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# Phosphorus retention in phosphorus ponds and internal eutrophication

## A case study of lake Vombsjön and its catchment area



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# List of abbreviations

P: phosphorus

[P]: phosphorus concentration

P ponds: phosphorus ponds

pH: hydrogen potential

mg/L: milligram per liter

in: inlet

out: outlet

SRP: Dissolved phosphorus or Soluble Reactive Phosphorus

PP: Particulate Phosphorus

ORP: Oxidation-Reduction Potential

# Introduction

Scania, the southern part of Sweden which is also called with its local name “Skåne”, is a well-known region for its agriculture fields and is most of the time nicknamed as the “pantry” of Sweden. The lakes, rivers and ponds are also very present in this Swedish landscape and the water is used for all the cultures around but also for the water production.

Vombsjön, the lake of Vomb (Scania), is one of the fresh water reservoir managed by the Swedish company Sydvatten AB. Today, more than 450 000 inhabitants have the privilege to use the high quality drinking water produced thanks to this lake.

However, the intensive agriculture around Vombjön is threatening the quality of the water. Actually, the fertilizers, used for the crops, are rich in phosphorus and the phosphorus runoffs could lead to premature eutrophication of the lake. The sudden increase of phosphorus concentration in the water has many consequences as the rapid growth of algae blooms and the risk of cyanobacteria toxin production which are very harmful for human beings and animals.

In order to prevent the occurrence of algae blooms and cyanobacteria, one water management action had been led by Sydvatten: the construction of phosphorus ponds (P ponds) upstream from Vombjön to “catch” the phosphorus and avoid to contaminate the lake. The first study consists in determining the phosphorus capacities retention of five ponds which are unknown for now.

Fertilizers and intensive agriculture are not the only one thing to increase the phosphorus concentration of the water. The accumulation of dead planktonic organisms (algae, bacteria and animals) in the bottom of the lake for years are cached by the sediments and can release the phosphorus contained in these sediments according to the water conditions and so, speeding up the eutrophication of the lake. That’s why, the second study is to investigate the water column by analyzing the chemical parameters and the hydrologic conditions of Vombjön to present the internal eutrophication of the lake.

In order to address these situations, the general context of eutrophication will be explained in the first part of the report. Furthermore, the different methods and materials will be described in the second part. Then, the results will be discussed in the last part and view perspectives of the problem might be proposed.

# I General presentation of Sydvatten and workplaces

## 1. Sydvatten AB

Sydvatten AB, founded in 1966, is a municipally owned company producing drinking water for about 900,000 inhabitants in the region of Skåne. The company supplies drinking water to 16 municipalities in the southern region of Sweden including Lund and Malmö, the third biggest Swedish city. The head office is located in Malmö and the research department office is in Lund.

With its 80 employees, Sydvatten works constantly to ensure the supply of drinking water to its municipalities. Many water catchments are used for drinking water: Bolmen (1,650 km²), Ringjön (400 km²) and Vombsjön (450km²), as shown in figure 1.

Each year, approximately 75 million cubic meters of water are produced which corresponds to about 2,400 liters per second.


**Figure 1 : Localisation of Sydvatten installations**

## 2. The lake of Vomb: Vombjön

### *2.1 Vombjön and its catchment area*

Vombjön is the lake used in the study concerning the phosphorus. It is located at 20km to the east of Lund City. The landscape of the lake is mostly composed of forests, agricultural lands and pastures. Vombjön surface area is about 12km² and the water volume is about 80 Mm$^3$.

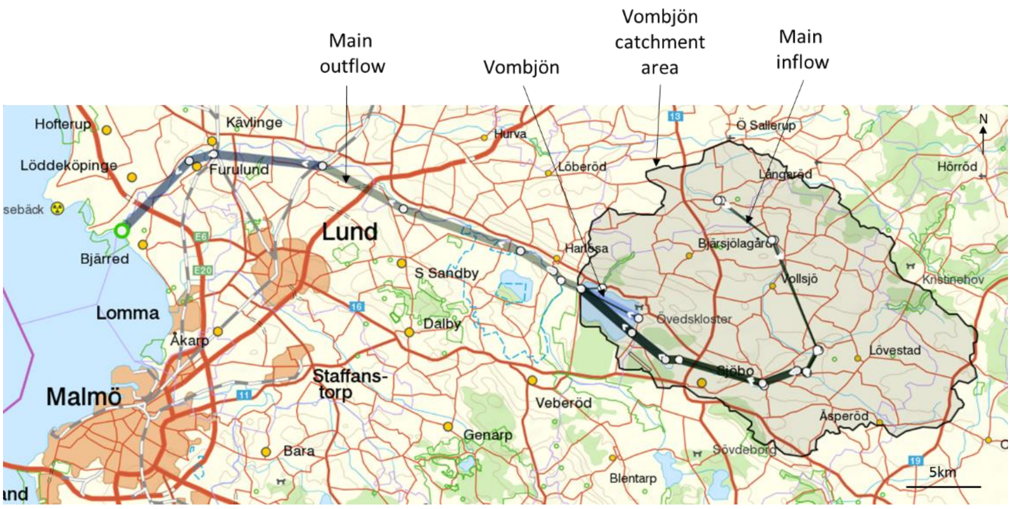



**Figure 2 : Localization of Vombsjön in Scania and its catchment area**

The catchment area (figure) is about 444km² and is mostly located in the northeast of the lake. Last, the time residence of the water is about two or three months.

### *2.2 The inlets and outlets*

The Vombjön water comes from four inlets and goes out from 1 outlet. The main inlet is located in the southwest of Vombjön and is called Björkaån (with an average inflow of $4m^3/s$). The two other inlets are Torpsbäcken and Borstbäcken with average inflow of $1.5m^3/s$ both. Furthermore, the fourth inlet is not visible on the map (figure3) but it is located between the point 2 and 3.

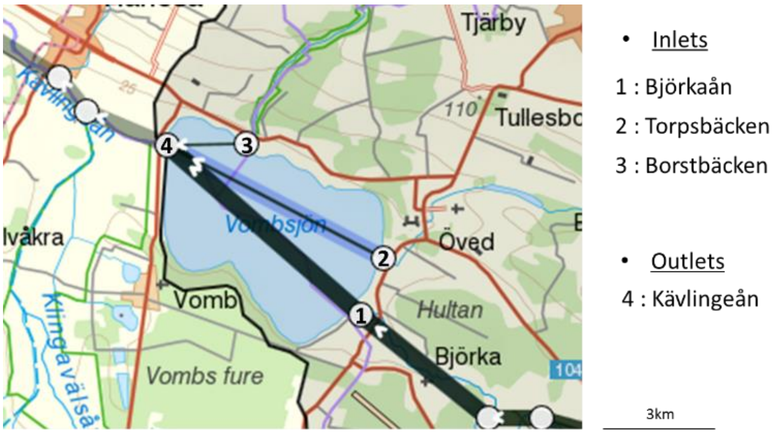



**Figure 3: Vombsjön Inlets and Outlets**

Last, the outflow is point 4, Kävlingeån and its average outflow is about $4m^3/s$.

## 3. The water production of Vombjön

The water treatment plant of Vomb, which is also called "Vombverket" in Swedish, was put into service in 1948. Vombverket's type of water purification is filtration and water softening. its capacity is about 1,500 liters/s.

After two or three months of residence in the lake, the water is pumped and is channeled into one of the 54 constructed infiltration basins with a total area of 400,000 square meters. Then, the water passes through gravel and sand before arriving to a natural groundwater storage. Then it is pumped once again and arrives in Vombverket. First of all, an aeration is needed to remove iron and manganese. After that, the softening water is useful to eliminate calcium ions contained in hard water thanks to NaOH. The soft water is collected on the top of the softening reactor and goes to the mixing chamber where it is mixed with ferrous chloride to create flocks. The last step consists in removing the flocks thanks to the rapid sand filters before a last disinfectant and the distribution of the drinking water to the inhabitants.

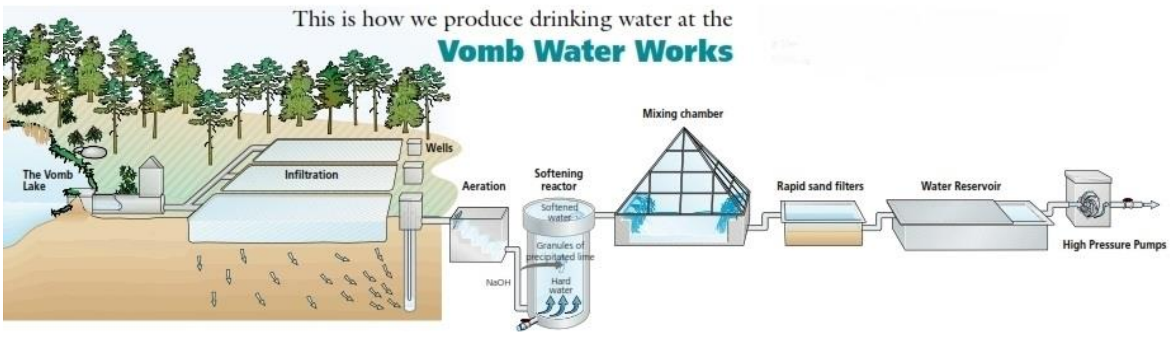



**Figure 4: Water production in Vombverket**

# II The phosphorus aspects

## 1. Phosphorus

### *1.1 General presentation*

Phosphorus is considered as the most important nutriment in a lake because it is the limiting nutrient for plant growth in freshwater systems. It is also the most important element to evaluate the water quality of a lake. Phosphorus naturally occurs in lakes in minute quantities measured in parts per billion (ppb). A growth of phosphorus concentration incites on an increase of the vegetable mass and as a consequence on the turbidity of the water.

Many forms of phosphorus are present in the water and two main classes can be considered: Total Dissolved Phosphorus (TDP) and Particulate Phosphorus (PP) (figure5). TDP is also divided in two parts, the inorganic and the organic part. The dissolved inorganic Phosphorus (SRP), also called Soluble Reactive Phosphorus, is composed in majority of orthophosphate which is easily available for plants.

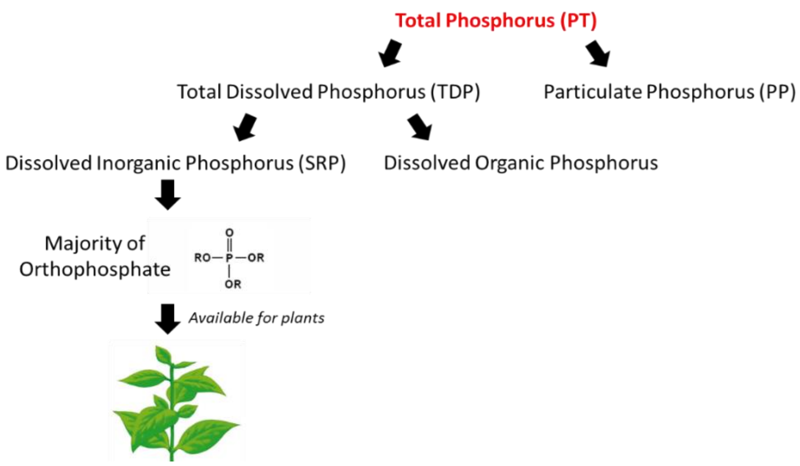



**Figure 5: Different kind of phosphorus**

Phosphorus is not considered directly as toxic for the human and animal health. However, phosphorus is dangerous for health when it causes an increase of the growth of algae, most of the time are toxic algae.

### *1.2 Phosphorus and algae uptake*

The Calvin cycle is the principal mechanism that leads to the conversion of $CO_2$ into sugars by plants, algae, photosynthetic bacteria (…) that use chemicals as an energy source instead of light. The main product of Calvin cycle Glyceraldehyde 3 Phosphate (G3P) which is used to produce sugar, main energy of plants. All the reaction takes place in the chlorophyll of the plants.

Phosphorus plays an important role in Calvin cycle. First of all, to reduce 3-Phosphoglycerate is G3P, ATP (Adenine tri phosphate) has to be transform in ADP (Adenine Diphosphate) and NADPH releases Phosphorus (Pi). The next step consists in regenerated RuBP (Ribulose bi-phosphate) from G3P by using energy as ATP.

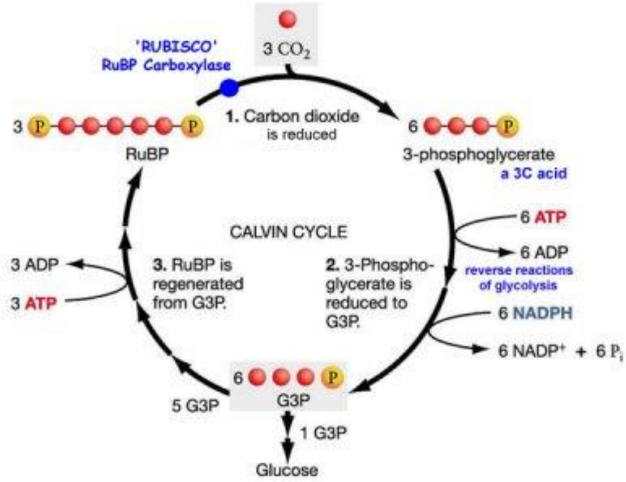



Figure 6: Calvin Cycle

This is an important cycle which produces energy as sugar by using another form of energy as ATP. Whiteout ATP, mainly composed of phosphorus, plant energy can't be produced and they marked to die.

## *1.3 Sediment phosphorus*

Phosphorus is also present in the soil and the sediments of a lake or a pond. Sediments phosphorus which can be found in the sediments can be divided into three parts: Phosphorus minerals, precipitates of surface and occluded forms.

Concerning the phosphorus minerals, there are few lead compounds as: Calcium bound (Ca-P), Iron bound (Fe-P) and Aluminum bound (Al-P) (…).
Moreover, precipitates of surface are composed of crystals described previously but they are precipitated on the surface: Calcium phosphate precipitate on calcium carbonates, Aluminum phosphate precipitate on aluminosilicate or on gibbsite and Iron Phosphate precipitate on iron oxides. To last, occluded forms are composed of: calcium phosphate included into matrices of calcium carbonates, Aluminum phosphate included into matrices of iron oxides (…)

## *1.4 Phosphorus in a water column*

In a water column of a lake, many reactions occur to have either the SRP (Dissolved phosphorus or Soluble Reactive Phosphorus) form or the PP (Particulate Phosphorus) form, depending on few conditions like the weather conditions for example. At the surface of the water, SRP is mainly converted on PP thanks to the phenomenon of photosynthesis of the blooms algae, present in the top of the water column.

In oxygenated water, an important reaction is realized: the complexation between SRP and the oxidized form of iron, Fe(III) which is called the ferric phosphate. This new form of complexation increases the amount of phosphorus in the water and is most of the time fix into the bottom sediments. In the presence of decreased oxygen levels at the interface, Fe(III) is reduced to Fe(II) and results in the release of SRP in the water. The ferric phosphate complex, combined with the anaerobic bacterial conversion of PP to SRP also leads to a significant increase of SRP in the water.

