDA ANN
WATER LEVEL=75.65m
TREANOR AVENUE
ASHLEY PLACE
550

Test #6
Dissolved Oxygen
2015-07-09
Tested by
Tracey & Alex

Results (mg/L)

① @1m 8.66
@1.5m 7.64

② @1m 9.79

③ @1m 9.88
@1.25m 9.94

④ @1m 10.47
@1.25m 10.43

⑤ @1m 10.01
@1.5m 10.09

⑥ @1m 10.17
@1.5m 11.14

⑦ @1m 10.20
@1.75m 10.08

Test #7
Dissolved Oxygen
2015-07-16
tested by
Tracey & Alex

Results (mg/L)

① @1m 9.64
@1.75m 9.26

② @1m 10.40

③ @1m 10.78
@2m 10.61

④ @1m 11.22

⑤ @1m 11.06
@1.75m 11.74

⑥ @1m 11.03
@1.5m 11.56

⑦ @1m 11.88
@1.25m 11.97

Test #8
Dissolved Oxygen
2015-07-23
Tested by
Tracey & Alex

Results (mg/L)

① @1m 10.410
@2m 10.18

② @1m 11.67

③ @1m 12.25
@2m 12.21

④ @1m 12.02
@1.25m 11.72

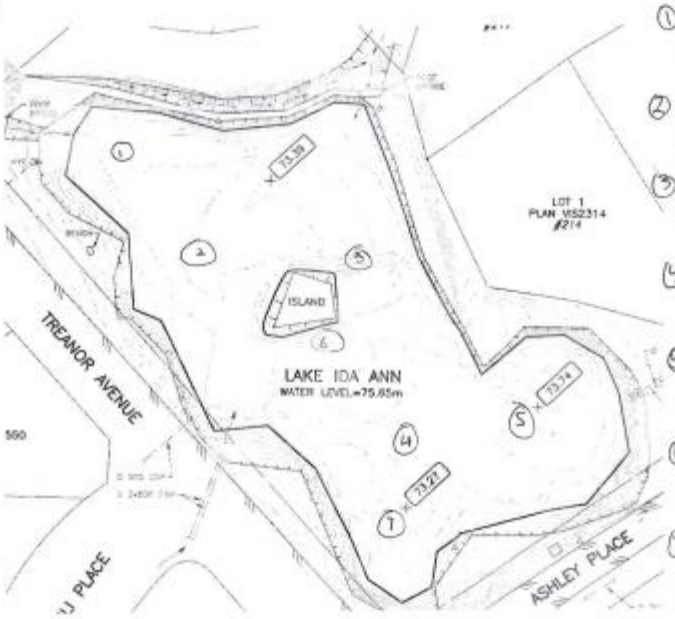
⑤ @1m 11.96
@1.5m 12.70

⑥ @1m 12.36
@1.5m 12.34

⑦ @1m 12.50
@1.75m 12.53

Test #9
Dissolved Oxygen
2015-07-30
Tested by
Tracey & Alex

DO
Results (mg/L)



① @1m 12.43
@1.75m 1665

② @1m 13.34
@1.25m 13.M

③ @1m 13.97
@2m 14.94

④ @1m 14.80
@1.5m 15.51

⑤ @1m 13.90
@1.5m 13.96

⑥ @1m 14.09
@1.25m 14.26

⑦ @1m 14.60
@1.25m 14.90

rain last week
Sunshine M ost

Test # 10
2015-08-06
Dissolved oxygen

Results (mg/L)

① @1m 10.37
@1.75m 10.08
② @1m 10.54
@1.5m 11.67
③ @1m 10.55
& @2m 10.45
④ @1m 10.95
@1.5m 10.03
⑤ @1m 11.17
@1.5m 11.22
⑥ @1m 10.77
@1.5m 10.70
⑦ @1m 10.15
@1.75m 11.47

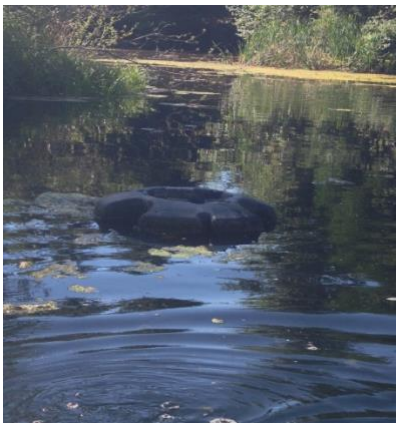
Dissolved Oxygen
2015-08-13
test #11
Tested by:
Alex & Tracey

Results (mg/L)

① @1m 10.9
@1.5m 10.92
② @1m 11.65
@1.5m 11.71
③ @1m 11.92
@2m 11.44
④ @1m 12.46
@1.25m 12.64
⑤ @1m 12.35
@2m 12.91
⑥ @1m 12.49
@1.75m 12.81
⑦ @1m 12.45
@1.5m 12.77

