

1. INTRODUCTION

Lake Isabel is located in the Gatineau Valley, about 80 kilometres from downtown Ottawa, in Low, Quebec (GEG 2019, Field Camp). In terms of topography, Lake Isabel is embedded in a zone called the Western Laurentides, which is a component of the Canadian Shield (GEG 2019, Field Camp). The region of Lake Isabel is a section of the Grenville geological province (GEG 2019, Field Camp). The Grenville geological province is a part of an old mountain range that was destroyed by erosion, approximately 900 million years ago, but once had altitudes of up to 6-800m (GEG 2019, Field Camp). All of the rocks surrounding and in Lake Isabel are metamorphic Precambrian rocks (GEG 2019, Field Camp). The main rock types are marble and gneiss, which were originally limestone and granite before undergoing the massive temperature and pressure of the Earth's crust (GEG 2019, Field Camp). These metamorphic rocks are usually covered by surface sediments, causing them to be hidden (GEG 2019, Field Camp). The common types of surface sediment are gravel, which is made of sand, pebbles, clay, and silt, and peat (GEG 2019, Field Camp). For approximately 100,000 years Canada was covered by a glacier called the Laurentian Inlandsis (GEG 2019, Field Camp). The glacier only began to melt and retreat from the Lake Isabel region approximately 8000 years ago, it left deposits of gravel as well as markings from its movement such as glacial striations (GEG 2019, Field Camp). Lake Isabel gets most of its water from groundwater, inside the gravel and marble, and a nearby stream (GEG 2019, Field Camp). There is a large presence of stream water below the lakes surface due to the dissolving of marble, but the groundwater runoff is not well known (GEG 2019, Field Camp). Lake Isabel's surface and deeper water temperatures rotate between warm and cold during the summer and winter (GEG 2019, Field Camp). This causes a mixing periods in the spring and fall which renews the deeper water as well as brings down oxygen (GEG 2019, Field Camp). Sedimentology in the deep lacustrine of the lake is a mix of sediments called gyttja, which occurs when stem sediments and lake sediments are combined (GEG 2019, Field Camp). Sedimentology in the littoral lacustrine consists of rocks, gravel, sand, and occasionally tree debris (GEG 2019, Field Camp). The average annual air temperature in the Lake Isabel region is 4°C with a mean of 160 days of precipitation per year (GEG 2019, Field Camp). The region has a mixed forest of deciduous and coniferous trees (GEG 2019, Field Camp). While deciduous trees dominate on the hills and around the lake; coniferous trees dominate on steep slopes along the lake and rocky hills (GEG 2019, Field Camp). The goal of this workshop was to determine the health of Lake Isabel by studying the general health of the lake and areas along it (GEG 2019, Field Camp). The following report will discuss the methodology used to conduct the general health study on Lake Isabel, the results, analysis, and interpretations of the data using graphs and maps.

2. METHODOLOGY

The limnological approach was used to determine the health of Lake Isabel. Limnology is the study and observation of inland bodies of water as ecological systems (Wetzel, 2003). To determine if the lake is healthy or not, general studies of Lake Isabel's physical and chemical

water properties, ecology, and sediments were conducted at 18 different sites (GEG 2019, Field Camp). To gather data, measurements were taken at 9 different depths at each site (GEG 2019, Field Camp). The water profile was observed using the YSI probe and the Van Dorn/ Multi-Parameter method (GEG 2019, Field Camp). These methods were used to find the Temperature (°C), pH, and Dissolved Oxygen (%) (GEG 2019, Field Camp). The temperature of a lake is significant in indicating its health as temperature is a large factor in biological activity (USGS,2005). The pH of the water is also an important factor in identifying a lakes health, as it indicates how acidic or basic the water is (Fondriest, 2013). Organisms prefer a specific pH level (Fondriest, 2013). Another element observed was the percentage of dissolved oxygen (DO). The DO% of the water is a large indicator of the productivity (Fondriest, 2013). The last property that was the lakes turbidity. The turbidity of a lake refers to the transparency of the water; the higher the turbidity, the murkier the water is (GEG 2019, Field Camp). The turbidity was measured using a secchi disk and an aquavue, to observe at what depth we could still see the secchi disk. Turbidity is essential in determining the health of a lake as when it is high, there is less sunlight reaching deeper parts of the lake which inhibits the plant growth (Britnnica, 2019). After measuring different elements of the water profile, the ecology of the lake and areas around it were observed. To study the vegetation around the lake the canopy density, the diversity of tree species, and the richness of trees were measured (GEG 2019, Field Camp). Canopy density was measured using a densitometer and is an indicator of the amount of sunlight that reaches the floor of the forest, therefore affecting the amount of photosynthesis occurring (Fort Collins Nursery, 2019). The tree species diversity is a large factor in how resilient a forest may be (Fort Collins Nursery, 2019). The richness of trees in the forest is also an important factor in the general health of Lake Isabel. Tree richness increases the amount of carbon dioxide absorbed from the atmosphere (Fort Collins Nursery, 2019). The second method used to observe the ecology of the lake was to observe the lake microorganisms. This was done by using plankton tows to collect microorganisms (Newton, R.J. et. al, 2011). Once the samples were collected they were brought back to the lab to measure the richness and diversity (Newton, R.J. et. al, 2011). The richness and diversity of microorganisms are an indication of the levels of productivity in a lake (Newton, R.J. et. al, 2011). Microorganisms are a large part of the food chain in lakes and any disturbance to them would affect the rest of the lake (Oxford, 2019). Finally, the sediments and topography of the lake were studied using lake sediment analysis and bathymetry. To collect the lake bottom sediment samples an Ekman Dredge was used (GEG 2019, Field Camp). Lake bottom sediments can indicate the water quality now and over time (Britannica, 2019). As the depth of the lake is a factor on which many of the indicators of lake health depend on, it was studied and mapped out using bathymetry (GEG 2019, Field Camp). Using a depth sounder, the deep and shallow regions of the lake were recorded. The results are then used to interpret the results of all of the previous studies (GEG 2019, Field Camp).

3. RESULTS AND ANALYSIS

3.1 WATER PROFILE OF THE LAKE

Lake Isabel's water profile was observed while studying the general health of the lake. These measurements were all taken during the summer. The temperatures (°C) of Lake Isabel were measured at 18 different sites using two methods: the YSI probe and the Multi-Parameter/ Van Dorn method (GEG 2019, Field Camp). The pH was also measured using two methods: the YSI probe and the Multi-Parameter/ Van Dorn method, and the dissolved oxygen (DO%) was measured using the YSI probe. The thermal layers of Lake Isabel occur at 0m-5m (epilimnion), 5m-12.5m (thermocline/metalimnion), and 12.5m- 20m+ (hypolimnion). The epilimnion layer is the layer closest to the surface (ScienceDirect, 2019). This thermal layer is where the bulk of the lakes photosynthesis occurs (ScienceDirect, 2019). The next layer is the thermocline layer (ScienceDirect, 2019). The metalimnion layer surrounds the thermocline which is where the temperature change is the most drastic (ScienceDirect, 2019). Since the metalimnion is located around the thermocline, there is a large range in which the temperature changes here (Lake Access, 2013). The last layer is the hypolimnion layer. This is the deepest and coldest area of the lake (Lake Access, 2013). The hypolimnion layer does not experience much influence from factors above the water's surface (Lake Access, 2013). This area of water can often become stagnant (Lake Access, 2013). Dissolved oxygen in this layer is typically used up faster than it can be produced (Lake Access, 2013). As Lake Isabel is a dimictic lake, the thermal layers cycle twice a year in the spring and in the fall (Lake Access, 2013). This cycling occurs due to the change in water temperature on the top and bottom layers, which changes the density (Lake Access, 2013). The fall and spring turnovers are essential in maintaining the lake's productivity and nutrient cycling (Lake Access, 2013).