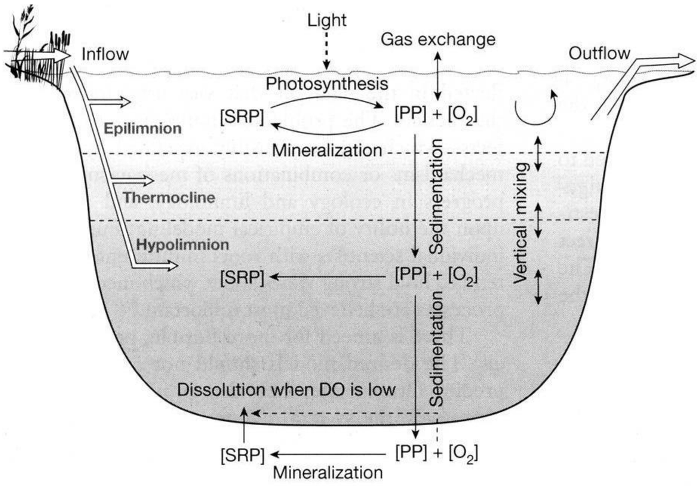



Figure 7: Phosphorus in a water column

The sediments of a lake can have phosphorus concentrations of 50-500 times the concentration of phosphorus in the water. Indeed, sediments can be an even larger source of phosphorus than external inputs. This can be explained by the fact that nutriments are not mixed in the epilimnion during the summer by of the stratification of temperature and so, SRP concentrations are concentrated in the lower hypolimnion until fall turnover.

# 2 The P ponds and their catchment area

## 2.1 P ponds, wetlands

One water management action commonly used in Sweden to trap the phosphorus is the construction of phosphorus ponds (P Ponds). The main aim of theses constructions is catching the phosphorus coming mainly from the land runoffs, charged in phosphorus of the fertilizers used. The P retention is the result of physical and biogeochemical natural processes as: sedimentation for PP, sorption and precipitation and uptake by plants for DP.

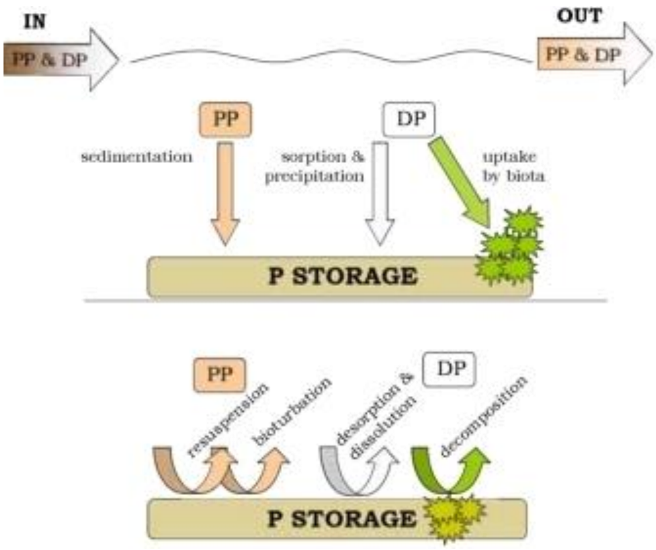



Figure 8: Catchment of P in P Ponds

PP (particulate phosphorus) is retained in the water column when the water velocity decrease, depending on the flow and the depth of the wetland (figure 8).

However, this P trap is reversible. That's why few parameters are needed to take account to determine the availability of the pond to catch P:

- Internal processes sedimentation and resuspension
- Adsorption and desorption by sediments
- Biological uptake and decomposition of algae and plants

The first part of this study consist in analyzing the P retention capacity of few ponds in order to determine if these wetlands are a sink or a source of P.

## *2.2 Phosphorus inlets in ponds*

To determine the availability of P retention by ponds, it is important to know the quantity of P which is brought in the water ponds by many ways. P can come from the waste water, septic tank of inhabitants, industries and also from the lands.

Thanks to the website http://vattenwebb.smhi.se, it has been possible to find the catchment area where all the P ponds studied were included. The information is the next one:

- Sub catchment area name: Mynnar I Vombsjön
- AROID number: SE 617629-136719
- Surface: 42.2 km²
- P concentration coming from **waste water**: 0 kg/year
- P concentration coming from **septic tank**: 117 kg/year
- P concentration coming from **industries**: 0 kg/year.

Animals dejections are also a cause of P release. A **cow** release 55g/day/animal, a **horse** release 60g/day/animal and a **sheep** release 15g/day/animal.

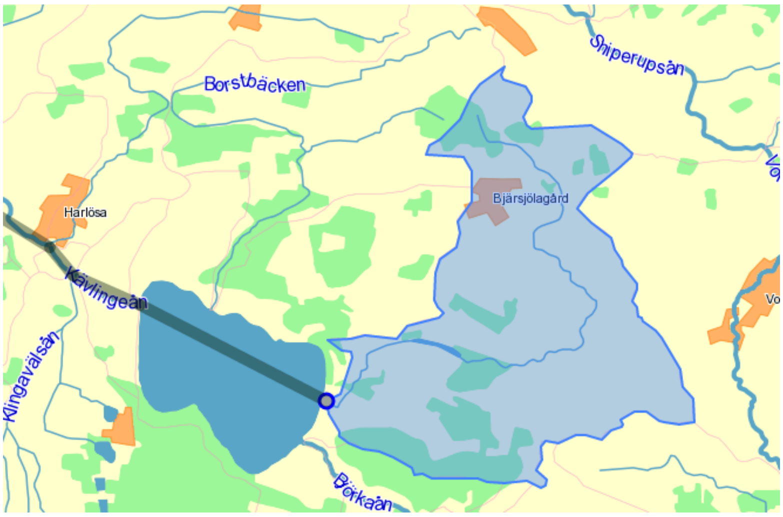



**Figure 9: Subcatchment area of Vombsjön**

# 3 The parameters for P determination

Few parameters are needed to determine the evolution of the phosphorus concentration without measuring it directly.

- **Weather**

The weather is analyzed in the P determination because the rain cause runoffs, depending on its intensity, which collect the phosphorus from the fertilizers and bring the phosphorus to the closest pond or river. The wind is also an important parameter because it results on the resuspension of the sediments causing an increase of turbidity and a phosphorus release. The air temperature can lead to a warming or a cooling of the water.

- **Temperature**

The temperature is a factor which can lead to a liberation of the phosphorus into the water, in particular, the sediments phosphorus. Actually, this factor impacts directly adsorption/desorption thanks to the increasing of the reaction speed: adsorption speed of phosphate is higher when the temperature is high. Moreover, the temperature has an impact on the biological process: an increase of the temperature leads to an increase of bacterial activities and organic matter mineralization on the bottom on the lake. The bacterial activities are also responsible of the ORP decrease at the sediment surface leading to the reduction of $Fe^{3+}$ and phosphate liberation in the water.
Oxygen concentrations are also influenced by the temperature. Indeed, higher the temperature is, lower the oxygen concentration is.

- **pH**

pH is also an important factor to evaluate the phosphorus presence in the water. An increase of pH can cause a remobilization of the phosphorus. Actually, an increase of pH in a water column is the result of photosynthetic activity responsible of the $CO_2$ decrease: $CO_2/HCO_3^-/CO_3^{2-}$ balance is modified. However, all the orthophosphate forms in solution depend on the pH as seen in figure 10.

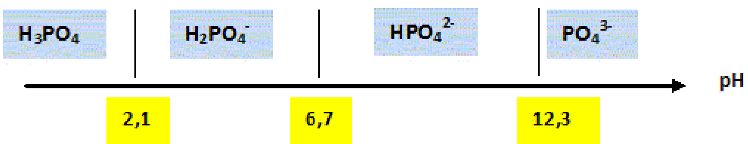



**Figure 10: Diagramme pH - phosphate**

pH has an effect on the availability of the phosphorus to link with the iron and modify the sedimentation process. It can be explained by the competition between hydroxyl ions and $PO_4^{3-}$ on a complex of two iron atoms.

### ❖ Turbidity

An increase of phosphorus in the water causes a growth of the plants and the consequence is a less clean water. The turbidity is also a sign of the resuspension of the sediments of the water, full charged of phosphorus. It can depend on the flow (more the water in calm, more the turbidity is low), the wind intensity, plants proportion in the pond (…). These values can be used: NTU < 5: clear water, NTU > 30: slightly turbid water, NTU >50: turbid water

### ❖ Flow

The flow is an essential element to know the evolution of the phosphorus concentration. A high flow causes the mobilization the sediments, their movements and as consequence, they can drop the phosphorus they contain.

### ❖ Oxidation-Reduction Potential (ORP)

ORP is the balance between the oxidized form and the reduced form of a couple and represents in a way the content in oxygen of the sediment.

In oxidizing conditions, when ORP is raised, the report $Fe^{3+}/Fe^{2+}$ increases and so, phosphate in solution can be linked with the ferric iron; Phosphate is transformed into precipitated or adsorbed form. In low ORP conditions, the $Fe^{3+}$ is reduced in $Fe^{2+}$, phosphate ions are freed in the interstitial water of the sediment. As a consequence, dissolved phosphor can then migrate to the column of water.

The next equations can explain the situation of the oxygenated water:

$$O_2 + 4Fe^{2+} + 4\,H^+ \rightarrow 4\,Fe^{3+} + 2\,H_20$$

$$Fe^{3+} + PO_4^{3-} = FePO_4$$

### ❖ Oxygen

The variations of oxygen in the water can come from few parameters: consummation of oxygen by animals, production of $O_2$ by plants the day thanks to the photosynthesis and consummation during the night, gas exchange at the water surface, movements of the water, flows (…)

### ❖ Conductivity

The conductivity is usually used to measure the ionic content is a solution. More the water contains ions like Calcium $Ca^{2+}$, Magnesium $Mg^{2+}$, Sodium $Na^+$, Potassium $K^+$, Bicarbonate $HCO_3^-$, sulfate $SO_4^{2-}$ and chlorine $Cl^-$, more it will be able to conduct an electric power. As a consequence, the conductivity will be high. Usually, the conductivity is always the same but an increase of conductivity means there are inlets of ions, because of pollutants or thanks to a natural way. Only a lab work can determine the increase of a certain ion.

# III Vombjön lake and the eutrophication phenomenon

## 1. What is the eutrophication phenomenon?

Eutrophication is a natural phenomenon characterized by an excessive growth of plant and algae in the water. Because of the human activities, eutrophication is premature and threats the environment and even the water quality.

The origin of this phenomenon is an excessive amount of nutrients, like nitrogen and phosphorus, coming from fertilizers and which are flushed from the land into rivers or lakes by rainwater. These essential nutriments cause an important growth of aquatic plants and algae, responsible of the production of algae blooms. Being light, the algae layer is on the surface of the water and they prevent sunlight for the other plants who died. At the bottom of the lake, dead plants are taken over by bacteria decomposers using oxygen and release of part the nutriments, still useful for blooms producers. After few years, the oxygen levels reach a point where no life is possible and all the organisms living in the water die.

Nowadays, eutrophication phenomenon is a real problem because of the algae blooms. Algae contain colonies of cyanobacteria and can drop their toxins in the water if they are in specifics conditions. Toxins are most of the time dangerous for the human and animal health and very difficult to remove because of the great variety.
Currently, the deal is to avoid the eutrophication phenomenon to prevent the water quality.

**Figure 11: Eutrophication in Vombsjön harbor and water**

Most natural lakes have phosphorus concentrations between 1 and 100 µg/L. On one hand, lakes are qualified of "Oligotrophic" when the phosphorus concentration is very low and are between 5 and 10 µg total phosphorus per liter. On the other hand, polluted lakes have a phosphorus concentration below 100µg/L and are qualified of "Hypereutrophic".


**Figure 12:Eutrophication and P amount**

## 2. Thermocline and eutrophication

Thermal stratification is a phenomenon which can be seen only during the summer and is an indicator of the water quality. Indeed, the thermal stratification is at the origin of phosphorus releases by the sediments of the lake.

During the summer, the solar radiations provoke a thermal stratification. Most of the heat coming from solar radiations heat the few first meters of the water column and the wind is a generator of currents which distribute the heat in all the water column. This first layer is called “Epilimnion”. Then two other layers are created, the “Metalimnion” with warm less dense water and the “Hyplimnion” which is at the bottom of the lake and composed of cold water. No exchanges are possible between the different layers of the lake.

Another important factor of a thermal stratification is the modification of oxygen concentration depending on the depth. At the bottom of the lake, an important bacterial activity is sets and explains the low oxygen concentration. At this period, most of the aquatic animals live in the epilimnion because of the lake of oxygen in the bottom. Moreover, because of the bacterial activity, an important amount of $CO_2$ is releases in the water which creates an acidification of the water and a decrease of pH. This acidification is the cause of the dissolution of calcium carbonate $CaCO_3$, coming from animal shells, in calcium $Ca^{2+}$ and carbonate ion $CO_3^{2-}$. Depending on the substratum of the lac, salicylic acid $Si(OH)_4$ might be present in the water if the substratum is composed of qwartz coming from rocks. A thermal stratification is also the cause of other ions releases like $H_2S$, $NH_4+$, $CH_4$ (…) by the bottom sediments. As a consequence, all these parameters explain the decrease of conductivity in the water column.

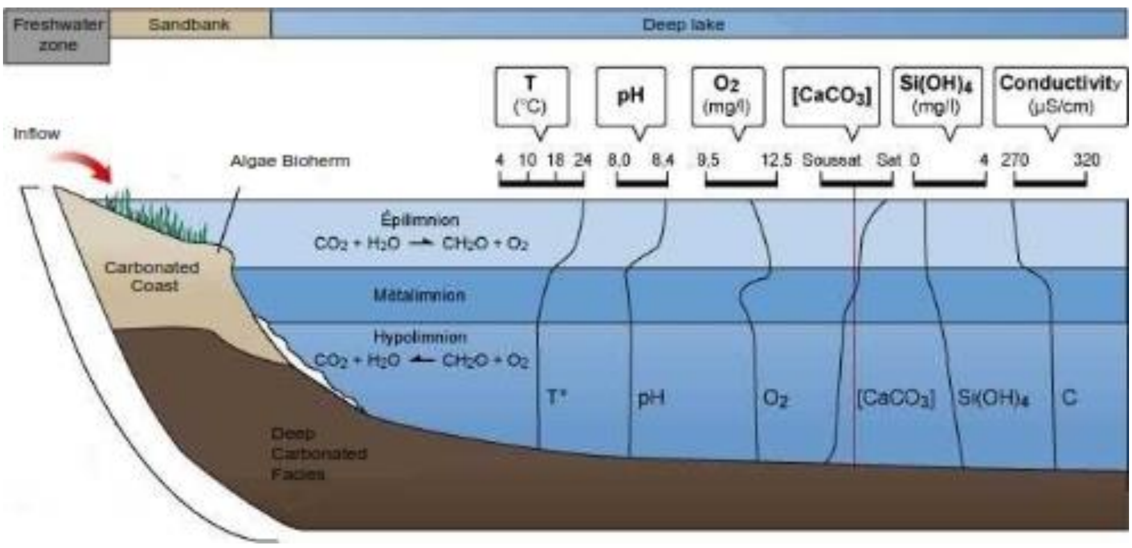



**Figure 13: Evolution of parameters in a thermocline**

The two main goals of the internship were to:

- Investigate the retention of phosphorus in phosphorus ponds in the catchment area
- Investigate the water column (profile) and hydrologic conditions in lake Vombsjön

Field works have been realized between 13th of June and 11th of August 2016 (8 weeks).