Appendix B

Test 5 – 2015-07-02



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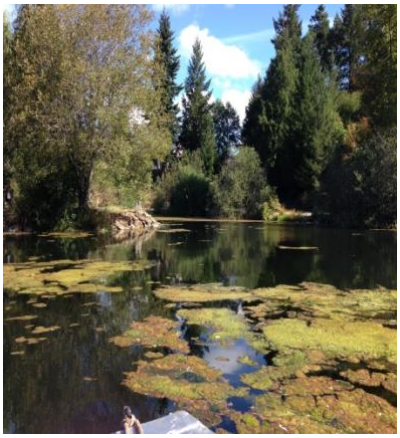

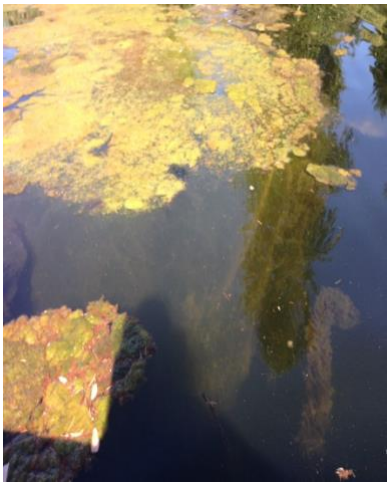

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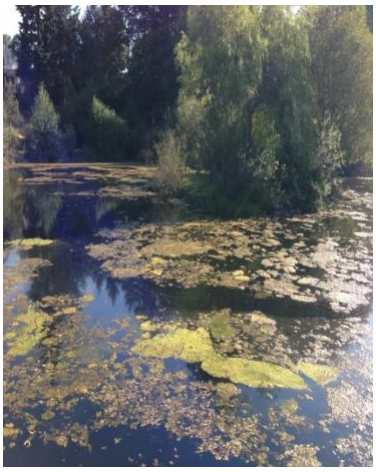

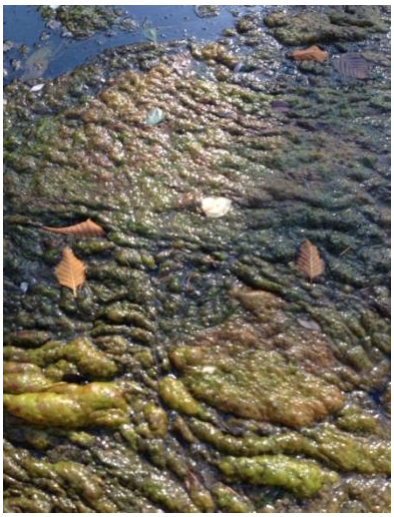
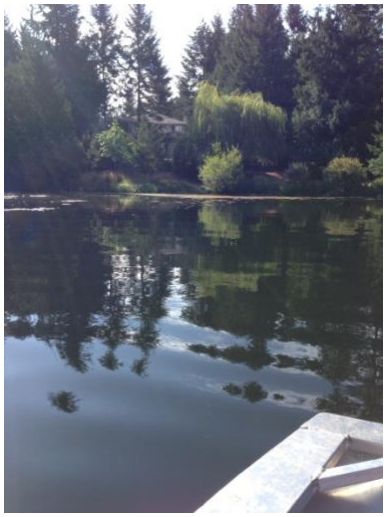
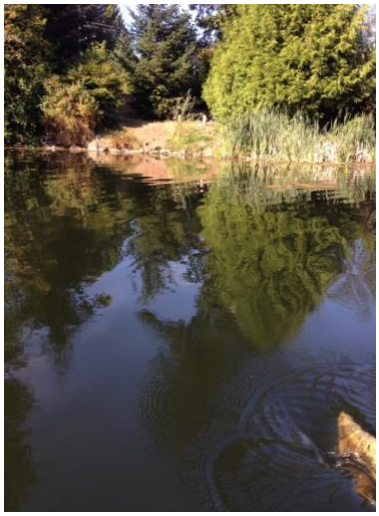
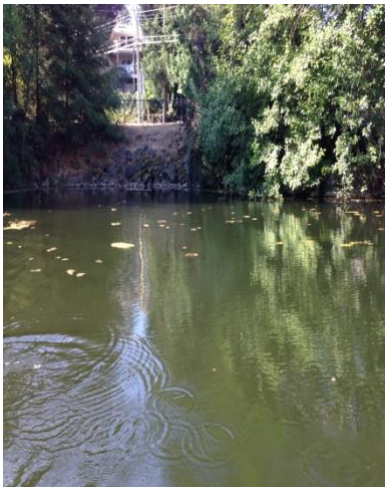