3.1.1 TEMPERATURE

Figure 1.1 illustrates a strong relationship between the depth (m) and temperature (°C) measured at all 18 sites of Lake Isabel using the YSI probe. The temperature ranged between 23.53 °C to 4.4 °C when measured at 2.5m intervals; the highest temperature occurring at 2.5m and the lowest temperature occurring at 20m. The graph illustrates the difference in temperature between the three thermal stratifications which lowers drastically as the depths increase. In the epilimnion layer, there was a temperature range of approximately 23.53 °C to 20.21 °C. The thermocline layer had a temperature range of about 20.99 °C to 6.05 °C. The hypolimnion layer had a temperature range of about 7 °C to 4.4 °C. The decrease in temperature as the depth increases is caused by the level of exposure to sunlight (Britannica, 2019). Observing Figure 1.1 shows an indication of which layers in Lake Isabel would also have higher levels of oxygen and pH during this time of year, due to temperature having an affect on the two parameters (Britannica, 2019). Since many organisms have a preferred temperature at which they thrive, temperature can indicate the richness and diversity of organisms in each layer of the lake (Britannica, 2019). The richness and diversity of organisms in the lake have a direct correlation to DO levels (Britannica, 2019). The more photosynthesis that occurs, the more oxygen (Britannica, 2019). The levels of pH also decrease when the temperature of the lake increases (Lake Access, 1989). There was not much spatial variation in regards to the temperatures at the

different sites. The sites closer to the shores of the lake had slightly warmer temperatures as their locations were shallower. Drawing from the Figure 1.1, there would be an abundance of plant life in the epilimnion layer due to its temperature, causing an increase in decomposers in the hypolimnion layer (Fondriest, 2013). It can also be assumed from only the temperature that the DO% would be increased in the epilimnion layer and very low in the hypolimnion layer, due to the increased consumption of oxygen needed to decompose the excess plant debris that sinks to the bottom (Fondriest, 2013).

Figure 1.2 compares the temperature ($^{\circ}\text{C}$) measurements, at the same depths (m), of the YSI probe and the Multi-Parameter/ Van Dorn. Only the temperatures from site E1A1 were used. The two types of measurements illustrate similar patterns in which the temperature decreases as the depth increases. The temperature range of the YSI measurements were 23.53°C to 4.4°C where as the range for the Multi-Parameter Meter was 20.8°C to 7°C . The YSI probe produced a more rapid decrease in temperature in the thermocline compared to the Multi-Parameter meter which had a much more steady and gradual decrease in temperature. Although the temperatures for both were generally in the same range, they were still different. This could be due to the Van Dorn bottle accidentally capturing water from different depths in the lake. As well as the water being exposed to the outside air temperature prior to being tested by the Multi-Parameter device. When using the YSI probe there is much less room for user error but a longer calibration time.

3.1.2 POTENTIAL HYDROGEN (pH)

Figure 1.3 demonstrates the relationship between the depth (m) and the pH of the water in Lake Isabel. The measurements in this figure were taken at 18 sites using the YSI probe at increments of 2.5m. The pH ranges from 8.38 to 4.4 according to Figure 1.3. The measurement of 4.4 seems very unlikely and incorrect. If 4.4 is ignored, the range is 8.38 to 6.46 which is much more likely. It is difficult to see the changes in pH in regards to the epilimnion, thermocline, and hypolimnion layer but each team recorded a slight decrease in pH as the depth increased. This decreasing of pH as depth increases is due to the decomposition occurring in the hypolimnion layer (Lake Access, 1989). The decomposition of plant matter releases CO_2 which acts as carbonic acid in water (Lake Access, 1989). That being said, the presence of a low pH at the bottom of the lake is an indicator of lake productivity (Lake Access, 1989).. The higher the productivity, the more algae and plants are being grown at the top of the lake (Lake Access, 1989). This increases the amount of plant and algae debris that sink to the bottom to then be decomposed by bacteria or fungi (Lake Access, 1989).. Many organisms have a preferred pH ranging from approximately 6.5 to 8.4 (Lake Access, 1989).. If the pH increases or decreases too far out of this range it can cause mortality in the aquatic life (Lake Access, 1989).. As higher DO% and temperatures tend to indicate lower pH levels, there are natural chemical reactions that occur to balance out pH levels (Lake Access, 1989).. There was little to no spatial variation when the pH was measured at 18 sites, but there seemed to be one error at the point (4.4, 12.5).

Figure 1.4 illustrates the comparison between the pH measurements at the same depth(m) increments (2.5m) taken by the YSI probe and the Multi-Parameter meter/ Van Dorn. Only the pH values from group E1A1 were used to create this graph. There is a noticeable difference in the results of the compared methods of data collection. The measurements from the YSI probe were all considerably lower than the results of the Multi-Parameter Meter/ Van Dorn method. The differences in results were mostly likely due to user error. The YSI probe has a longer calibration period in order to accurately measure the pH. This calibration time could have been misjudged or cut short causing inaccurate results. The Multi-Parameter/ Van Dorn method also could have accidentally caused measurement of water outside of the specific depth, by trapping water from upper levels of the water. The data from the Multi-Parameter device is also incomplete so it is difficult to compare the two methods. Both of the results show a slight decrease in pH at 5m, an increase at 7.5m and then another decrease at 10m. This is mostly likely due to a change in DO% or temperature as you move into the thermocline layer of the lake.

3.1.3 DISSOLVED OXYGEN

Figure 1.5 in the appendix depicts the changes in dissolved oxygen (%) in regards to depth (m) at 18 different sites in Lake Isabel. The DO% ranges from 122.2% to 3.6%; with the highest percentage occurring at 0m, and the lowest percentage occurring at 12.5m. The most evident trend is the decrease of DO% as the depth increases. These decrease is due to increased oxygen consumption in the hypolimnion at this time of year (Fondriest, 2013). The increased plant and algae growth in the epilimnion during the warmer summer months causes higher dissolved oxygen percentage in the upper layer of the lake, as well as increased amount dead plant matter which sinks to the bottom of the lake (Fondriest, 2013). This plant matter is then decomposed by bacteria and fungi which consumes oxygen and releases CO₂ (Fondriest, 2013). At majority of the study sites, there is an increase of DO% at a depth of 7.5m (Figure 1.5). This small spike in oxygen is caused by the decrease in temperature in the thermocline layer of the lake. The lower temperature allows for higher solubility of oxygen in the water (Fondriest, 2013). While observing Figure 1.5, there appears to be a substantial amount of spatial variation in the levels of dissolved oxygen. Dissolved oxygen percentage can be affected by many factors such as the external air, plants, and wind (Fondriest, 2013). Sites that are located closer to the shores of Lake Isabel are more likely to have a higher DO% due to the exposure of more oxygen from the atmosphere (Fondriest, 2013). Dissolved oxygen is also a product of photosynthesis which occurs in the epilimnion layer (Fondriest, 2013). Sites that are more exposed to the sun have a higher capability for photosynthesis, and therefore higher levels of DO. The dissolved oxygen percentages throughout the lake are strong indicators of lake health (Fondriest, 2013). Since aquatic organisms need oxygen to thrive, a higher percentage of dissolved oxygen gives the aquatic life an increased chance in surviving and reproducing (Fondriest, 2013). The DO% is also an indicator of the amount of photosynthesis happening in a lake, which decreases the carbon dioxide (CO₂) levels and increases DO% (Fondriest, 2013).