# I Workings places: Vombjön and the P Ponds

## 1. Vombjön

The first step of the profile measurements of water column in Vombsjön was to choose six judicious points. The locations have been chosen depending on the depth, the inflows and outflows in order to have a good representation of all the aspects of the lake. A GPS has been used for locating precisely the six locations presented below.

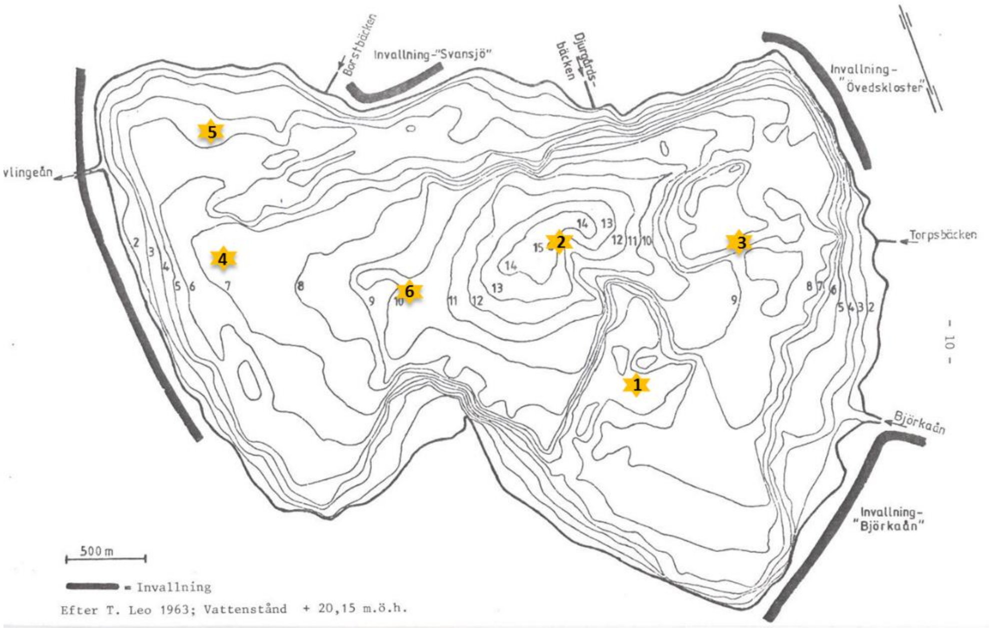



**Figure 14: Localization of working points - Vombsjön**

Coordinates WGS84 at six locations

L1: 55°40.486 N 13°35.556E (depth 7m)

L2: 55°41.085 N 13°35.539E (depth 14m)

L3: 55°40.689 N 13°36.348 E (depth 6m)

L4: 55°41.340 N 13°34.128 E (depth 7m)

L5: 55°41.853 N 13°34.114 E (depth 4m)

L6: 55°41.047 N 13°34.736 E (depth 6m)

## 2. Ponds localization

Ponds studied have been chosen because one of the main inflow is coming from those ponds. There are all located in north-east of the lake, in its catchment area. All the ponds are built next to fields or even sometime in the middle of the field (Pond 2 – Inlet). Each pond is isolated even if Pond 3 (Vassen) and Pond 4 (Mölledammen) are link together (figure 15).

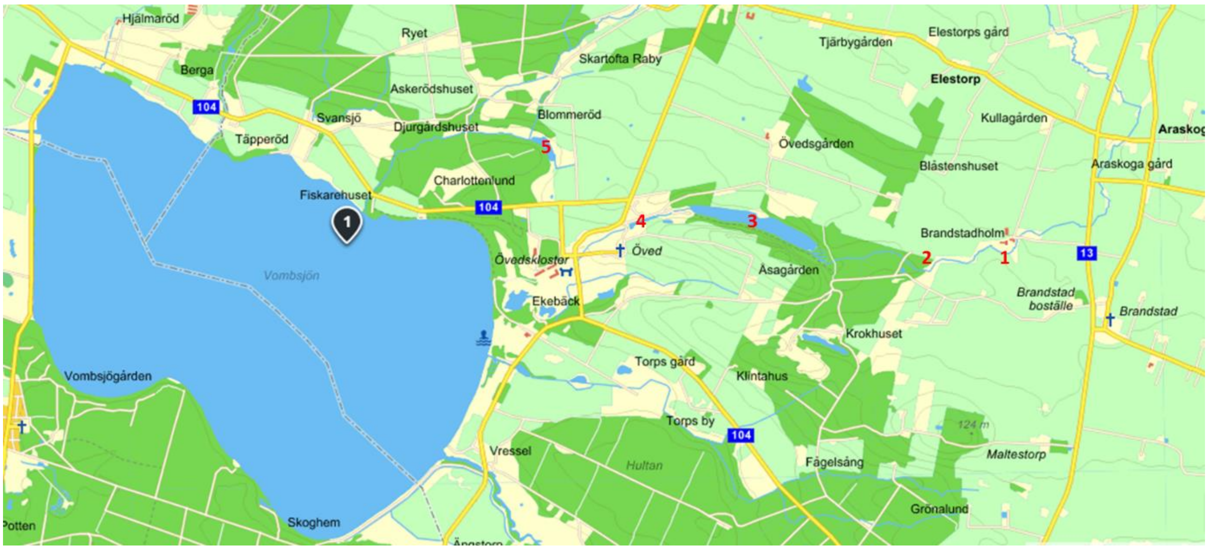



Figure 15: P Ponds localization

Coordinates WGS84 of the five ponds :

1: 55°41’14.6” N 13°42’18.7” E

2: 55°41’7.3” N 13°41’30.5” E

3: 55°41’26.1” N 13°40’1.7” E (Pond Vassen)

4: 55°41’24.5” N 13°38’42.6” E (Pond Mölledammen)

5: 55°41’50.5” N 13°37’58.4” E (Pond Blommeröd)

| POND | ESTATE | WATER SURFACE | CATCHMENT AREAS | INLET | OUTLET | POND VOLUME AT HIGH TIDE | POND DEPTH |
|---|---|---|---|---|---|---|---|
| **1** | Brandstadholm | 0.6 ha | 500 ha (90% farm land) | Drainage pipe from farm land | Well | 4,500 $m^3$ | 0.7 m |
| **2** | Brandstad | 0.1 ha | 130 ha (95% farm land | Well (at 100m East Pond on farm land) | Well + Pipe outl further downstream | 800 $m^3$ | 0.5m |
| **3** | Övedskloster | 17.5 ha | 3,200 ha (70% farm land) | Open ditch | Damn | 298,000 $m^3$ | 1.7 m |
| **4** | - | | | - | Pipe | | 1.9 m |
| **5** | Övedskloster | 2 ha | 350 ha (90% farm land) | Two open ditches | Well + Pipe witl outlet in open ditch downstrea | 20,000 $m^3$ | 0.9m |

Table 1: P Ponds description

The five ponds are more or less big, depending on their depth, length and building year (table 1). All the inlets and outlets of the lake are different. Some inlets are pipes, well or open ditches. Concerning the outlets, most of the time, there are wells, pipe and also a damn.

Pictures and maps of all the ponds are on the appendix.

# II Profiles measurements of water column in Vombsjön

The water profile has been measured once a week, on Tuesdays, by boat, using a surface water measurement tool. Measurements are taken from the surface of the water to the bottom at each meter. The start begins at a depth of 1m below the surface and the measures are made between the first meter to one meter above the bottom.

For each meter, few parameters are measured thanks to the multiparameter (appendix): temperature (°C), pH, dissolved oxygen (mg/L), conductivity (µS/cm), ORP (mV).

# III Investigation of P Ponds

## 1. Works in the ponds

Twice a week, on Mondays and Thursdays, at each of the five ponds, the followings are executed:

- Pond inlet:
  - 1 water sample for phosphorus analyses (250mL container)
  - 1 water sample for turbidity (1L container)
  - Measurements of oxygen, temperature, pH, ORP, conductivity
  - Water flow
  - Photos of the inlet
- Pond Outlet:
  - 1 water sample for phosphorus analyses (250mL container)
  - 1 water sample for turbidity (1L container)
  - Measurements of oxygen, temperature, pH, ORP, conductivity
  - Water flow
  - Photos of the outlet

- **The water samples** are taken by hand in a container or by a water sampler. The samples are put in a cool box immediately after sampling and kept cold during transport to lab. If analyses are not performed on sampling day, the samples are stored in the fridge overnight.

Pond 4 Inlet has not been studied because of the difficulty of access.

- The **measurements** of oxygen, temperature, pH, ORP and conductivity are taken with a surface water measuring device, also called multiparameter in the same time as sampling in the ponds.

- The **water flow** is measured thanks to different ways:
  - Time measurements of the filling of a bucket with a given volume (most of the time, the volume is 5L). This method was used for Pond 1 Inlet & Outlet, Pond 2 Inlet & Outlet, Pond 5 Outlet.

$$Flow\ (L/s) = \frac{volume\ of\ the\ bucket\ (L)}{time\ (s)}$$

  - Time measurements of float flow in a certain length (5m) of the open ditch. The width and the height were also measured in order to know the volume of the section. This method was used for Pond 3 Inlet & Outlet.

$$Flow\ (L/s) = \frac{length\ (m) x\ width\ (m) x\ height (m) x\ 1000}{time\ (s)}$$

The water flow of Pond 4 Outlet and Pond 5 Inlet haven't been measured because of a non-appropriate construction.

Depending on the weather, it was sometimes impossible to measure the flow. When we can't access to the flow, it is written "- "in the results whereas when it is dry, it is written "0".

- **Photos** are taken for the observation of water flow, water level of ponds and vegetation coverage. At least three photos are taken: inlet, outlet and pond.

- **P-analyses** are made in a lab at a maximum of 24h after the sampling. P analyses consist in analyzing P-total and P-Orto thanks to the kit HACH LCK 349. Phosphate ions react with molybdate and antimony ions in an acidic to form an antimonylphosphomolybdate complex. This complex is then reduced by ascorbic acid to phosphomolybdenum blue. With hydrolysis, Total phosphorus is measured and without it, only orthophosphates are measured. A spectrophotometer HACH is used for the reading of P concentration. The range is 0.05 to 1.50mg/L $PO_4^-$ P. In case of a concentration below these range, the volume of water was doubled. The instructions of the kit are on appendix.

- **The turbidity** is measured thanks to a turbiditimeter. Before measuring the turbidity of samples, a blank is made with distilled water.

# 2. Depth measurements of the ponds

To be able to better understand phenomenons in the ponds, it is important to know the volume of water of each pond and as a consequence, to know the depth of ponds. Most ponds have been built recently and all the information can be found. However, Pond n°3 (Pond Vassen) and Pond n°4 (Pond Mölledammen) have been built in the 50's and there are no information concerning the depth of these ponds.

A canoe tour has been made during the working period to determine the depth of each pond. The depth was measured thanks to a rope with heights at the bottom.

Different points have been chosen in the two ponds to measure the depth. A map with all the points is available in the appendix.

- <u>Measuring sites, Vassen (total of 14):</u>

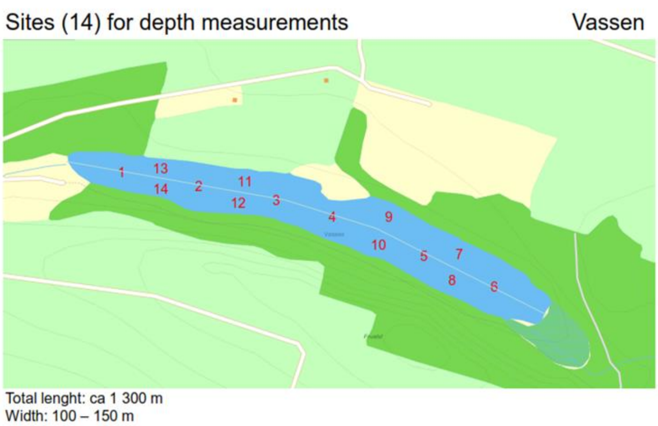
- 6 sites along a longitudinal line in the middle of the pond (n° 1-6 in map)
- 4 sites on either side of the longitudinal line of the middle (n° 7,9,11,13 + 8,10,12,14 in map)

**1**: 55° 41'30.0" N 13°39'29.7" E
**2**: 55° 41'28.6" N 13°39'39.5" E
**3**: 55° 41'27.2" N 13°39'53.2" E
**4**: 55° 41'25.9" N 13°40'00.2" E
**5**: 55° 41'22.7" N 13°40'12.7" E
**6**: 55° 41'19.2" N 13°40'24.3" E
**7**: 55° 41'22.0" N 13°40'19.4" E
**8**: 55° 41'20.5" N 13°40'17.6" E
**9**: 55° 41'26.0" N 13°40'06.2" E
**10**: 55° 41'24.0" N 13°40'04.5" E
**11**: 55° 41'29.1" N 13°39'46.0" E
**12**: 55° 41'27.3" N 13°39'45.6" E
**13**: 55° 41'30.1" N 13°39'31.8" E
**14**: 55° 41'28.6" N 13°39'31.3" E

- <u>Measuring sites, Mölledammen (total of 5):</u>

- 2 sites in the outlet area (south end) (n° 1-2 in map):
- 3 sites along a longitudinal line in the middle of the pond between inlet (north end) and outlet (n° 3-5 in map).

**1**: 55° 41'24.9" N 13°38'45.1" E
**2**: 55° 41'25.4" N 13°38'44.6" E
**3**: 55° 41'26.2" N 13°38'48.2" E
**4**: 55° 41'26.9" N 13°38'52.1" E
**5**: 55° 41'27.8" N 13°38'56.4" E



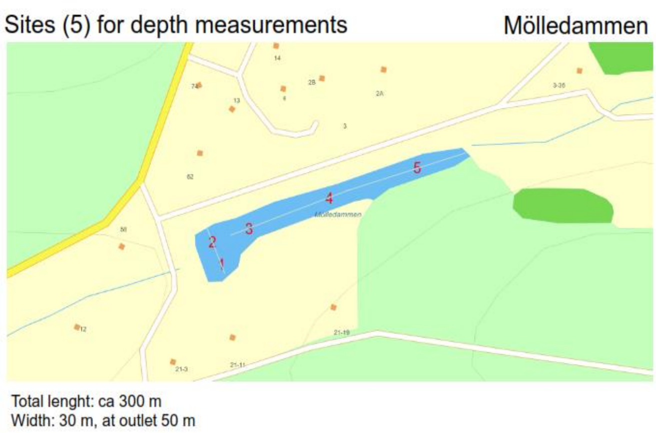




**Figure 16: Localization of depth measurement points**

# Results and discussion

The pond study and the lake study have been realized between the 13th of June 2016 and 11th of August 2016. To explain the phenomenons happening in the studies, knowing the weather is an important thing. The next graph represents the weather conditions between the 10th June 2016 and 11th August 2016.