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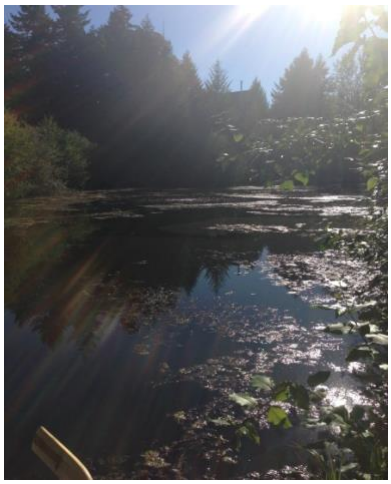


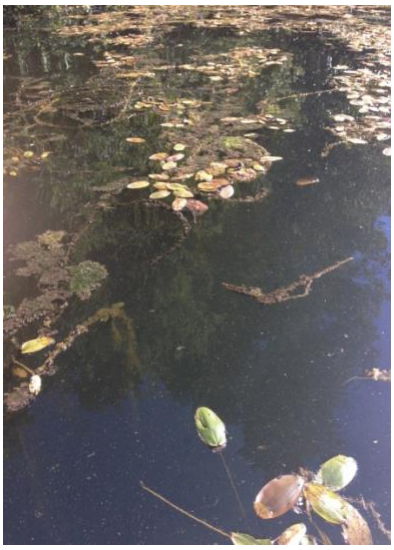

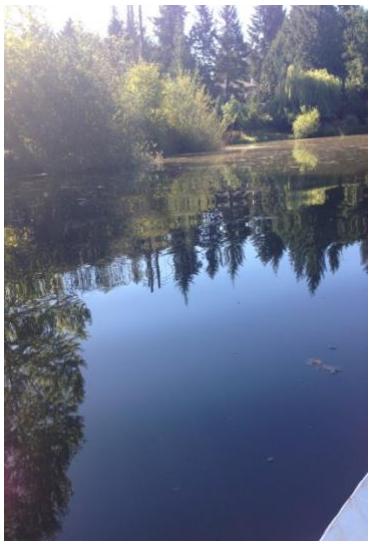
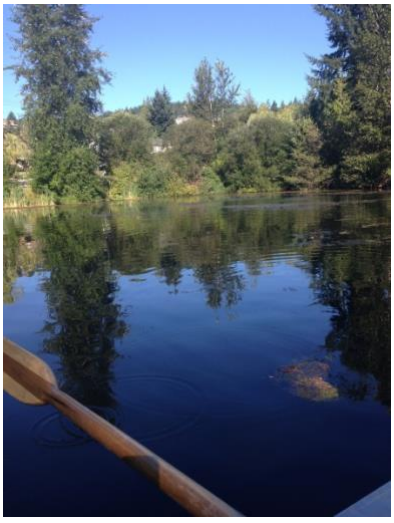




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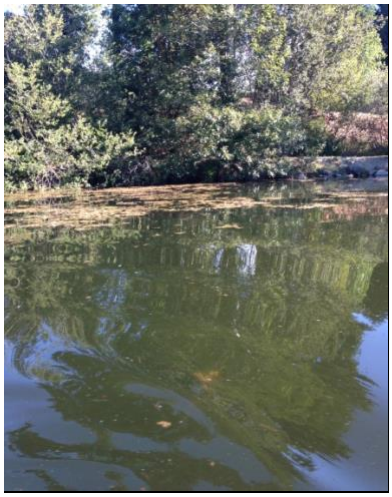



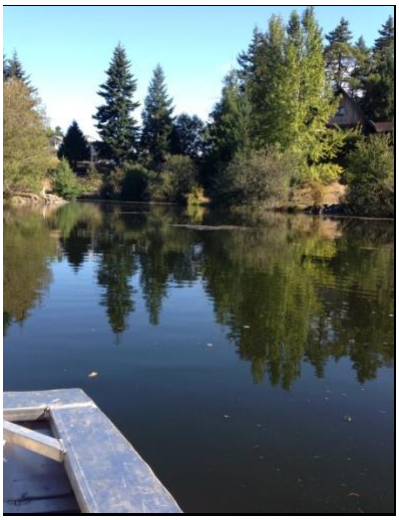

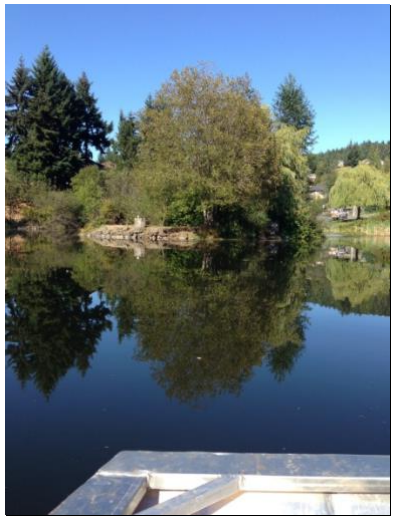

Test 11 – 2015-08-13