3.1.4 ALL PARAMETERS

All of the accurate results from measuring the temperature, pH, and dissolved oxygen % of Lake Isabel indicate a normal dimictic and stratified lake. These three parameters are all interconnected and the key to understanding the biological activity and productivity of the lake. The temperatures of the lake have a direct and indirect influence on the DO% and pH levels of the lake (Britannica, 2019). Colder water temperatures cause an increase in DO and pH (Britannica, 2019). The cooler temperatures are capable of holding more dissolved oxygen which aids in the survival of aquatic organisms and species (Britannica, 2019). Where there is an increase in DO%, there is typically an increase in plant and algae life (Fondriest, 2013). As there is more plant life on the epilimnion layer, more plant debris begins to sink to the hypolimnion layer (IISD, 2019). This plant debris is then decomposed by bacteria and fungi, which consumes oxygen in the bottom layer of the lake (IISD, 2019). The decomposition of plant matter decreases the DO% as well as the pH (IISD, 2019). The overconsumption of dissolved oxygen can occur in the hypolimnion layer which can cause it to become almost stagnant (IISD, 2019). As the atmospheric temperatures changes, so does the temperature of the epilimnion. The cooling or warming of the epilimnion causes it to lose or gain density (IISD, 2019). When the density and temperature difference between the top layer and the hypolimnion is decreased, they start to mix and the lake turns over (IISD, 2019). These turnovers occur in the spring and fall and are significant factors in the cycling of nutrients and oxygen throughout the lake (IISD, 2019). This renews dissolved oxygen levels in the hypolimnetic water, and brings the low oxygen hypolimnetic water to the surface to be reoxygenated (IISD, 2019). This newly oxygenated and warm water will now be perfect for the growth of plants and the cycle will occur again (IISD, 2019). Now that the oxygen is replenished at the bottom of the lake, the pH will increase slightly (IISD, 2019). In the winter the epilimnion layer will be the coldest and least dense layer of the lake and the hypolimnion will be the warmest and most dense (IISD, 2019). It will take some time after the turnover for the thermal stratification to become stable again (IISD, 2019). These parameters are indicative of the health of a lake, and are all co dependant on one another.

3.2 LAKE TURBIDITY

Figure 2 illustrates a map of the mean depth transparency at 18 different sites in Lake Isabel. The range of depth transparency was 0.7m to 18.99m; with the highest turbidity occurring on the south-west bay and the lowest turbidity occurring in the north. The lake bottom was reached while taking turbidity measurements at 4 different sites. There is evident spatial variation in the measurements of Lake Isabel's turbidity. The sites that reached the bottom were located mainly on the south shores of the lake; with one occurring on the northern shore. The most common mean depth of transparency was between 7.5m and 10m. This occurred mainly all over the lake, scattered around the edges, and excluding the north shore. On the days that the turbidity measurements were taken, the weather was mostly cloudy or partly cloudy, and windy. This weather causes lake turbidity to be raised as more particulate matter is suspended in the

water, lowering the depth transparency (Fondriest, 2014). The wind increases the water velocity, inhibiting the particles from settling onto the bottom of the lake (Fondriest, 2014). The lack of sun due to cloud coverage also makes it more difficult to see at higher depths (Fondriest, 2014). One of the most critical factors in turbidity levels is the presence of phytoplankton in the epilimnion layer (Fondriest, 2014). When there is sunlight, the warm, oxygenated epilimnion layer becomes a home to an abundance of algae, plants, and phytoplankton (Fondriest, 2014). These organisms increase the turbidity of the lake (Fondriest, 2014). Vegetation surrounding the lake can also affect the turbidity (Fondriest, 2014). Where there are trees, there is usually soil. The soil and small plant debris from the forest floor gets swept from the shores and into the water, increasing the amount of suspended particles (Fondriest, 2014). The richness of lake microorganisms, lake sediments, and bathymetry can all decrease the depth transparency, which raises turbidity (Fondriest, 2014). The mean depth transparency measures of Lake Isabel are indicative of a generally healthy lake. The turbidity remains fairly low throughout the majority of the lake. Low turbidity indicates water clarity and the clearer the water is, the more sunlight will penetrate the water (Fondriest, 2014). When sunlight can reach deeper into the water, it creates more opportunity for photosynthesis and therefore more oxygen in the water (Fondriest, 2014).

3.3 VEGETATION SURROUNDING THE LAKE

Figure 3 portrays the different types of vegetation at 18 sites around Lake Isabel. The types of vegetation are categorized into three types: coniferous, deciduous, and mixed. The forest is dominated by mixed vegetation around Lake Isabel, but there are certain areas where coniferous trees are the majority. There is not much spatial variation as the forest is predominantly mixed, but coniferous trees tend to dominate more on steep slopes around the south of the lake, as well as on rocky hills (Enzor, 2019). Some factors that could affect the vegetation type are the amount of sun, soil quality, the amount of rain, and the exposure to harsh environments that a tree receives (Enzor, 2019). Coniferous trees are able to withstand harsh weather conditions such as cold temperatures, ice, and snow (Enzor, 2019). This causes them to thrive on steep hills and summits (Enzor, 2019). At a slightly higher altitude than the rest of the trees, they are exposed to more of the harsh elements that would damage deciduous trees (Enzor, 2019). The quadrant that my team was assigned (E1A) was along the east shore of Lake Isabel. This site had a rocky and steep terrain, with a closed canopy. There was a density of 27 trees that measured over 15cm at approximately breast height, and a diversity of 4 species of trees. These species include white cedar, white spruce, and birch trees, indicating a dominance of coniferous trees.

3.4 LAKE MICROORGANISMS

Figure 4.1 and Figure 4.2 in the appendix exhibit richness and diversity of lake microorganisms at 18 sites, using the horizontal profile and the vertical profile. The horizontal profile has a range of 1 to >100 organisms and 3 to 13 different species. The vertical profile has a range of 2 to 80 organisms and 2 to 10 species. According to the figures, there is quite a high