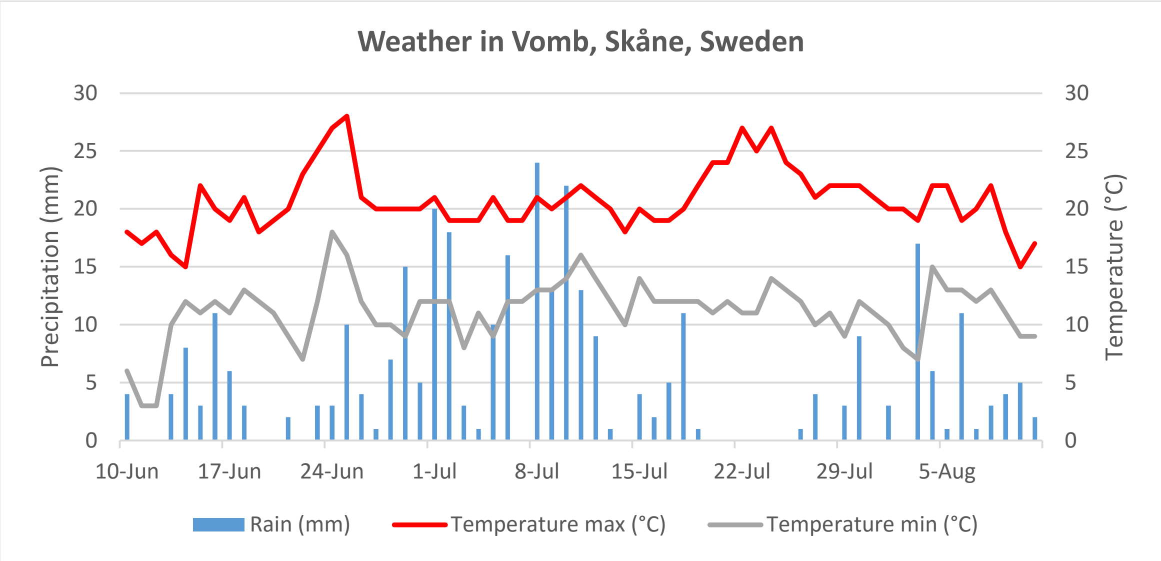



Figure 17: Weather graph - Vomb

# I Efficiency of the P ponds

## 1. Depth measurements of the ponds

A depth measurement has been made during the working period. The aim was to know the depth of Pond n°3 (Pond Vassen) and Pond n°4 (Pond Mölledammen). As described in the next table, the average depth of Pond 3 is about 1.8m whereas it is about 1.9m for Pond 4. These depths are useful to estimate the water volume of each pond and to explain phenomenons as phosphorus release.

| *Depth points (m)* | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* | *11* | *12* | *13* | *14* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Pond 3*** | 2.6 | 2.4 | 2.4 | 2.6 | 1.9 | 0.7 | 1.0 | 1.4 | 1.4 | 1.8 | 1.5 | 2.0 | 1.5 | 1.5 |
| ***Pond 4*** | 3.0 | 2.1 | 1.6 | 1.2 | 1.35 | - | - | - | - | - | - | - | - | - |

Table 2 : Depth measurement results

## 2. Ponds & parameters

In this part, studied parameters (temperature, pH, …) are analyzed. However, because of evolution of the weather conditions (pipes empty of water and dry pond in July for pond 2), difficulties to access to the inlet or outlet (as pond 4 inlet) and impossibilities to determinate the flow (for pond 5 inlet because the samples are taken in a no deep surface), it is difficult to analyze results. For Pond 1 and Pond 3 (Vassen), sampling methods haven't change during the internship.

Moreover, the Phosphate Kit LACK 349 mentioned that values under 0.05 mg/L P are not precise. Values under this range have been studied still analyzed in order to have a trend line of the parameters evolution.

## *2.1 Evolution of Phosphorus concentration during the summer*

During the summer 2016 (between 13th June 2016 and 11th August 2016), evolution of phosphorus has been studied to determine the amount of phosphorus coming in the pond and leaving it. In the next two graphs, one inlet and outlet have been chosen for this study. Total phosphorus has been divided into Ortho-phosphate and Particulate phosphorus.

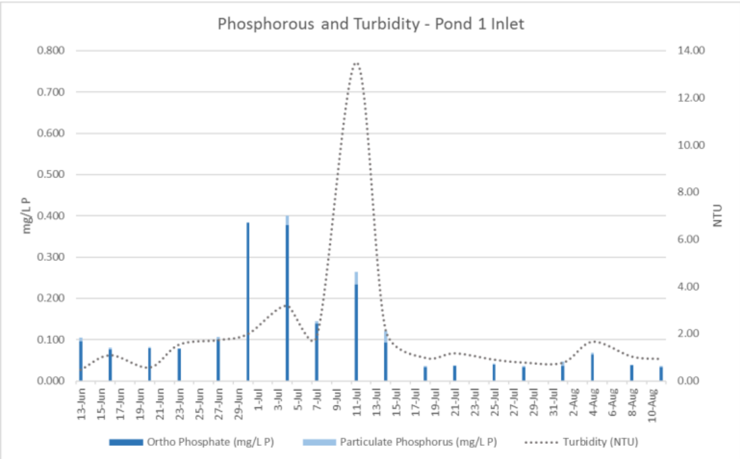



**Figure 19: Phosphorus and turbidity - Pond 1 Inlet**

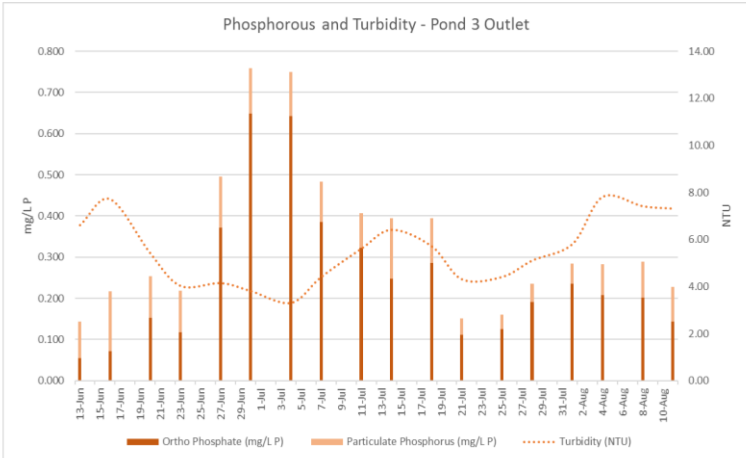



**Figure 18 : Phosphorus and turbidity - Pond 3 Outlet**

In those graphs, the amount of phosphorus seems to be stable during the month of June for Pond 1 Inlet, around 0.1 mg/L P and Pond 3 Outlet, around 0.2 mg/L P. However, a peak of phosphorus concentration can be observed around the 1st July 2016. This important concentration of P is available for one week before decreasing during all the July month. The pick of phosphorus can be seen in all ponds at the same period.

This rapid increase of phosphorus can be explained. Actually, the ponds are surrounded by at least 70% of farmland. Rainy conditions provoke runoffs catching all the fertilizers and nutrients which were spread in the crops. Thanks to the weather model of Vomb (figure 17), an intense rainy period was noticed between the 25th June and 2nd July. As water runoffs take time until arriving at ponds, the rain can explain this peak of phosphorus.

Moreover, it is also interesting to mention that during the summer, crops are growing and farmers use fertilizers for the growth be faster. The fertilizers spread might have been realized during the month of June but the consequence of the phosphorus increasing is noticed few days after. After the peak, the phosphorus concentration is lower for pond 1 (around 0.04 mg/L P) and around 0.25mg/L for pond 3, between the end of July and mid-august. After that, even if there is a rainy period, the amount of phosphorus doesn't increase anymore. It might be explained by the runoffs which have taken all the fertilizers into the water.

As mentioned in the literature part, depending on the phosphorus concentration in water, a pond can be more or less eutrophicated; below the range of 100µg/L P (=0.1 mg/L P), a pond can be considered as "polluted". Regarding all the results, most of the phosphorus concentration are below this range and as a consequence are polluted. However, those artificial ponds are used to catch the phosphorus coming from the fields and it is "normal" that the water is polluted in order not to pollute Vombsjön.

Turbidity is also a synonym of phosphorus release by the sediments. In theory, an increase of turbidity means a release of phosphorus. On one hand, except for the peak of phosphorus in pond 1, most of the time, turbidity is around 1.5. At the same time, the amount of particulate phosphorus is also very low, around 0.02 mg/L. On the other hand, turbidity of pond 3 is between 4 and 8 and the particulate phosphorus is around 0.1 mg/L. This phenomenon can be explained by the shape of the ponds. Pond 1 is small and no deep pond (1m) whereas Pond 3 is 1.3km long and the depth is about 2.5m. As a consequence, Pond 3 can store more sediments at the bottom and they release easily the particulate phosphorus and so, increase the turbidity. This PP can be seen at the outlet.

Most of the time, turbidity seems not to be link with the particulate phosphorus. For some points, as Pond 5 Inlet, the turbidity varies a lot because the sample was made at the surface of the mud and a sudden movement could increase the turbidity value.

All the graphs of the other ponds are on appendix.

## *2.2 Evolution of the other parameters*

It is also important to have a look at the evolution of the other parameters studied. Once again, one inlet and one outlet have been chosen: Pond 1 Inlet and Pond 5 Outlet. The next graphs represent the evolution of turbidity(NTU), flow (L/s) and dissolved oxygen (mg/L) depending on the time.

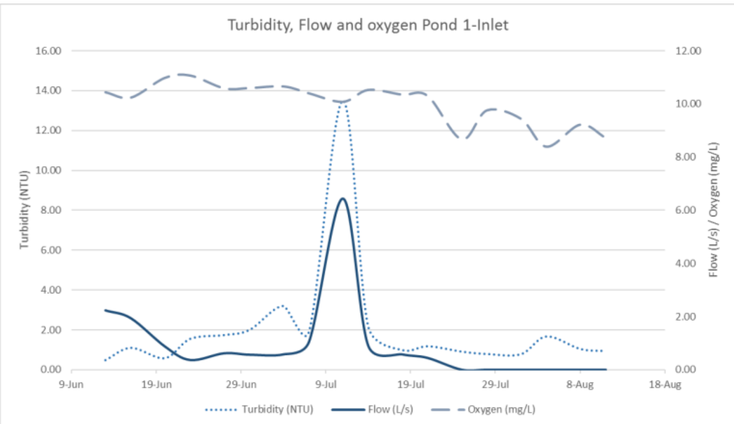



Figure 20: Turbidity, flow and oxygen - Pond 1 Inlet

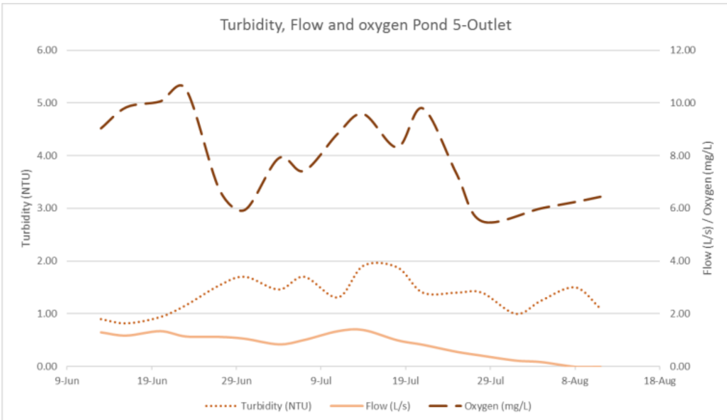



Figure 21: Turbidity, flow and Oxygen - Pond 5 outlet

The turbidity is studied once again to find a link between it and the flow. In practice, as saw previously there is not a direct link between the turbidity and [P] but it is the case in theory. However, the turbidity is supposed to be link with the flow. Actually, an increase of flow is supposed to resuspend sediments in the water column and so, increase the turbidity.

A decrease of water flow will let time to the sediments to go at the bottom of the lake and so, to decrease the turbidity. In pond 1 inlet graph, on the 11th July, the flow has been multiplied by six compared to the previous stable values. In the same time, there is a pick of turbidity. This case well respects the theory. Nevertheless, for Pond 5 outlet graph, even if there is a decrease of flow depending on the time, the turbidity seems to stay at the same value, between 1 and 2 NTU which is a very low value. As the flow is yet very low, around 1L/s, the sediments are already at the bottom of the water column and that's might be explain the low turbidity. As surprising as it is, this case respects also the theory.

Another important parameter is the dissolved oxygen. In the inlet and outlet, the oxygen concentration decrease depending on the time. The decrease of oxygen at the outlet can be explain by an important bacterial activity. The dead organic matter which have sediment at the bottom of the ponds because of the very low flow between mid-July and mid-august, are decomposed by bacteria, a great oxygen consumer. For the inlet, the decrease of oxygen is linked with the decrease of flow. Indeed, the flow avoids water brewing and that's explain the oxygen decrease. It seems to be the same phenomenon for the other ponds.

Concerning pH, it is almost constant around 8.5 but the maximum was about 9.5 for pond 3 Outlet. It might be explaining by the resuspension of sediment due to the increase of flow and a liberation of ions. At the same time, the ORP is bigger than usually and conductivity too. This case is the same for all the ponds when there is a flow increasing.

## 3. Efficiency of the ponds

The artificial ponds have been built in order to catch a maximum of phosphorus. One of the aim of the study is to determine if the pond works well that is to say: the amount of phosphorus at the outlet should be less important than the amount of inlet phosphorus.

The next two graphs represent the evolution of total phosphorus in pond 1 and 3. Concerning Pond 1, we notice that P Total Inlet is greater than P Total Outlet: it means that the pond catches phosphorus thanks to its sediments or plants. However, P total Outlet for Pond 3 is more important than P Total Inlet: the pond "produces" phosphorus.

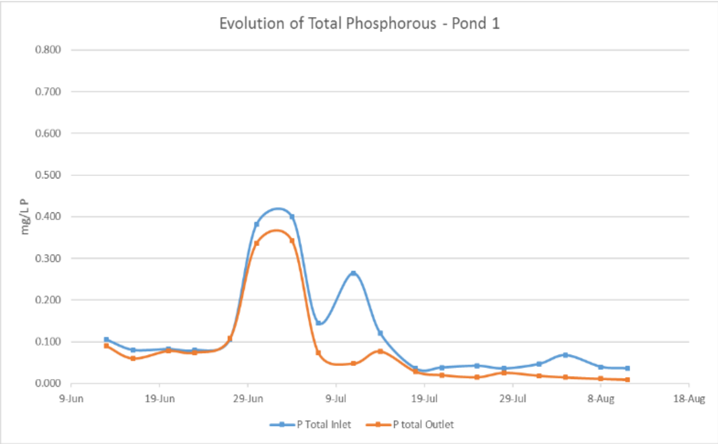



Figure 23: Evolution of total P - Pond 1

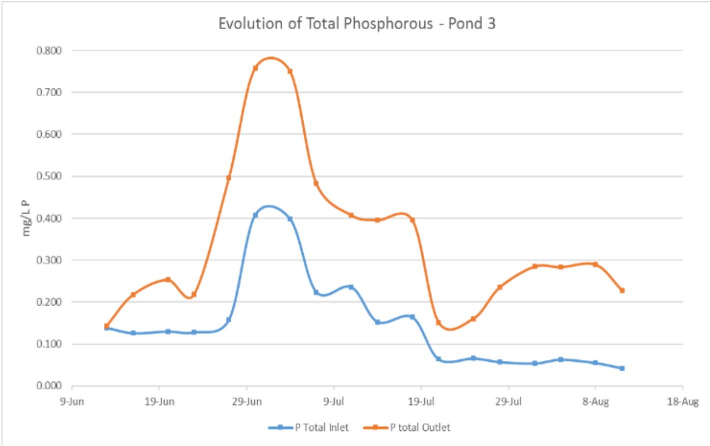



Figure 22: Evolution of total P - Pond 3

Pond 1 is a pond which has been renovated in 2003 in order to improve its efficiency by making it bigger. The map of the new part is in the appendix. Thanks to this study, the new part of pond 1 seems to have increase the efficiency of the pond. One the other hand, Pond 3 is the biggest P ponds and it seems to act as a small lake where a thermocline could happen. This thermocline could explain the release of phosphorus sediments and as a consequence, the bigger amount of P concentration at the outlet.