amount of spatial variation. The horizontal and vertical profiles both have large ranges in their diversity and richness. The differing amounts of richness and diversity are quite scattered throughout the 18 sites. Most of the organisms were found on the south-west side of the lake. The shallower waters and sun exposure on the south west side of the lake are factors in increasing the richness of the lakes microorganisms (Newton, R.J.et al, 2019). The sunlight penetrates the epilimnion layer of the lake, increasing the photosynthetic potential (Newton, R.J.et al, 2019). The increased amount of nutrient availability in this area causes richness of the microorganisms (Newton, R.J.et al, 2019). The areas of the lake with the most microorganism diversity are quite scattered, but are somewhat focused towards the centre of Lake Isabel. This areas increases species diversity due to their mixed/ organic sedimentology (Newton, R.J.et al, 2019). Species diversity in lakes are dependant on nutrient availability and location. These mixed and organic sediments contain many nutrients needed to thrive such as oxygen, nitrogen, and phosphorus (Newton, R.J.et al, 2019). This area also had the lowest mean turbidity, allowing sunlight to penetrate further into the lake and allow for more photosynthesis. There are slight differences between the horizontal and vertical profiles of the lake. The horizontal profile has a larger range for both diversity and richness, and the vertical profile has smaller ranges. When collecting a horizontal profile sample, the plankton net is covering more area, as well as being pulled in the epilimnion layer of the lake, which is rich in microorganisms due to sun exposure and oxygen levels (Newton, R.J.et al, 2019). When collecting a vertical profile sample the plankton net covers less area and collects a sample from the thermocline/ epilimnion layer, which is not as rich in organisms as just the epilimnion layer (Newton, R.J.et al, 2019). Richness and diversity of microorganisms can be affected by many factors such as land use, and the water profile (Newton, R.J.et al, 2019). Depending on the type of land use surrounding the area, pollutants can reach the lake through surface runoff (Newton, R.J.et al, 2019). These pollutants can include nutrients such as CO₂, nitrogen, and phosphorus (Newton, R.J.et al, 2019). These nutrients get absorbed into the sediments and can play a large factor in the growth of microorganisms (Newton, R.J.et al, 2019). Elements of the water profile also affect microorganisms. The temperature of the water increases the rate at which biological activity occurs (USGS, 2005). When there is more photosynthesizing potential, there will be more key nutrients and dissolved oxygen in the lake (Newton, R.J.et al, 2019). The pH can affect the microorganisms in the lake. If the pH remains in the preferred zone of 6.5 to 8.5, it gives the organisms a place to thrive (Lake Access, 1989). The lakes microorganisms need dissolved oxygen to survive. Closer to the surface, the DO% increases and therefore so do the microorganisms (IISD, 2019). As well as being affected by the water profile, the organisms can also affect the water characteristics (Newton, R.J.et al, 2019). Based on the results of the study on lake turbidity and lake microorganisms, I believe that this lake is oligotrophic. The first indication of this is the mean for the secchi disk measurements for lake turbidity. Transparency in oligotrophic lakes is fairly high (Logue, J.B.et al, 2012). Another factor is the low species diversity but high organism richness (Logue, J.B.et al, 2012). There is also still quite a bit of oxygen in the hypolimnion before experiencing fall turnover (Logue, J.B.et al, 2012).

3.5 LAKE SEDIMENT

Figure 5 illustrates the spatial variation of lake sediments in Lake Isabel at 18 different sites. The sediment types were split into four: gyttja, organic, inorganic, and mixed sediments. Depth (m) range in which the sediments were deposited is 1m to 39.1m; with mixed sediment being the shallowest, and gyttja being the deepest. The variation of each sediment type is quite scattered. Gyttja usually occurs in the centre of Lake Isabel, organic sediments occur from the north to the south of the lake, inorganic sediments are not produced here, and mixed sediments are concentrated towards the south of the lake. Mixed sediments (a mixture of organic and inorganic sediment) are the most common in this lake, They are located in the far north and south, in fairly shallow waters. The depth of a lake is a contributing factor to the types of sediments produced. Gyttja is produced in waters ranging from 18m to 39.1m. These are moderately deep waters as it is made from the mixing of sediments from the lake which have been produced through biological and chemical activity, as well as sediments from exterior sources (Limnology, 2011). It contains no oxygen and is able to preserve organic material (Limnology, 2011). Organic sediment is also deposited in fairly deep waters ranging from 13.9m to 26m as it commonly originates from organic material such as plant debris and animal remains (Britannica, 2019). Inorganic sediments are typically found in the littoral zones of lakes as they are more prone to weathering and harsher environments (Britannica, 2019). Mixed sediments are found in fairly shallow depths ranging from 1m to 14.3m as they obtain their sediment from organic plant debris, and inorganic clastic sediments from the littoral zone (Britannica, 2019). All of the sites mapped (Figure 5) could be completely different from where these sediments were first deposited (Britannica, 2019). Factors such as wind, waves, bank erosion, and exterior land use could have caused these sediments to become resuspended and deposit in another location (Britannica, 2019). The gyttja is the deepest forming sediment in Lake Isabel; due to organic sediments gathering right above the lake bed where the water is commonly nutrient filled, but low in dissolved oxygen (Britannica, 2019). The organic sediments in Lake Isabel are deposited in fairly deep waters, but close to the littoral zone of the lake. Because of the nature and size of organic sediments, they tend to be found closer to the shores where there is more organic debris (Britannica, 2019). The mixed sediments are very scattered around Lake Isabel and have a medium to shallow depth range. The sites that observed mixed sediments are all closer to the north and south edges of the lake and only a few were observed in the middle. Since mixed sediments contain inorganic, clastic, material the distance from the littoral zones that they are deposited at depends greatly on the coarseness (size) of the sediment (Britannica, 2019). Inorganic sediments that contain smaller particle sizes tend to drift towards the centre (sand, mud, silt) and bigger sizes (rocks, gravel, pebbles) stay towards the edges of the lake (Britannica, 2019). When the lake is surrounded by steep hills and boulders, it is more common to have larger pieces of clastic material around the littoral zone due to erosion (Britannica, 2019).

3.6 BATHYMETRY

Figure 6 depicts the differences in depth (m) throughout different areas of Lake Isabel. The shallowest points occur along the littoral zone of the lake, and around the island. The deepest points occur around the coordinates (414707, 5071177). The 10 measurements taken by my team (E1A) validate the approximate depths on the bathymetry map in regards to the 5m increments used to draw in depths. The depth sounder was quite accurate as it uses sound to measure the distance between the probe and the lake bed. The graduated line did not give off very accurate measurements for a few different reasons. The first reason being the weather; the day the measurements were taken it was extremely windy and overcast. The wind caused the graduated line to move away from being perpendicular to the canoe, which invalidated the depth measurement. Another uncertainty I experienced with the graduated line was that if we had managed to get the line to stay still, our canoe would drift away from our point because of the wind and the lack of weight in the anchor; again invalidating the measurement. The last uncertainty I have about measuring the depth using the depth sounder is false answers. The depth sounder could take the distance of a rock or plant underneath the canoe as opposed to the lake bed.

4. CONCLUSIONS

After conducting studies on the water profile, lake turbidity, vegetation, microorganisms, sediments, and depths of Lake Isabel It was observed that:

The water profile of the lake:

- A temperature range of 23.53 °C to 4.4 °C .
- A slowly declining pH as the depth increases
- Healthy amount of DO% but not much use

The lakes turbidity :

- Had a range of 0.7m to 18.99m of mean depth transparency
- The deepest parts of the lake are concentrated into the middle

The vegetation surrounding the lake:

- Composed of mainly mixed forests
- Some areas where coniferous trees dominate
- Coniferous trees were found on the higher, rockier, steeper slopes

The lake microorganisms:

- The horizontal profile has a range of 1 to >100 organisms and 3 to 13 different species
- The vertical profile has a range of 2 to 80 organisms and 2 to 10 species
- Organism richness occurs in the more nutrient rich layers of the lake
- Organism diversity is dependant on the nutrient availability
- Richness occurs near the south- west shore of the lake
- Diversity near the centre of the lake

The lake sediments:

- Deposition range of 1m to 39.1m
- Lake Isabel is predominantly mixed sediments which occurred around the littoral zone

- Lake Isabel has no sites of just inorganic matter

The lakes bathymetry:

- Very shallow towards to littoral zone and the islands shores
- Deepest just north-east of the island
- Graduated lines measurements were not accurate

All of the biotic and abiotic factors contributing to the biological activity in Lake Isabel are all somehow co- dependant on each other. After concluding the general studies of Lake Isabel, It would be considered a healthy lake. All of the characteristics studied can encourage the productivity of the lake. Since Lake Isabel is a dimictic lake, it has a spring and autumn turnover. Due to the timing of the study and the season, the stratified layers within the lake were at their most defined and it showed a larger contrast between the epilimnion and hypolimnion layers in the lake. Although the study does work to indicate the lake's health, there were still limitations. More time could have been used to properly calibrate the probes and take more caution with the accuracy of the results. Another limitation was the age of the machines and how some of them would break apart. In order to truly study the health of the lake, we would need to monitor it over the course of a year, to observe the turnovers and how they affect the productivity of the lake.

5. REFERENCES

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6. APPENDIX

1. WATER PROFILE OF THE LAKE

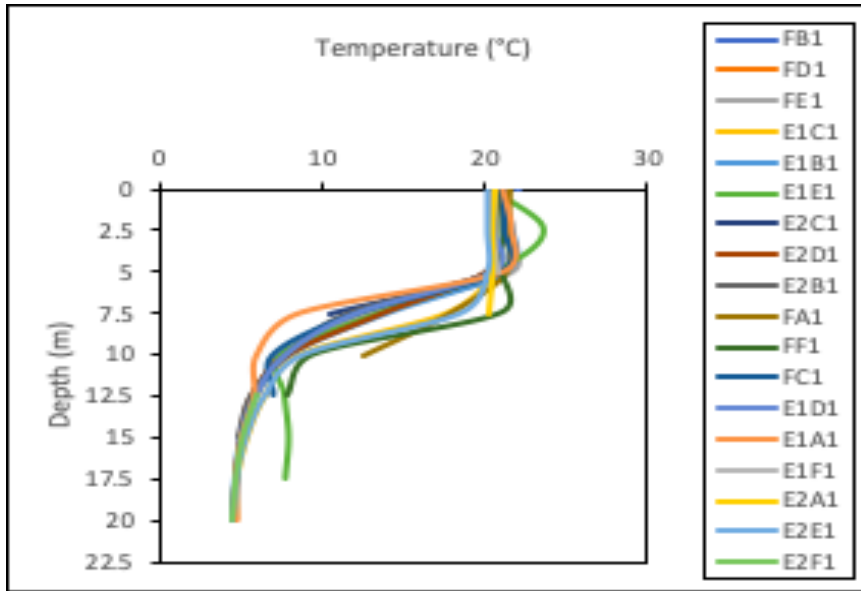


Figure 1.1 Lake Isabel water temperature profile

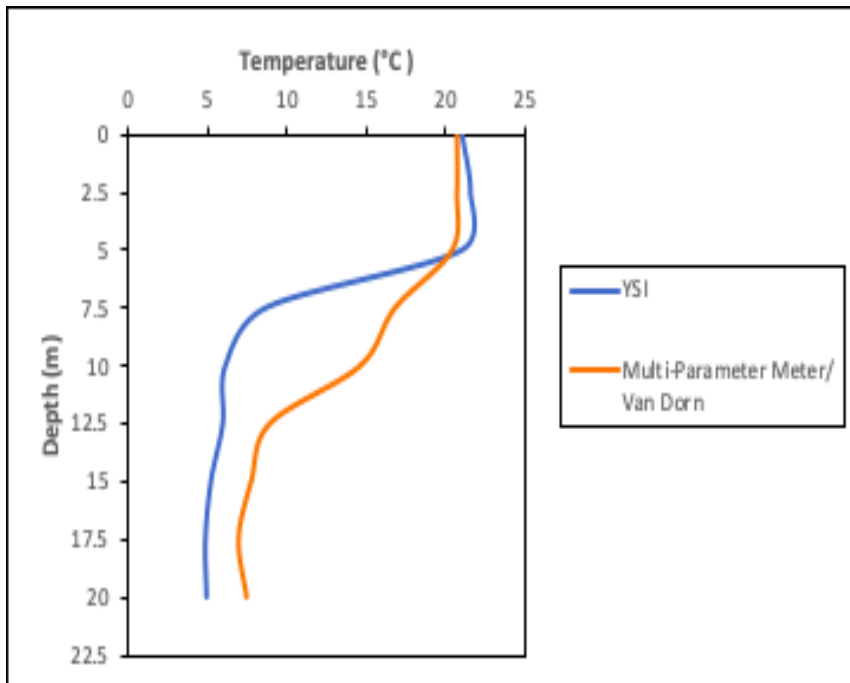


Figure 1.2 Lake Isabel water temperature profile YSI and Multi-Parameter Meter/ Van Dorn comparison

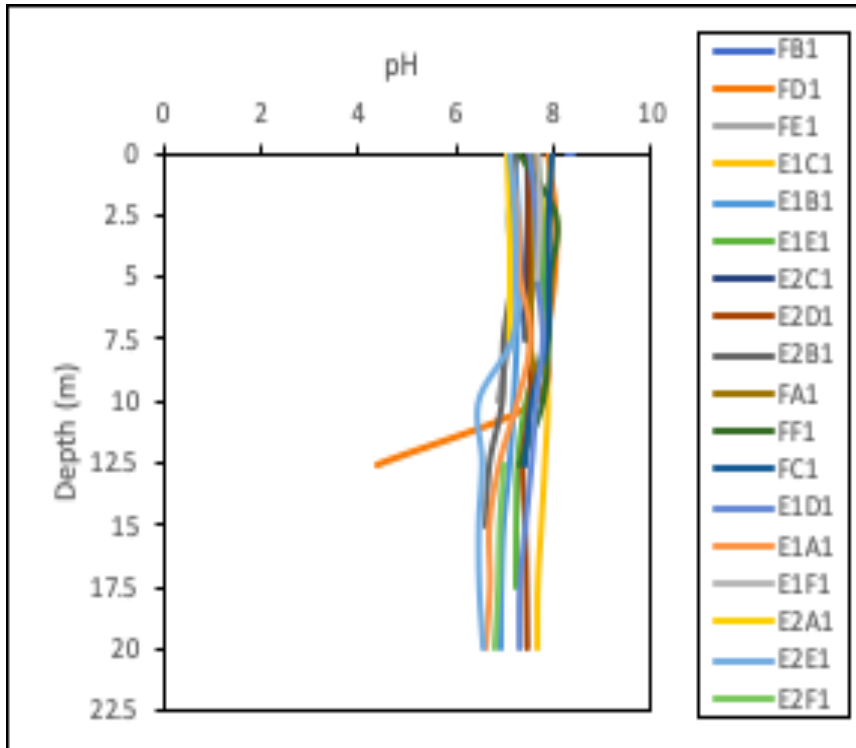


Figure 1.3 Lake Isabel water pH profile

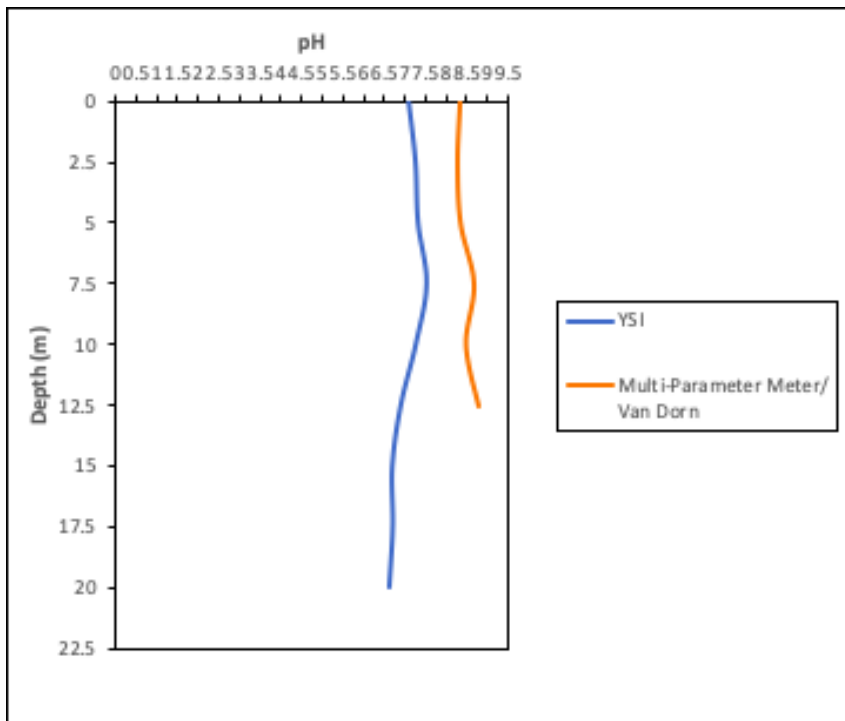


Figure 1.4 Lake Isabel water pH profile YSI and Multi-Parameter Meter/ Van Dorn Comparison