For pond 5, the ratio between the P inlet and P outlet seems to be equal as 1 and it means that as there as much as P arriving in the pond than going out of it. Pond 2 is difficult to analyze because the sampling place of the outlet has been changed in the middle of the experiment because of the dryness.

The efficiency has also been calculated for each pond. It has been calculated thanks to the percentage of reduce of P Total and Ortho-phosphate. The formula is:

$$\boldsymbol{Percentage\ reduce\ of\ [P] = \frac{[P]\ inlet - [P]\ outlet}{[P]\ outlet}\ x\ 100}$$

where [P] means “Phosphorus concentration”.

The two next graphs represent the efficiency of Pond 1 and Pond 2. The green color means that the pond is efficient whereas the red color means that the pond is inefficient. The lighter color is the percentage reduce of Ortho-phosphate and the other one is the percentage reduce of Total Phosphorus.

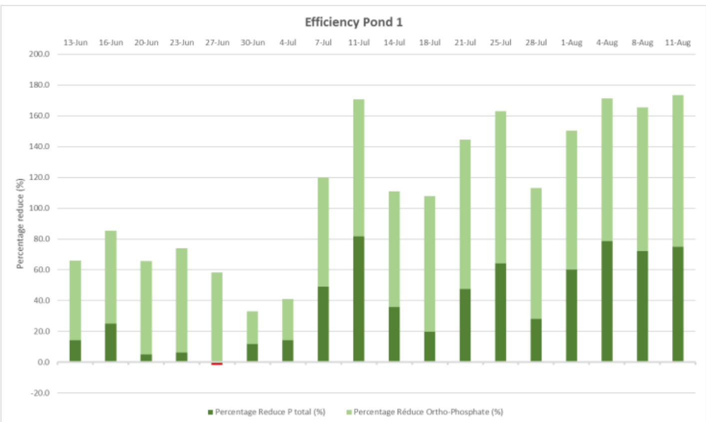



Figure 24: Efficience Pond 1

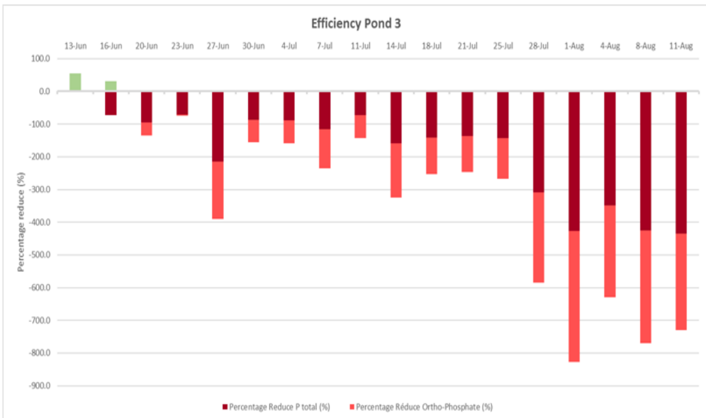



Figure 25: Efficience Pond 3

On those graphs and in comparison with the previous graphs, the pond 1 has a positive efficiency which seems to increase with the time. Furthermore, this pond has an important percentage of reduce of the orthophosphate. It could mean that the plants, great consumer of orthophosphate, use a lot of this phosphorus type and that the sediments at the bottom don't catch a lot of phosphorus, as it is a no deep pond.

At the opposite, Pond 3 has a" negative efficiency". This sort of efficiency leads to an important release of phosphorus at the outlet compared to the [P] at the inlet. It is also important to understand that even if there is a "negative efficiency", the [P] in general can be under the eutrophication value and be a good value: it only means that [P]outlet is greater than [P]inlet. For Pond 3, there is a "production" of Total phosphorus which can be explained by the phosphorus sediments release at the bottom. The sediments activity is, as a consequence, very intense.

## 4. Determination of the quantity of phosphorus in ponds

### *4.1 Phosphorus quantity catch by ponds*

It is an interesting point to know the quantity of phosphorus catch by the ponds and to know approximately the quantity arriving in Vombsjön. This study of quantity could valid the efficiency of a P Pond.

The estimation of phosphorus quantity has been realized thanks to the average of [P] and also the average of flow. Thanks to this average, an approximation of quantity release by the pond can be made. The next formal has been used:

$$\boldsymbol{Quantity\ of\ phosphorous}\left(\frac{\boldsymbol{kg}}{\boldsymbol{summer}}\right)=\frac{[\boldsymbol{P}]\boldsymbol{average}\left(\frac{\boldsymbol{mg}}{\boldsymbol{L}}\right)}{\boldsymbol{Flow\ average}\left(\frac{\boldsymbol{L}}{\boldsymbol{s}}\right)}\boldsymbol{x\ time}\,(\boldsymbol{day})$$

A period of 60 days has been chosen in order to represent the time of the experiment (between 13th June and 11th August ~ 60 days = summer).

| | | ***Pond 1*** | ***Pond 2*** | ***Pond 3*** | ***Pond 4*** | ***Pond 5*** |
|---|---|---|---|---|---|---|
| ***Inlet*** | *[P] Inlet average (mg/L)* | 0.117 | 0.054 | 0.148 | 0.341 | 0.106 |
| | *Flow Inlet average (L/s)* | 1.38 | 0.24 | 62.11 | 113.02 | 0.80 |
| | *Quantity of phosphorus (kg/s)* | 1.61E-07 | 1.30E-08 | 9.19E-06 | 3.85E-05 | 8.48E-08 |
| | *Time (day)* | 60 | 60 | 60 | 60 | 60 |
| | *Quantity of phosphorus (kg/summer)* | **0.84** | **0.07** | **47.65** | **199.79** | **0.44** |
| ***Outlet*** | *[P] Outlet (mg/L)* | 0.079 | 0.083 | 0.341 | 0.338 | 0.112 |
| | *Flow average (L/s)* | 3.2 | 0.1 | 113.02 | 100 | 0.93 |
| | *Quantity of phosphorus (kg/s)* | 2.53E-07 | 8.30E-09 | 3.85E-05 | 3.38E-05 | 1.04E-07 |
| | *Time (day)* | 60 | 60 | 60 | 60 | 60 |
| | *Quantity of phosphorus (kg/summer)* | **1.31** | **0.04** | **199.79** | **175.22** | **0.54** |
| | *Quantity P catch by the pond (kg/summer)* | **-0.5** | **0.0** | **-152.1** | **24.6** | **-0.1** |

The quantity of P catch by the pond represents the difference between the inlet and the outlet. A "negative quantity" means a P release by the pond.

Few assumptions have to be done for some values. An average of the flow 2 Outlet was made when the pond was not dry. The [P] and flow of the pond 4 inlet are considered as the same of [P] 3 Outlet because the distance between pond 3 and 4 is very small. The last assumption made was about the flow of pond 5 inlet; as it is lower as the outlet, an average of 0.6L/s has been chosen.

As described in the previous table, there are efficient, inefficient and unless catchment ponds. The more inefficient pond is 3 with 152.1kg P/summer released. Regarding the descriptions of the ponds, pond 3 is big and might contain a lot of sediments. Moreover, some fertilizers can enter directly in the pond and not be included in the inlet calculations.

Concerning Pond 1 and 5, they have a quantity of P release very close from 0. However, it is surprising to notice with the efficiency graph that pond 1 is efficient is theory. This negative value is the result of an average and doesn't represent the reality. The difference between the inlet and outlet [P] is not so important and the values of [P] are low: it leads to this error with the average.

Pond 5 P store might be considered as equal to zero because the flow of the inlet is an assumption. Indeed, if the inlet flow was about 0.8 L/s instead of 0.6 L/s, the quantity of P catch should be "-0.03 kg/summer". In contrast, a decrease of flow as 0.4 L/s, would increase the P release and should be "-0.25kg/summer". This can be explained that an increase of flow means a bigger amount of P arriving or leaving the water because the P has no time to sediment. The opposite happens if there is a decreasing of flow.

Nevertheless, the ponds catching the most P are Pond 2 and 4. However, as the outlet of Pond 2 was dry most of the time, it is difficult to know exactly the efficiency of this pond.

Pond 4 is the most efficient pond but the values of the inlet are an approximation. It is very close from Pond 3 and its water come from Pond 3. It is not a very long pond but the deeper point is about 3m. As a consequence, P has time to sediment and to be catch. The outlet of Pond 4 is at the surface of the water that's why the [P] outlet is less important than the inlet.

## *4.2 Phosphorus quantity contributions by external environment*

Fertilizers are not the only one bringing P into the water. Actually, as seen in the literature part, industries, waste water and septic tank are a source of P. In the catchment area including the P ponds, there is only a source of P coming from septic tank (117 kg/year). However, animals' dejections are also a source of P release into the water. Actually, for 4 ponds over 5, animals are directly around the ponds.

| | ***Pond 1*** | ***Pond 2*** | ***Pond 3*** | ***Pond 4*** | ***Pond 5*** |
|---|---|---|---|---|---|
| *Kind of animal* | Sheep | Horse | - | Horse | Cow |
| *Number of animals* | 20 | 2 | - | 2 | 8 |
| *P quantity release by dejections (g/day/animal)* | 15 | 60 | - | 60 | 55 |
| *P quantity release by dejections (g/day)* | 300 | 120 | - | 120 | 440 |
| *Time (day)* | 60 | 60 | - | 60 | 60 |
| *P quantity release by animals in ponds (kg/summer)* | 18 | 7.2 | - | 7.2 | 26.4 |
| *Percentage in water (%)* | 1 | 1 | - | 1 | 1 |
| *P quantity animals in ponds (kg/summer) - Modified* | **0.18** | **0.072** | - | **0.072** | **0.264** |

**Table 3 : P quantities by animals' dejections**

The previous table represents the quantity of P release by animals' dejections directly into the water of ponds. A period of 60 days is still available. Thanks to the literature part, only 2.5% to 0.5% of P animals' dejections go into the closest river or pond. For this model, an average of 1% has been chosen.

After this modification, the part of the animals seems quite important in the P input. These results can be discussed. Actually, thanks to the next graph, the P catchment of pond 2 was about 0.03 kg/summer whereas the part of P in animals' dejections is the double (0.072kg/summer). The same problem can be seen in pond 5. This might be explaining by the absence of consideration of the infiltration, the punctual presence of the animal in the land (…). Moreover, this calculation doesn't take account of the surface of the land: an animal dejection in a big land has less chance to arrive in the water pond than if the field around the pond is very small.

Models are designed in the appendix.

P ponds are more or less efficient depending on external parameters like: the weather conditions, the fertilizer spread, the surface of the pond, the animals around (…). A small pond with an important depth seem to be the best design of P pond, as Pond 4.

# II Evolution of the different water column's parameters

As seen previously, the presence of a thermocline in a lake is a synonym of phosphorus release by the bottom sediments. In a thermocline case, the main parameter studied is oxygen because it is the sign of an important amount of phosphorus in the bottom of the lake.

All the data concerning these experiment (pH, conductivity, ORP, temperature, oxygen) are available in appendix.

## 1. Presence of a thermocline in Vombsjön

### *1.1 General view of a thermocline*

A thermocline is defined by the presence of different water layers in a lake and it is a phenomenon which can be described as an important decrease of the water temperature and oxygen amount depending on the depth. Each brutal decrease of temperature at a certain depth is at the origin of a new layer, with a total number of three: Epilimnion, Metalimnion and Hypolimnion at the bottom. Usually, a thermocline is seen in a lake during the summer, when the air temperature is the warmest. Actually, the sun and the air warm are responsible of the increase of temperature in the first depth meters of the lake but not the deeper water.

The two next graphs represent thermocline which can be seen in Vombsjön. These graph have been chosen because they haven't the same depth: Point 1 is 7m depth whereas Point 2 is 14m depth. Moreover, the graphs were analyzed in different dates, about one month is set between the two thermocline.

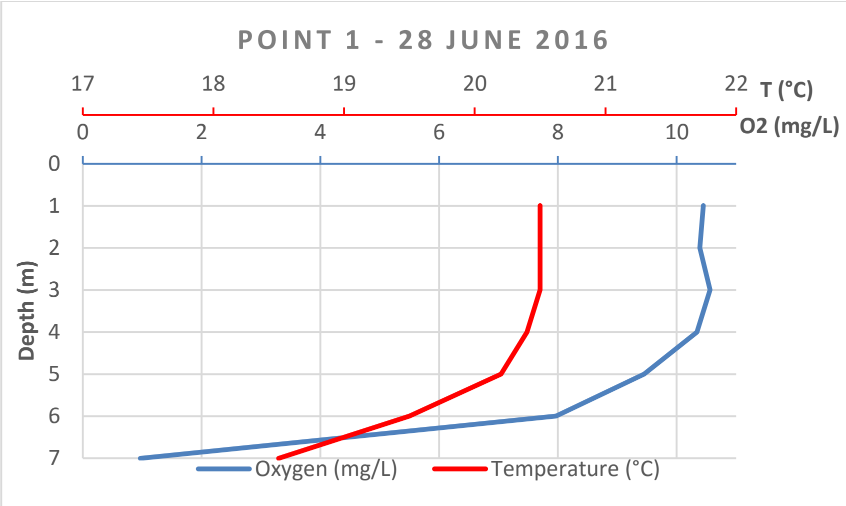



**Figure 26 : Thermocline Point 1 – 28/06/16**

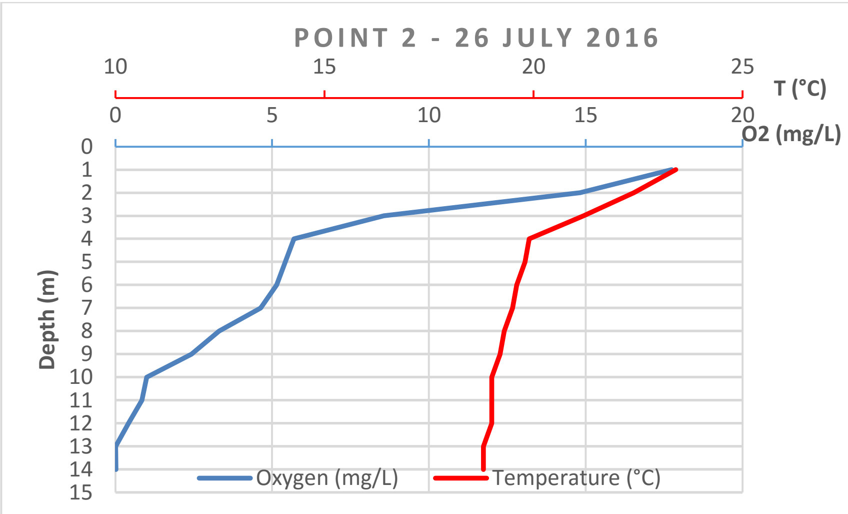



**Figure 27: Thermocline Point 2 - 26/07/16**

The first thing which strikes the most on these graphs, is when water temperature falls, the dissolved oxygen amount decreases also. Different brutal decrease of temperature can be observed which are the sign of the segregation between the layers. For point 1, the first layer can be seen at 3m whereas for point 2 it is at 4m. The second layer, where the oxygen is the lower is at 10m for point 2 and 5m for point 1. Actually, the different layer depth depends on the geography of the lake. Vombsjön has not a flat bottom which can provide water movements and as a consequence a movement of the water layers at a certain depth.