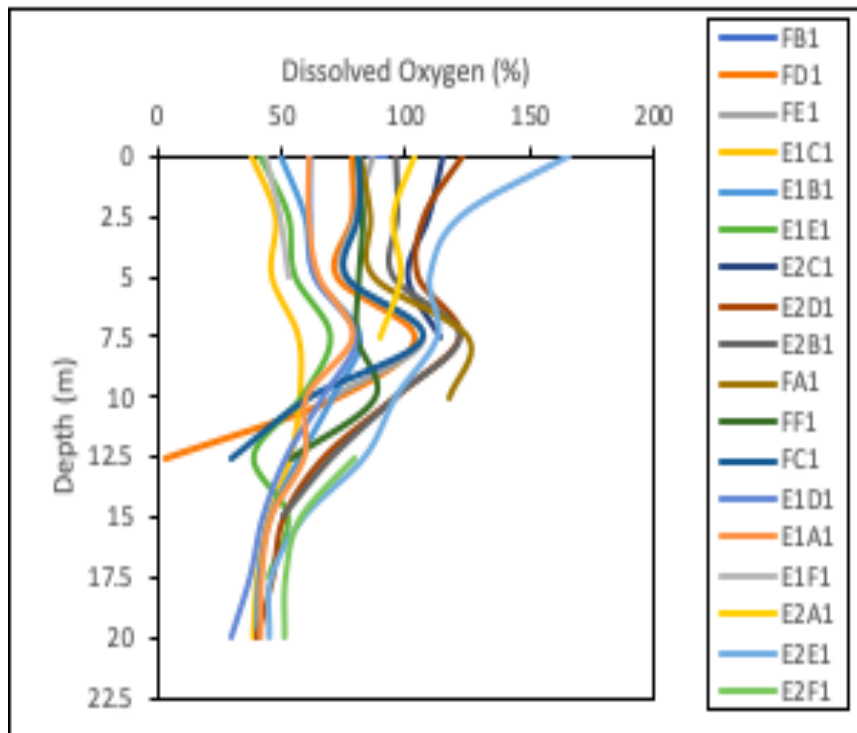


Figure 1.5 Lake Isabel water dissolved oxygen profile

2. LAKE TURBIDITY

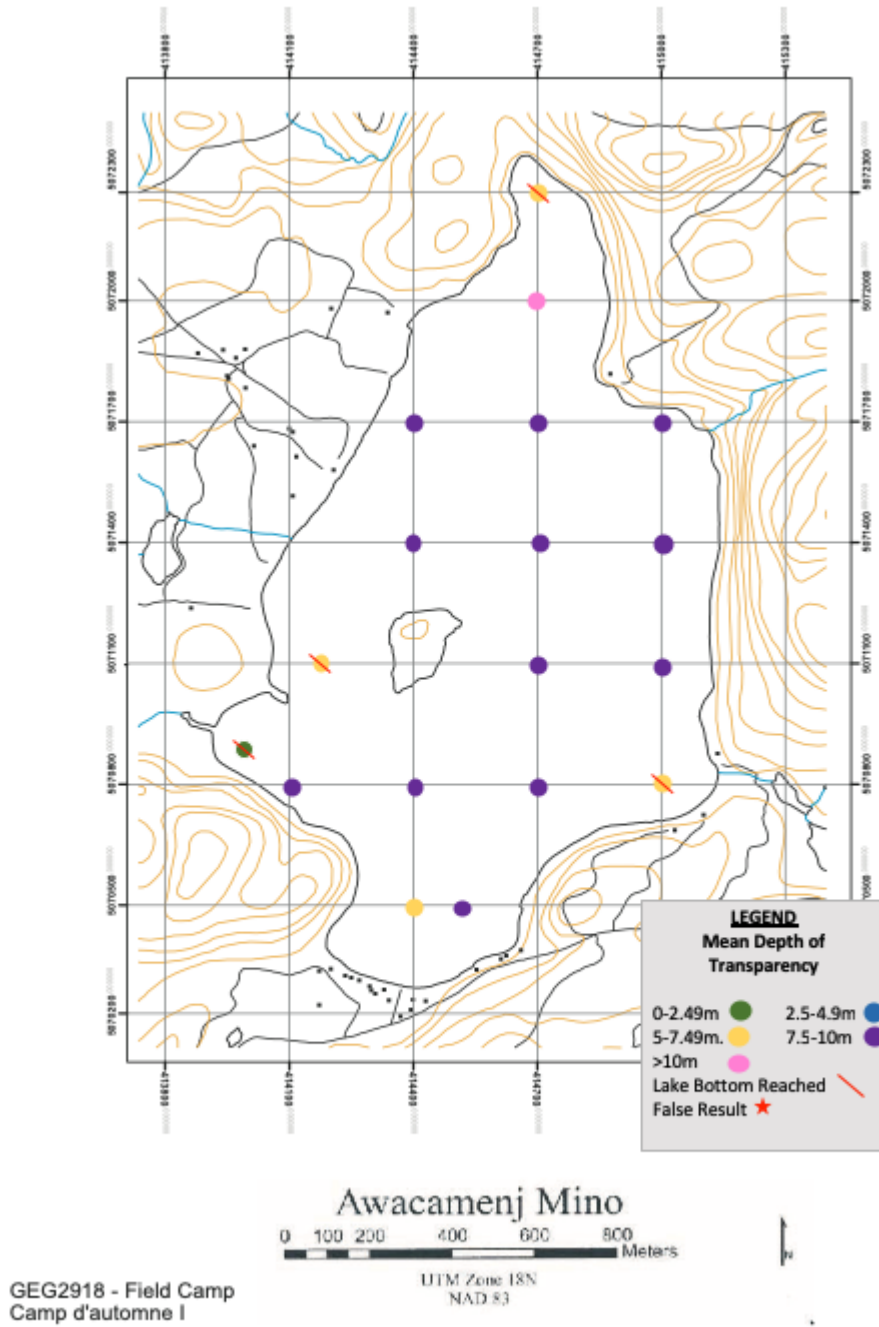
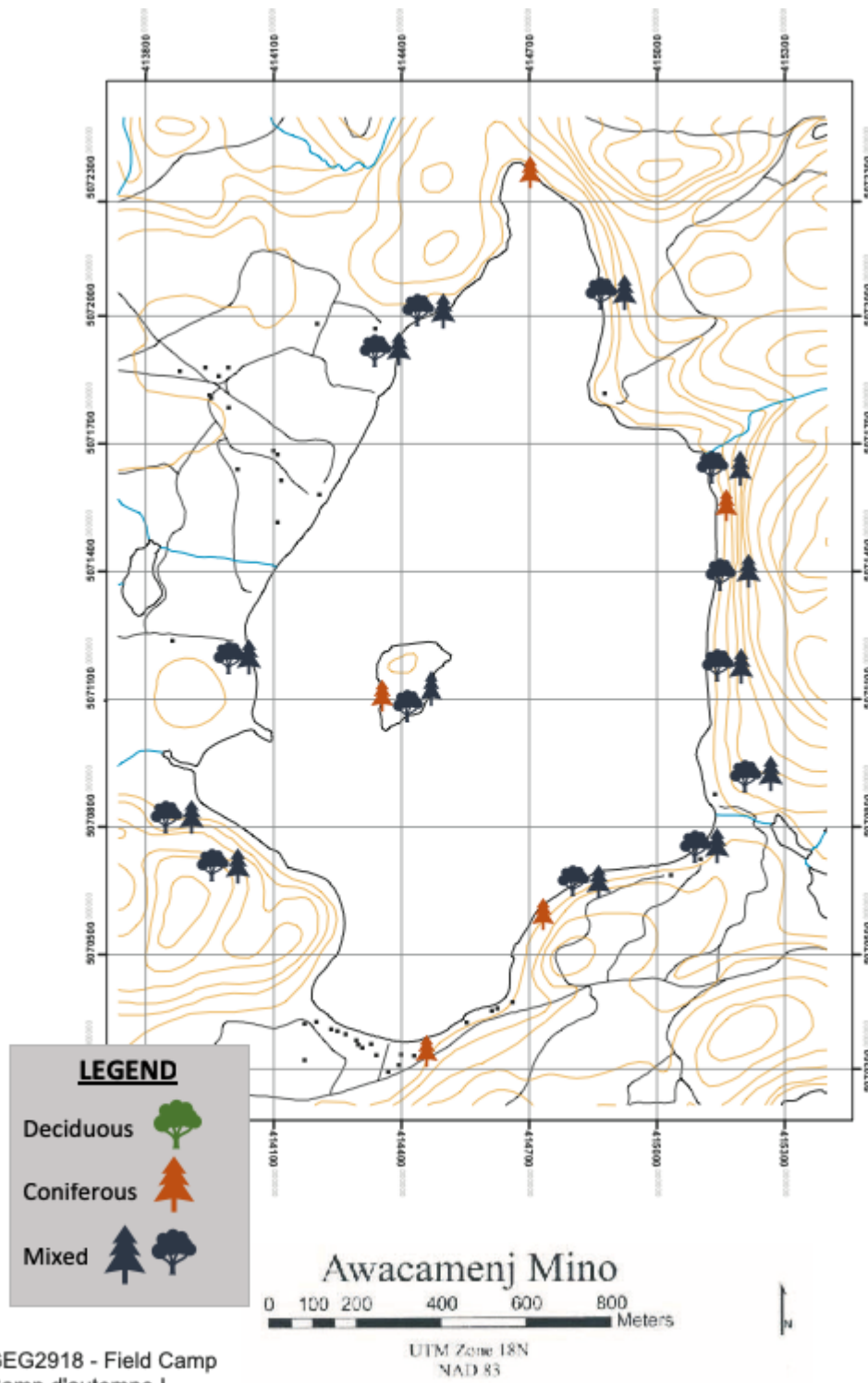


Figure 2 Lake Isabel mean turbidity

ca

3. VEGETATION



GEG2918 - Field Camp
Camp d'automne I

Figure 3 Vegetation Surrounding Lake Isabel

4. LAKE MICROORGANISMS

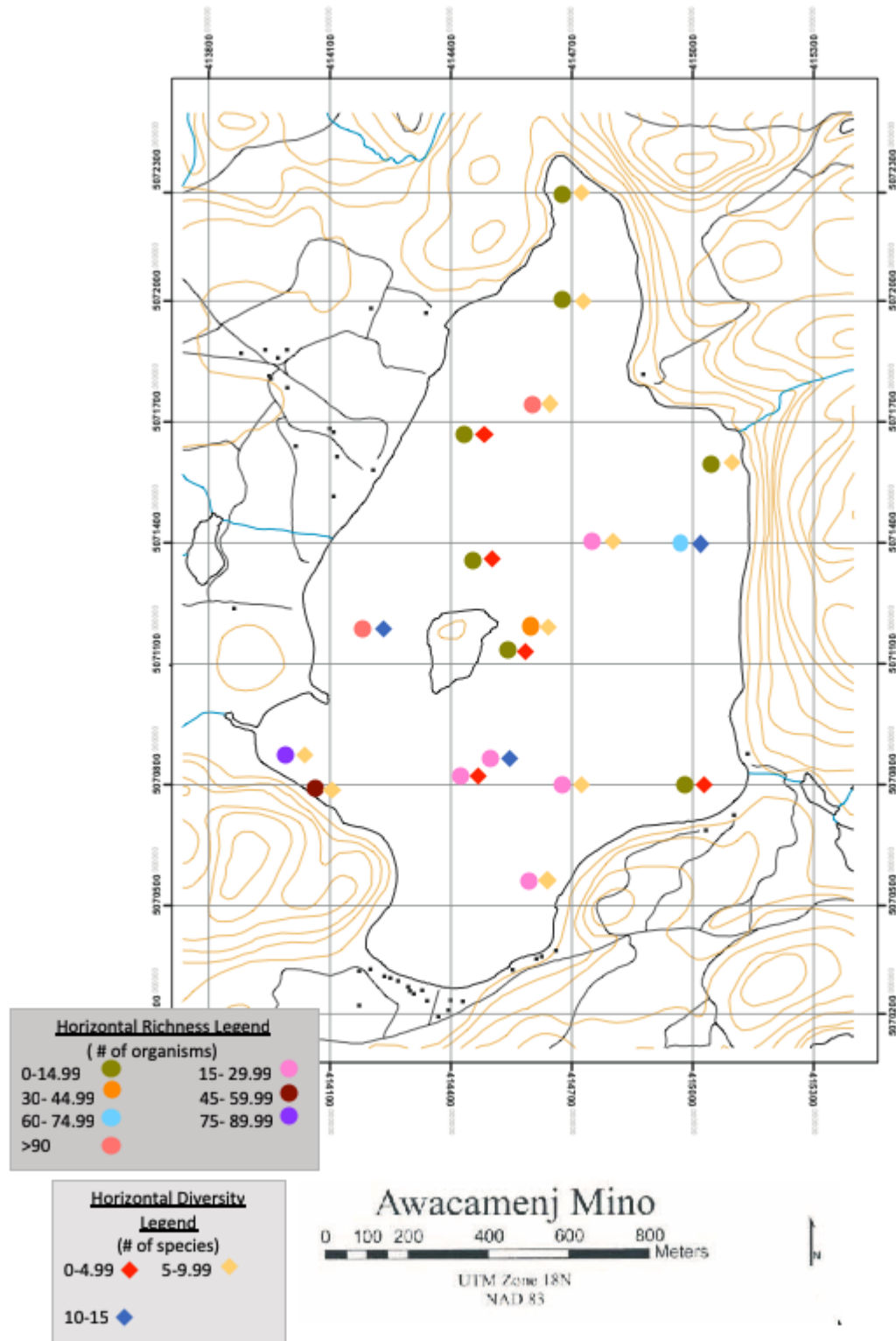


Figure 4.1 Lake Isabel horizontal profile of richness and diversity of microorganisms