Regarding at the weather in Vomb few days before the 28$^{th}$ of June 2016 and 26$^{th}$ of July 2016, they were the two warmest period during the summer. Those days were warm without wind and not a lot of clouds. As a consequence, there was not an important mixing in the water column and the solar radiations could easily warm the surface of the water for few days, causing the thermocline. It is environmental conditions which are responsible of the presence of a thermocline. Depending on the weather of each summer, more or less thermocline can be seen in the lake.

Moreover, those weather conditions are ideals for cyanobacteria growth. On the 5$^{th}$ of July 2016, an algae bloom was observed on the calm surface water of the lake. The week before, a thermocline was seen. Because of the thermocline, Phosphorus released by the sediments is catch by the water bottom layer. As Vombjön is not a very deep lake, water is quickly agitated in the water column and the phosphorus can feed the algae bloom at the surface. That is the 5th July 2016 phenomenon (figure 11).

### *1.2 Other parameters influenced in a thermocline*

During a thermocline phenomenon, few other parameters have been studied. The next graph is about the thermocline at point 2 on the 26th July 2016. As studied with the temperature and oxygen parameters, conductivity and pH can also translate the subdivision of the water column into different layers: at 4m and 10m.

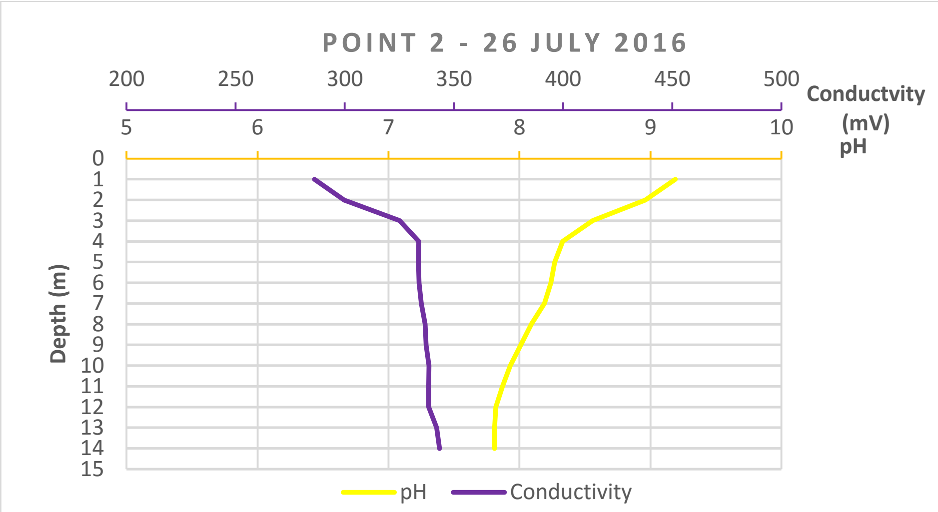



Figure 28: Parameters -Thermocline - Point 2 - 26/07/16

pH decreases at a certain depth, between 9.2 at the surface and 7.7 at the bottom of the lake. It is the result of the bacterial activity and the photosynthesis increasing the amount of $CO_2$ and causing the acidification of the water column. This sudden acidification of the water is dangerous for the fishes and animals living in the lake causing neurological and behavioral endpoints of concern.

Conductivity is also increasing depending on the depth of the lake. As explained in the literature study, the thermocline phenomenon causes a release of ions at the bottom of the lake, included nitrate. Fishes are sensitive to these evolution of ions concentration and with the decrease of oxygen, this can lead to a premature death of fish, as it happened in Vombsjön in mid-July (http://www.skd.se/2011/07/15/fiskdod-i-vombsjon-i-ar-igen/)

## 2. Particular case of thermocline

The thermocline phenomenon is the synonym of water temperature and dissolved oxygen decreasing depending on the depth of the water column. Usually, thermocline is a constant fact in big lakes. Actually, even if there are movements into the water, wind at the surface (…), the important volume of water in big lakes moves very slowly in the column and the absence of exchange between layer leads to a small variation of water temperature.

Vombsjön is a 15m deep lake and it is not enough to maintain a constant thermocline. The weather conditions, as rain and wind, have a great impact on the thermocline. A case of this phenomenon have been observed at point 2 on the 2nd of August 2016.

On one hand, on the next graph, there is an important decrease of oxygen between 6 and 8m of the water column and an absence of oxygen between 8m and the bottom of the lake. On the other hand, the water temperature decrease varies only of 1.5°C. This case can't be call a "thermocline" because of the small water temperature variation.

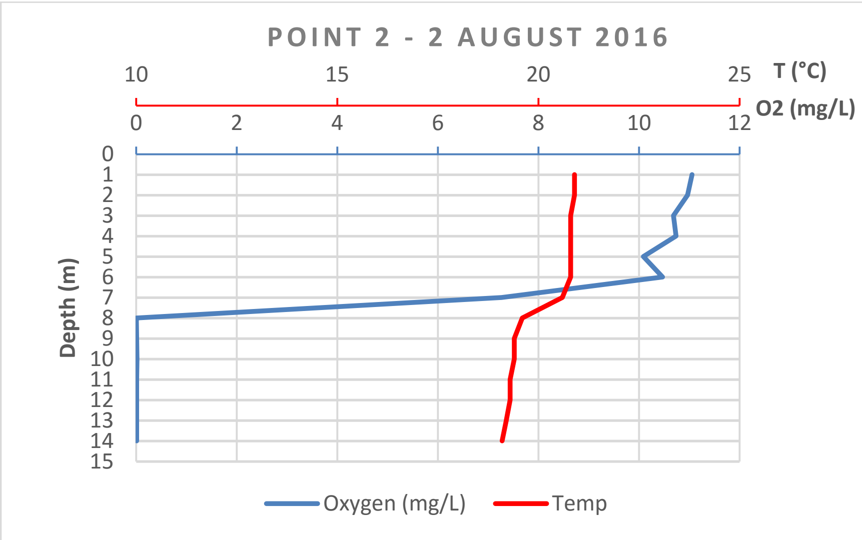



**Figure 29: Point 2 - 02/08/16**

It can be explained by the weather conditions the days before. Indeed, there were rainy and windy days before the 2nd of August. These weather conditions can explain the little variation of the water temperature in the water because of the water mixing.

However, the bacterial activity seems to be still important at the bottom of the lake and explain the absence of oxygen from 8m. What strikes the most is the important layer of anoxic conditions at the bottom of the lake which represents actually 6m. It can also be explained by the accumulation of dead organic matter at the bottom. Actually around the 26th of July, there was a warm period which has create a thermocline and as a consequence, an important bacterial activity. A large part of the bacterial activity products and dead matter has sedimented on the bottom and bacteria to degrade, oxygen consumer, are active at the bottom to just blow the matter. This layer is dangerous for oxygen consumer animals as fish because of the lack of oxygen.

To conclude this part about the thermocline phenomenon, it is important to know that this phenomenon is variable depending on the weather conditions. Vombsjön, victim of eutrophication problem, doesn't have a constant thermocline but it is the succession of this phenomenon in summer and the weather condition in autumn (rainier and windier than in summer) which allow the phosphorus to be release in the water.

# Conclusion

Vombsjön is a Swedish lake, managed by Sydvatten AB, victim of a premature eutrophication due to intensive agriculture around its waters. This lake is used for drinkable water but its quality is threat. Actually, fertilizers used for the rapid growth of the crops put in danger the inhabitants and animals' health because of the spectacular algae growth, producers of mortal toxins.

To solve the problem of premature eutrophication, Phosphorus Ponds have been created upstream of Vombsjön and are surrounded at least by 70% of farmland. Their main function is catching the maximum of phosphorus thanks to their sediments and algae by avoiding it to enter in Vombsjön waters. Indeed, phosphorus is a limitant factor for algae growth and its concentration has to be reduced.
In this study, five P Ponds have been studied in order to determine their efficiencies. Depending on the shape of each pond and the intensive agriculture around, ponds are more or less efficient. Their ability of catching P is most of the time depending on external parameters as: weather (rain and wind), their depths, their water volume, the percentage of farmland around, number of animals and inhabitants (with septic tanks) (…) around them. Each P Pond has its advantages and disadvantages. Big deep P Ponds can store phosphorus in their sediments but even if they have a huge store capacity, they are influenced by the weather and also can release PP. On the other side, smaller ponds catch more orthophosphates than PP. As a conclusion, we might think about alternating between small and big ponds with the same flow in order to catch a maximum of Phosphorus.

Another study concerning the water profiles of Vombsjön has also been realized since many summers. Once more, the analyses show a thermal stratification which causes an important decrease of oxygen in the water column. The oxygen lack at the bottom of the lake has many consequences as the release of PP by the sediments. The thermal stratification has also an environmental consequence first, because of visual degrading of the lake but also for the animals living inside Vombsjön waters. Swedish summer are not warm, about 21°C for the maximum, but it is enough to create a thermocline in Vombsjön. Most of the time, the thermocline can be seen during few days but it is these weather changings and the fertilizers contribution which degrade the water quality.

Thanks to these studies, Sydvatten is able to know the efficiencies of P Ponds and real state of Vombsjön during the summer and as a consequence, can easier solve the eutrophication problem.

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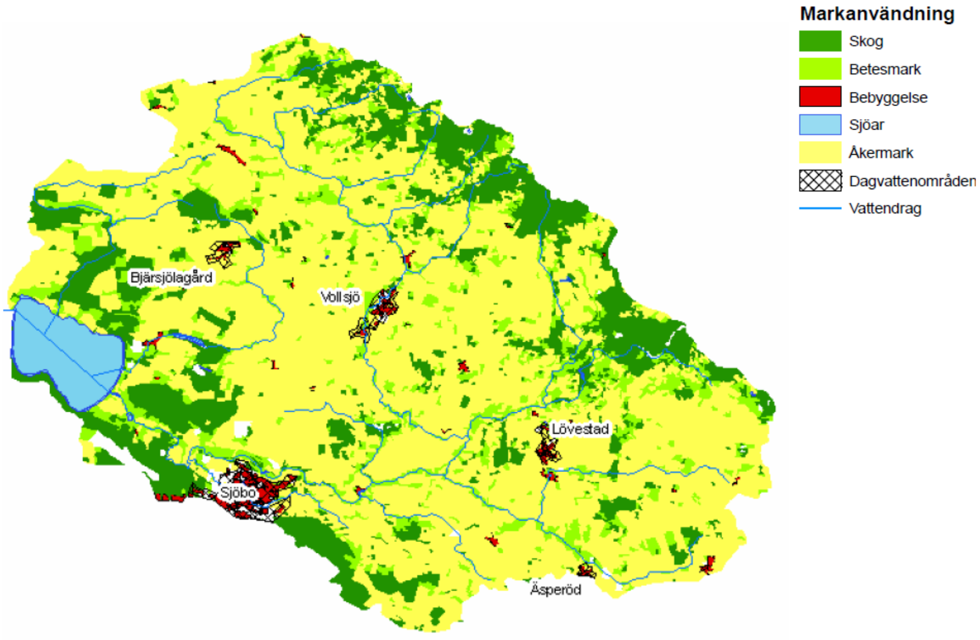
- Water Quality depending on P concentration: http://www.mddelcc.gouv.qc.ca/eau/eco_aqua/rivieres/annexes.htm
- http://vattenwebb.smhi.se

# List of appendixes

# Appendix 1: Topography Vombjön




Agricultural land *yellow*, pastures *light green*, forest *green*, fresh water *blue*, villages *red*


The four sub-catchment areas (black lines) of lake Vombsjön (blue).