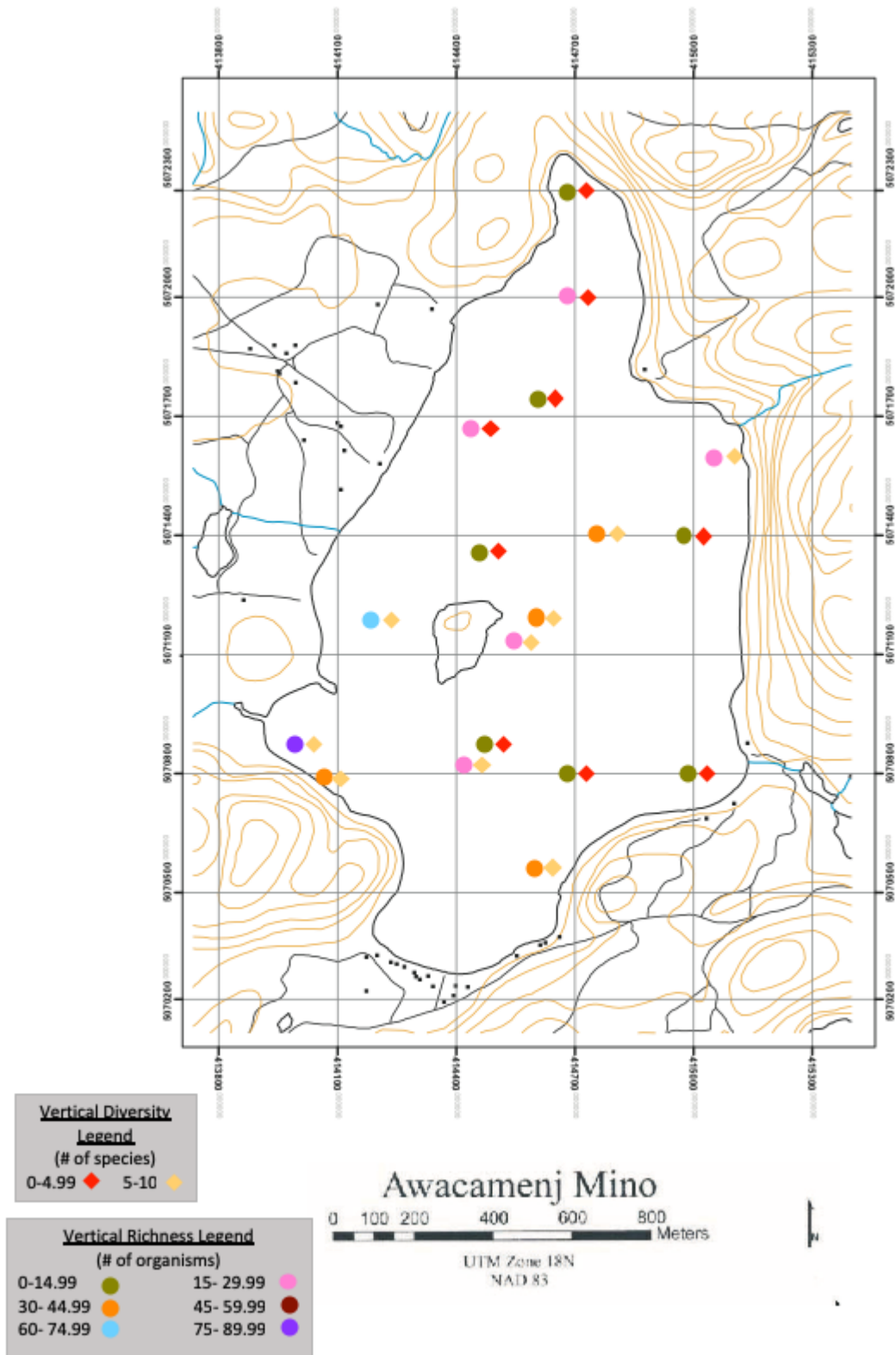


Figure 4.2 Lake Isabel vertical profile of richness and diversity of microorganisms

5. LAKE SEDIMENTS

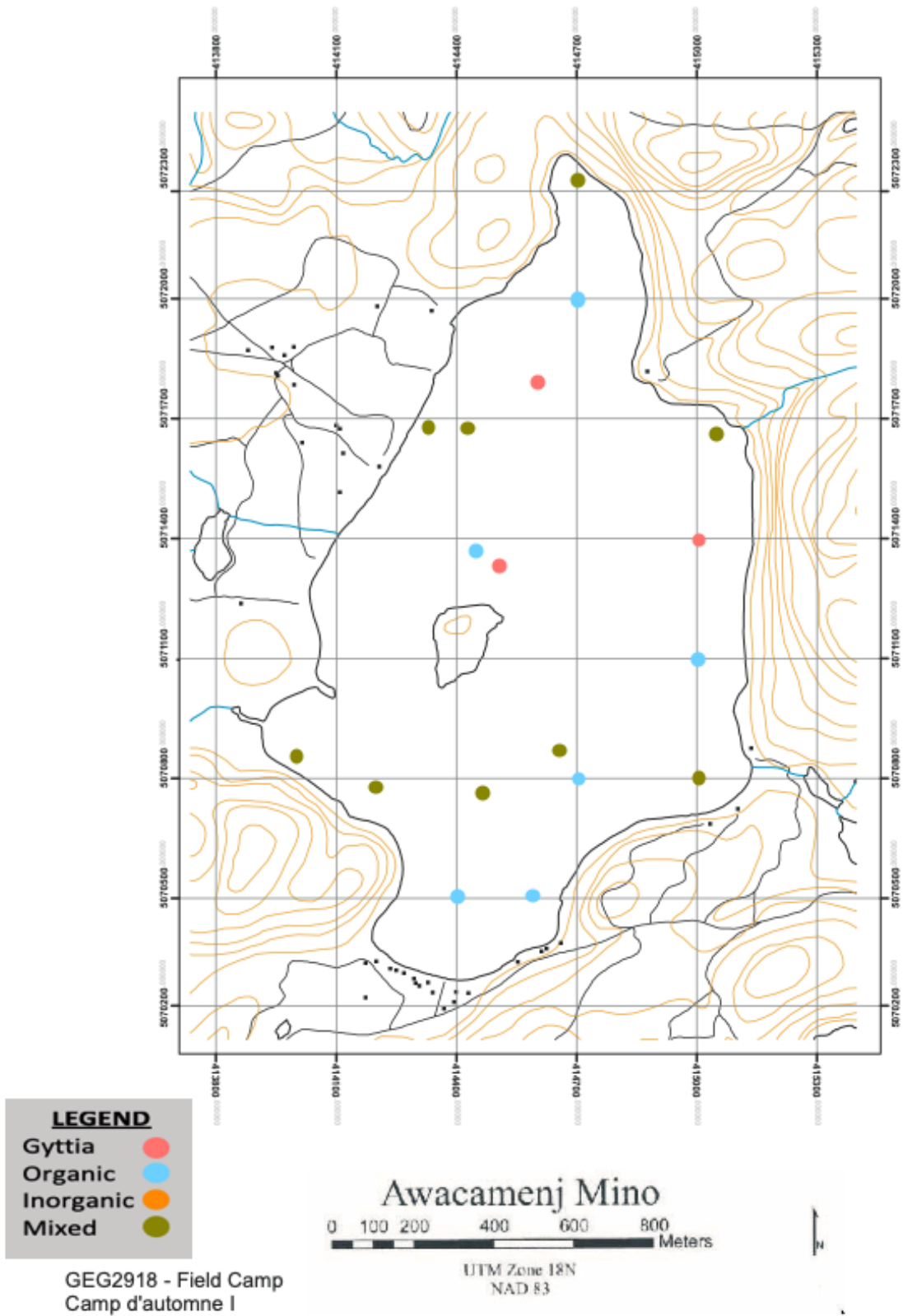


Figure 5 Lake Isabel sediment types