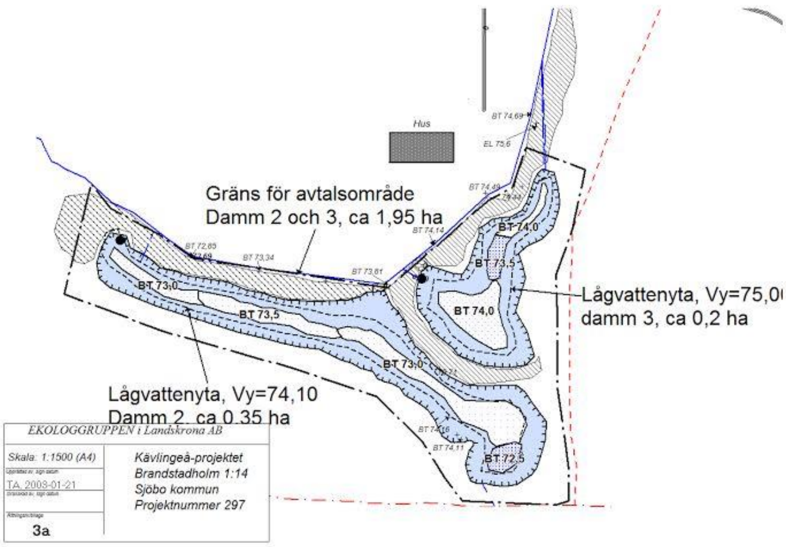
# Appendix 2: Description of Pond 1

INLET


OUTLET


POND 1


**Damm 1 vid Brandstadholm 1:14**




MAP POND 1

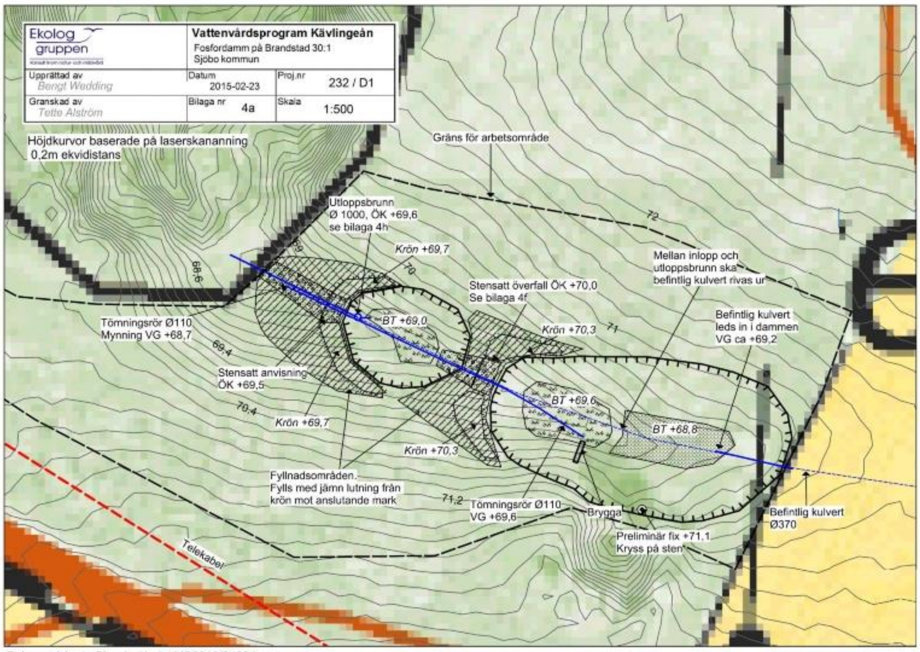
# Appendix 3: Description of Pond 2

INLET

OUTLET


POND 2


MAP POND 2



Bakgrundskarta ©Lantmäteriet MS2013/04204

# Appendix 4: Description of Pond 3

INLET

POND 3

OUTLET

# Appendix 5: Description of Pond 4

POND 4

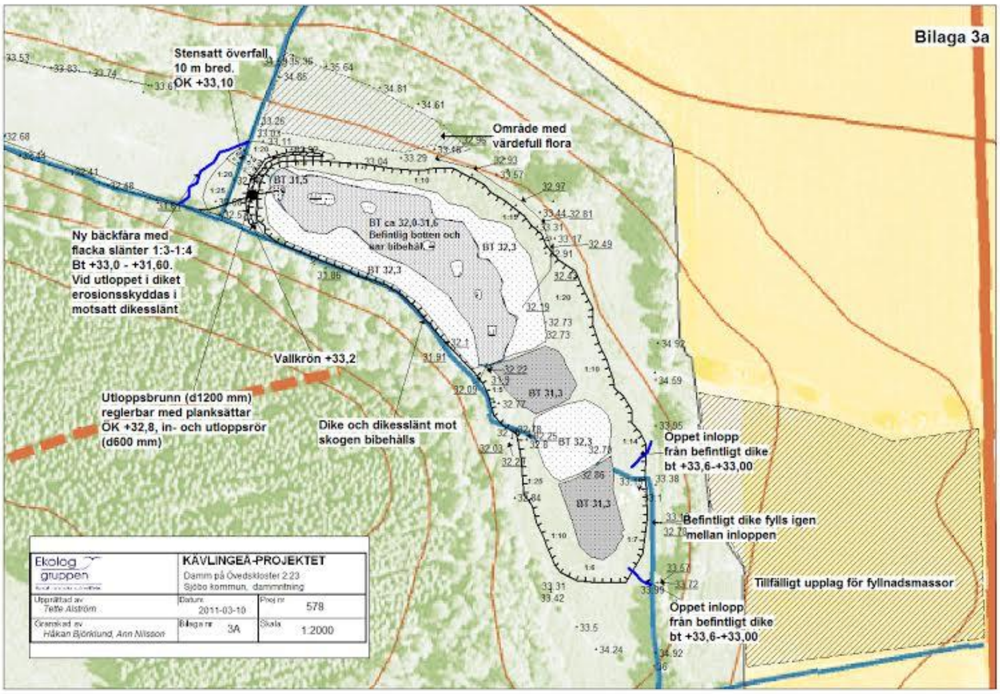

OUTLET

# Appendix 6: Description of Pond 5

INLET

OUTLET


POND 5


Maps Pond 5

# Appendix 7: Material used on the field works

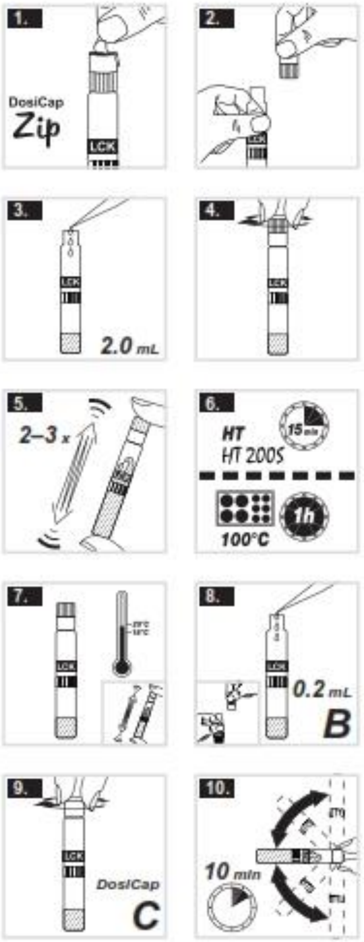

**Photo of the Multimeter (left) / Multimeter in the water lake (right)**


**Photo of the turbidimeter (left) / Spectrophotometer used for determination of P concentration**

**Photo of the Phosphate kit (left) / Photo of the samples (right)**

# Appendix 8: Phosphorus analyses

**LCK 349 – $PO_4$-P / $PO_4$ / $P_2O_5$** 06/2013




**1. – 10.**
**Gesamt-Phosphor**
**Phosphore total**
**Fosforo totali**
**Fosfor totaal**
**Total Phosphorus**

**3., 6. – 10.**
**Ortho-Phosphat**
**Orthophosphate**
**Ortofosfati**
**Orthofosfaat**
**Orthophosphate**

**DE**

1. Siegelfolie von dem aufgeschraubten **DosiCap® Zip vorsichtig** abziehen.
2. **DosiCap® Zip** abschrauben.
3. ***2.0 mL*** Probe pipettieren.
4. **DosiCap® Zip *fest*** aufschrauben; Riffelung oben.
5. Kräftig schütteln.
6. Im Thermostaten erhitzen. ***HT 200 S: 15 min*** im Standardprogramm ***HT*** ***Thermostat: 60 min*** bei ***100°C***
7. Auf Raumtemperatur abkühlen. Kräftig schütteln.
8. In erkaltete Küvette pipettieren: ***0.2 mL*** Reagenz ***B*** (LCK 349 B). Reagenz B nach Gebrauch ***sofort*** verschließen.
9. ***Graues* DosiCap® C** (LCK 349 C) auf die Küvette schrauben.
10. Küvette schwenken, dabei mehrfach auf den Kopf drehen. Nach ***10 min*** Küvette noch einmal schwenken, außen gut säubern und auswerten.

**FR**

1. Enlevez ***délicatement*** la feuille de protection du **DosiCap Zip** détachable.
2. Dévissez le **DosiCap Zip**.
3. Pipetter ***2.0 mL*** d'échantillon.
4. Vissez le **DosiCap Zip *fermement***, dirigeant le cannelage vers le haut.
5. Secouer énergiquement.
6. Chauffer dans le thermostat. ***HT 200 S: 15 min*** avec le programme standard ***HT*** ***Thermostat: 60 min*** à ***100°C***
7. Laisser refroidir à température ambiante. Secouer énergiquement.
8. Pipetter dans la cuve une fois refroidie: ***0.2 mL*** de réactif ***B*** (LCK 349 B). Fermer ***immédiatement*** le réactif B après emploi.
9. Visser un **DosiCap C** (LCK 349 C) ***gris*** sur la cuve.
10. Mélanger le contenu de la cuve en la retournant plusieurs fois de suite. Attendre ***10 min***, mélanger de nouveau, bien nettoyer l'extérieur de la cuve et mesurer.

**IT**

1. Rimuovere ***con attenzione*** il foglio di alluminio.
2. Svitare il **DosiCap Zip**.
3. Pipettare ***2.0 mL*** di campione.
4. Avvitare ***saldamente*** il **DosiCap Zip**; scanalatura esterna verso l'alto.
5. Agitare energicamente.
6. Riscaldare nel termostato. ***HT 200 S: 15 min*** nel programma standard ***HT*** ***Termostato: 60 min*** a ***100°C***
7. Fare raffreddare a temperatura ambiente. Agitare energicamente.
8. Pipettare nella cuvetta raffreddata: ***0.2 mL*** di reattivo ***B*** (LCK 349 B). Dopo aver prelevato il reattivo B, richiudere ***immediatamente***.
9. Avvitare un **DosiCap C *(capsula grigia)*** (LCK 349 C).
10. Mescolare capovolgendo la cuvetta più volte. Dopo ***10 min*** mescolare nuovamente, pulire bene la cuvetta esternamente e leggere.

**NL**

1. Afdekfolie ***voorzichtig*** verwijderen.
2. **DosiCap Zip** afschroeven.
3. ***2.0 mL*** monster pipetteren.
4. **DosiCap Zip *stevig vast*** opschroeven; geribbelde zijde naar boven.
5. Krachtig schudden.
6. In het thermostaat verhitten. ***HT 200 S: 15 min*** in standaard-programma ***HT*** ***Thermostaat: 60 min*** bij ***100°C***
7. Laten afkoelen tot kamertemperatuur. Krachtig schudden.
8. In afgekoelde kuvet pipetteren: ***0.2 mL*** reagens ***B*** (LCK 349 B). De reagens B-fles na gebruik ***onmiddellijk*** dicht draaien.
9. Een ***grijze* DosiCap C** (LCK 349 C) op het kuvet schroeven.
10. Kuvet zwenken en daarbij meerdere malen op zijn kop houden. Na ***10 min*** het kuvet opnieuw zwenken, van buiten goed reinigen en meten.

**EN**

1. ***Carefully*** remove the foil from the screwed-on **DosiCap Zip**.
2. Unscrew the **DosiCap Zip**.
3. Pipette ***2.0 mL*** sample.
4. Screw the **DosiCap Zip** back ***tightly***; fluting at the top.
5. Shake firmLy.
6. Heat in the thermostat. ***HT 200 S:*** in standard program ***HT*** for ***15 min*** ***Thermostat: 60 min*** at ***100°C***
7. Allow to cool to room temperature. Shake firmly.
8. Pipette into the cooled cuvette: ***0.2 mL*** Reagent ***B*** (LCK 349 B). Close Reagent B ***immediately*** after use.
9. Screw a ***grey* DosiCap C** (LCK 349 C) onto the cuvette.
10. Invert a few times. After ***10 min*** invert a few times more, thoroughly clean the outside of the cuvette and evaluate.

# Appendix 9: Results Pond 1

| | Date Analyses P | 14/06/16 | 17/06/16 | 20/06/16 | 23/06/16 | 27/06/16 | 30/06/13 | 7/4/2016 | 7/7/2016 | 11/7/2016 | 14/07/16 | 18/7/2016 | 21/7/2016 | 25/7/16 | 28/07/16 | 1/8/2016 | 4/8/2016 | 8/8/2016 | 11/8/2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Date Samples | 13-Jun | 16-Jun | 20-Jun | 23-Jun | 27-Jun | 30-Jun | 4-Jul | 7-Jul | 11-Jul | 14-Jul | 18-Jul | 21-Jul | 25-Jul | 28-Jul | 1-Aug | 4-Aug | 8-Aug | 11-Aug |
| 1.In | Turbidity (NTU) | 0.48 | 1.10 | 0.58 | 1.55 | 1.74 | 2.00 | 3.20 | 1.90 | 13.50 | 2.15 | 0.99 | 1.18 | 0.91 | 0.79 | 0.78 | 1.67 | 1.04 | 0.94 |
| | P Total (mg/L P) | 0.105 | 0.080 | 0.082 | 0.079 | 0.106 | 0.381 | 0.400 | 0.145 | 0.264 | 0.120 | 0.036 | 0.038 | 0.042 | 0.036 | 0.047 | 0.068 | 0.040 | 0.036 |
| | Ortho Phosphate (mg/L P) | 0.095 | 0.076 | 0.079 | 0.077 | 0.101 | 0.384 | 0.378 | 0.138 | 0.234 | 0.092 | 0.034 | 0.036 | 0.040 | 0.034 | 0.036 | 0.064 | 0.037 | 0.033 |
| | Particulate Phosphorus (mg/L P) | 0.010 | 0.004 | 0.003 | 0.002 | 0.005 | 0.000 | 0.022 | 0.007 | 0.030 | 0.028 | 0.002 | 0.002 | 0.003 | 0.002 | 0.011 | 0.004 | 0.003 | 0.003 |
| | Temperature (°C) | 11 | 11.4 | 11.7 | 11.9 | 12.3 | 12.1 | 12.1 | 12.2 | 13.5 | 12.4 | 12.7 | 12.8 | 13.5 | 13.2 | 13 | 13.4 | 13.1 | 12.5 |
| | Pressure (Atm) | 0.9856 | 0.9794 | 0.9983 | 1.0018 | 0.9928 | 0.9895 | 0.995 | 0.9924 | 0.9818 | 0.9913 | 0.9939 | 0.9948 | 0.9965 | 0.9909 | 0.99 | 0.9843 | 0.9887 | 0.9936 |
| | Oxygen (mg/L) | 10.44 | 10.24 | 10.98 | 11.07 | 10.59 | 10.6 | 10.66 | 10.4 | 10.08 | 10.53 | 10.35 | 10.3 | 8.67 | 9.76 | 9.44 | 8.39 | 9.22 | 8.72 |
| | Conductivity (µS/cm) | 468.2 | 455.2 | 489.2 | 492.7 | 499.5 | 477.4 | 436.7 | 487.7 | 453.3 | 512 | 513 | 502 | 526 | 528 | 496.8 | 510 | 515 | 335 |
| | pH | 8.29 | 8.37 | 8.35 | 8.11 | 8.11 | 8.46 | 8.52 | 8.67 | 8.37 | 8.65 | 8.49 | 8.45 | 8.53 | 8.17 | 8.72 | 8.22 | 8.62 | 8.68 |
| | ORP (mV) | 164 | 46.3 | 74.6 | 54.4 | 76.6 | 92.2 | 73 | 100.8 | 102.2 | 115.3 | 74.7 | 105.1 | 83.6 | 87.6 | 63 | 88.2 | 63.4 | 98.5 |
| | Flow (L/s) | 2.23 | 1.94 | 0.88 | 0.37 | 0.62 | 0.57 | 0.58 | 1.04 | 6.44 | 0.89 | 0.58 | 0.44 | - | - | - | - | - | - |

| | | 13-Jun | 16-Jun | 20-Jun | 23-Jun | 27-Jun | 30-Jun | 4-Jul | 7-Jul | 11-Jul | 14-Jul | 18-Jul | 21-Jul | 25-Jul | 28-Jul | 1-Aug | 4-Aug | 8-Aug | 11-Aug |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.Out | Turbidity (NTU) | 3.40 | 4.10 | 4.70 | 4.88 | 5.14 | 5.60 | 5.00 | 4.20 | 1.49 | 6.12 | 9.80 | 2.10 | 2.08 | 8.40 | 4.10 | 3.68 | 1.45 | 2.05 |
| | P Total (mg/L P) | 0.090 | 0.060 | 0.078 | 0.074 | 0.108 | 0.336 | 0.343 | 0.074 | 0.048 | 0.077 | 0.029 | 0.020 | 0.015 | 0.026 | 0.019 | 0.015 | 0.011 | 0.009 |
| | Ortho Phosphate (mg/L P-PO4) | 0.046 | 0.030 | 0.031 | 0.025 | 0.042 | 0.303 | 0.277 | 0.040 | 0.026 | 0.023 | 0.004 | 0.001 | 0.001 | 0.005 | 0.004 | 0.005 | 0.003 | 0.001 |
| | Particulate Phosphorus (mg/L P) | 0.044 | 0.030 | 0.047 | 0.049 | 0.066 | 0.033 | 0.066 | 0.034 | 0.022 | 0.054 | 0.025 | 0.019 | 0.015 | 0.021 | 0.015 | 0.010 | 0.009 | 0.009 |
| | Temperature (°C) | 18.0 | 17.4 | 17.6 | 20.3 | 20.8 | 18.4 | 17.7 | 16.6 | 18.4 | 18.8 | 18.6 | 20.2 | 21.1 | 19.8 | 19.4 | 18.5 | 18.2 | 15.5 |
| | Pressure (Atm) | 0.9855 | 0.9797 | 0.9983 | 1.0019 | 0.9930 | 0.9898 | 0.9951 | 0.9924 | 0.9819 | 0.9909 | 0.9940 | 0.9947 | 0.9965 | 0.9909 | 0.9900 | 0.9843 | 0.9884 | 0.9936 |
| | Oxygen (mg/L) | 11.92 | 10.42 | 11.19 | 11.24 | 7.02 | 6.90 | 7.98 | 8.34 | 8.56 | 8.55 | 9.47 | 7.25 | 8.05 | 5.96 | 6.97 | 6.75 | 8.19 | 9.18 |
| | Conductivity (µS/cm) | 363.10 | 377.60 | 396.00 | 386.20 | 382.70 | 366.90 | 377.60 | 361.40 | 398.70 | 387.90 | 404.60 | 424.80 | 419.90 | 400.30 | 429.00 | 349.20 | 381.60 | 364.80 |
| | pH | 8.85 | 8.77 | 8.45 | 8.39 | 8.22 | 8.30 | 8.44 | 8.55 | 8.35 | 8.45 | 8.49 | 8.55 | 8.62 | 8.31 | 8.38 | 8.51 | 8.69 | 8.95 |
| | ORP (mV) | 120.8 | 93.6 | 57.7 | 36.3 | 65.8 | 96.8 | 138.2 | 159.4 | 119.3 | 120.9 | 88.5 | 67.4 | 69.8 | 66.7 | 57.7 | 42.6 | 47.3 | 82.1 |
| | Flow (L/s) | 3.79 | 5.92 | 2.59 | 2.14 | 1.33 | 1.91 | 1.94 | 2.80 | 23.12 | 2.90 | 0.87 | 1.49 | 1.55 | 1.50 | 1.08 | 1.57 | 0.62 | 0.45 |
| | Percentage Reduce P total (%) | 14.3 | 25.0 | 4.9 | 6.3 | -1.9 | 11.8 | 14.3 | 49.0 | 81.8 | 35.8 | 19.7 | 47.4 | 64.3 | 28.2 | 60.2 | 78.5 | 72.2 | 75.0 |
| | Percentage Réduce Ortho-Phosphate (%) | 51.6 | 60.5 | 60.8 | 67.5 | 58.4 | 21.1 | 26.7 | 71.0 | 88.9 | 75.0 | 88.1 | 97.2 | 98.7 | 85.1 | 90.3 | 93.0 | 93.2 | 98.5 |

# Appendix 10: Results Pond 2

| | Date Analyses P | 14/06/16 | 17/06/16 | 20/06/16 | 23/06/16 | 27/06/16 | 30/06/13 | 7/4/2016 | 7/7/2016 | 11/7/2016 | 14/07/16 | 18/7/2016 | 21/7/2016 | 25/7/16 | 28/07/16 | 1/8/2016 | 4/8/2016 | 8/8/2016 | 11/8/2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Date Samples | 13-Jun | 16-Jun | 20-Jun | 23-Jun | 27-Jun | 30-Jun | 4-Jul | 7-Jul | 11-Jul | 14-Jul | 18-Jul | 21-Jul | 25-Jul | 28-Jul | 1-Aug | 4-Aug | 8-Aug | 11-Aug |
| 2.In | Turbidity (NTU) | 0.35 | 0.73 | 0.29 | 0.50 | 0.57 | 0.70 | 2.25 | 0.69 | 1.80 | 0.68 | 0.39 | 0.32 | 0.34 | 0.30 | 0.58 | 1.11 | 0.56 | 0.47 |
| | P Total (mg/L P) | 0.050 | 0.039 | 0.037 | 0.033 | 0.047 | 0.300 | 0.295 | 0.045 | 0.050 | 0.047 | 0.004 | 0.004 | 0.004 | 0.002 | 0.004 | 0.002 | 0.003 | 0.002 |
| | Ortho Phosphate (mg/L P) | 0.054 | 0.039 | 0.038 | 0.032 | 0.046 | 0.304 | 0.288 | 0.044 | 0.049 | 0.023 | 0.002 | 0.002 | 0.002 | 0.003 | 0.002 | 0.004 | 0.002 | 0.000 |
| | Particulate Phosphorus (mg/L P) | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.007 | 0.001 | 0.001 | 0.024 | 0.002 | 0.002 | 0.002 | 0.000 | 0.002 | 0.000 | 0.001 | 0.002 |
| | Temperature (°C) | 10.2 | 10.3 | 10.4 | 10.7 | 11.3 | 10.6 | 11.0 | 11.0 | 11.8 | 11.4 | 11.6 | 12.0 | 12.1 | 12.2 | 12.1 | 12.4 | 12.5 | 12.2 |
| | Pressure (Atm) | 0.9858 | 0.9802 | 0.9988 | 1.0022 | 0.9931 | 0.9900 | 0.9954 | 0.9926 | 0.9822 | 0.9911 | 0.9941 | 0.9949 | 0.9968 | 0.9914 | 0.9904 | 0.9847 | 0.9886 | 0.9940 |
| | Oxygen (mg/L) | 10.61 | 10.78 | 11.41 | 11.01 | 10.91 | 11.18 | 10.85 | 10.96 | 10.42 | 10.94 | 11.18 | 9.82 | 8.97 | 8.15 | 9.24 | 8.99 | 8.83 | 8.95 |
| | Conductivity (µS/cm) | 391.8 | 399.0 | 397.5 | 383.7 | 411.5 | 400.0 | 410.8 | 397.5 | 409.9 | 408.9 | 429.8 | 417.2 | 416.5 | 421.5 | 430.1 | 432.3 | 433.6 | 418.8 |
| | pH | 8.30 | 7.83 | 8.05 | 7.57 | 7.85 | 8.21 | 8.16 | 8.51 | 7.97 | 8.40 | 8.15 | 8.00 | 7.94 | 7.62 | 8.34 | 8.06 | 8.05 | 8.65 |
| | ORP (mV) | 124.7 | 113.0 | 75.9 | 208.4 | 79.4 | 144.7 | 143.6 | 173.1 | 135.8 | 134.2 | 124.1 | 93.5 | 101.2 | 94.6 | 83.6 | 78.5 | 67.8 | 71.7 |
| | Flow (L/s) | 0.38 | 0.32 | 0.28 | 0.24 | 0.21 | 0.22 | 0.20 | 0.23 | 0.45 | 0.25 | 0.23 | 0.21 | 0.18 | 0.17 | 0.17 | 0.18 | 0.16 | 0.17 |

| | | 13-Jun | 16-Jun | 20-Jun | 23-Jun | 27-Jun | 30-Jun | 4-Jul | 7-Jul | 11-Jul | 14-Jul | 18-Jul | 21-Jul | 25-Jul | 28-Jul | 1-Aug | 4-Aug | 8-Aug | 11-Aug |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.Out | Turbidity (NTU) | 1.14 | 1.60 | 1.29 | 3.10 | - | 2.60 | 1.80 | 2.80 | 19.10 | 10.04 | 1.25 | 0.65 | 0.77 | 0.80 | 0.58 | 0.47 | 0.44 | 0.48 |
| | P Total (mg/L P) | 0.087 | 0.066 | 0.072 | 0.156 | - | 0.347 | 0.324 | 0.067 | 0.146 | 0.070 | 0.016 | 0.011 | 0.011 | 0.014 | 0.011 | 0.005 | 0.005 | 0.005 |
| | Ortho Phosphate (mg/L P) | 0.066 | 0.029 | 0.046 | 0.102 | - | 0.287 | 0.277 | 0.037 | 0.104 | 0.024 | 0.002 | 0.001 | 0.002 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 |
| | Particulate Phosphorus (mg/L P) | 0.021 | 0.037 | 0.026 | 0.054 | - | 0.060 | 0.047 | 0.030 | 0.042 | 0.046 | 0.015 | 0.011 | 0.010 | 0.013 | 0.010 | 0.005 | 0.005 | 0.005 |
| | Temperature (°C) | 14.1 | 15.3 | 14.2 | 14.4 | - | 16.5 | 16.5 | 16.4 | 18.1 | 18.2 | 18.4 | 20.2 | 20.4 | 18.6 | 17.2 | 18.0 | 18.2 | 13.9 |
| | Pressure (Atm) | 0.9864 | 0.9807 | 0.9993 | 1.0028 | - | 0.9903 | 0.9956 | 0.9930 | 0.9828 | 0.9909 | 0.9942 | 0.9951 | 0.9967 | 0.9915 | 0.9906 | 0.9847 | 0.9887 | 0.9940 |
| | Oxygen (mg/L) | 7.91 | 7.95 | 8.78 | 3.91 | - | 9.42 | 13.00 | 12.62 | 9.17 | 12.31 | 9.10 | 9.22 | 6.38 | 6.72 | 7.85 | 8.45 | 8.17 | 9.30 |
| | Conductivity (µS/cm) | 365.4 | 369.5 | 365.9 | 395.8 | - | 372.9 | 359.9 | 346.0 | 364.8 | 343.4 | 422.3 | 415.7 | 417.9 | 425.5 | 378.8 | 382.6 | 381.1 | 340.5 |
| | pH | 8.07 | 8.04 | 7.86 | 7.68 | - | 8.00 | 8.38 | 8.66 | 7.90 | 8.17 | 7.89 | 7.90 | 7.87 | 7.86 | 8.07 | 8.26 | 8.17 | 8.51 |
| | ORP (mV) | 34.6 | 87.3 | -4.1 | 136.2 | - | 140.0 | 128.2 | 180.7 | 124.7 | 157.1 | 87.0 | 69.5 | 74.2 | 84.1 | 95.7 | 68.9 | 60.6 | 72.0 |
| | Flow (L/s) | 0.03 | 0.06 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.74 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Percentage Reduce P total (%) | -74.0 | -69.2 | -94.6 | -372.7 | | -15.7 | -9.8 | -48.9 | -192.0 | -48.9 | -357.1 | -214.3 | -214.3 | -575.0 | -200.0 | -150.0 | -100.0 | -125.0 |
| | Percentage Réduce Ortho-Phosphate (%) | -22.2 | 25.6 | -21.1 | -218.8 | | 5.6 | 3.8 | 15.9 | -112.2 | -4.3 | 0.0 | 66.7 | 25.0 | 80.0 | 66.7 | 100.0 | 100.0 | #DIV/0! |
| | | | | | Standing Water | | Pond | Pond | Pond | | Pond | Pond | Pond | Pond | Pond | Pond | Pond | Pond | Pond |

# Appendix 11: Results Pond 3

| | Date Analyses P | 14/06/16 | 17/06/16 | 20/06/16 | 23/06/16 | 27/06/16 | 30/06/13 | 7/4/2016 | 7/7/2016 | 11/7/2016 | 14/07/16 | 18/7/2016 | 21/7/2016 | 25/7/16 | 28/07/16 | 1/8/2016 | 4/8/2016 | 8/8/2016 | 11/8/2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Date Samples | 13-Jun | 16-Jun | 20-Jun | 23-Jun | 27-Jun | 30-Jun | 4-Jul | 7-Jul | 11-Jul | 14-Jul | 18-Jul | 21-Jul | 25-Jul | 28-Jul | 1-Aug | 4-Aug | 8-Aug | 11-Aug |
| 3.In | Turbidity (NTU) | 0.85 | 1.70 | 1.00 | 1.15 | 1.13 | 2.10 | 1.50 | 3.90 | 10.00 | 4.20 | 2.30 | 2.00 | 1.80 | 1.50 | 1.25 | 2.05 | 4.80 | 1.30 |
| | P Total (mg/L P) | 0.139 | 0.126 | 0.130 | 0.128 | 0.158 | 0.407 | 0.398 | 0.224 | 0.236 | 0.153 | 0.164 | 0.064 | 0.066 | 0.058 | 0.054 | 0.063 | 0.055 | 0.043 |
| | Ortho Phosphate (mg/L P) | 0.123 | 0.105 | 0.108 | 0.112 | 0.135 | 0.382 | 0.379 | 0.175 | 0.189 | 0.093 | 0.135 | 0.053 | 0.056 | 0.051 | 0.047 | 0.055 | 0.046 | 0.037 |
| | Particulate Phosphorus (mg/L P) | 0.016 | 0.021 | 0.022 | 0.016 | 0.023 | 0.025 | 0.019 | 0.049 | 0.047 | 0.060 | 0.029 | 0.011 | 0.010 | 0.006 | 0.007 | 0.009 | 0.010 | 0.006 |
| | Temperature (°C) | 12.5 | 13.8 | 13.1 | 15.3 | 15.2 | 14.2 | 13.4 | 13.9 | 17.3 | 15.9 | 15.5 | 16.4 | 16.8 | 15.9 | 14.7 | 15.9 | 16.0 | 11.9 |
| | Pressure (Atm) | 0.9887 | 0.9832 | 1.0018 | 1.0052 | 0.9958 | 0.9929 | 0.9987 | 0.9961 | 0.9852 | 0.9940 | 0.9974 | 0.9979 | 0.9995 | 0.9944 | 0.9932 | 0.9876 | 0.9916 | 0.9971 |
| | Oxygen (mg/L) | 10.02 | 9.59 | 10.44 | 9.83 | 10.09 | 9.88 | 10.40 | 10.00 | 8.97 | 9.54 | 9.86 | 7.62 | 8.07 | 7.93 | 7.90 | 7.37 | 7.72 | 8.91 |
| | Conductivity (µS/cm) | 410.5 | 421.6 | 437.8 | 476.5 | 440.9 | 387.3 | 394.6 | 398.0 | 350.7 | 343.0 | 405.0 | 428.9 | 456.0 | 446.3 | 446.6 | 442.7 | 468.4 | 411.1 |
| | pH | 8.36 | 8.29 | 8.15 | 8.14 | 8.22 | 8.28 | 8.29 | 8.43 | 8.22 | 8.37 | 8.28 | 8.43 | 8.47 | 8.43 | 8.38 | 8.43 | 8.32 | 8.51 |
| | ORP (mV) | 122.6 | 97.1 | 62.5 | 98.8 | 62.4 | 130.2 | 145.2 | 191.3 | 128.0 | 143.2 | 105.9 | 74.0 | 90.0 | 79.7 | 77.3 | 73.1 | 64.6 | 90.4 |
| | Flow(L/s) | 63.30 | 68.06 | 53.57 | 47.43 | 27.85 | 39.92 | 37.86 | 167.78 | 235.03 | 194.54 | 47.97 | 31.35 | 21.26 | 16.82 | 18.55 | 22.45 | 13.98 | 10.34 |

| | | 13-Jun | 16-Jun | 20-Jun | 23-Jun | 27-Jun | 30-Jun | 4-Jul | 7-Jul | 11-Jul | 14-Jul | 18-Jul | 21-Jul | 25-Jul | 28-Jul | 1-Aug | 4-Aug | 8-Aug | 11-Aug |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.Out | Turbidity (NTU) | 6.60 | 7.70 | 5.40 | 4.02 | 4.14 | 3.80 | 3.30 | 4.40 | 5.60 | 6.40 | 5.70 | 4.30 | 4.40 | 5.10 | 5.80 | 7.80 | 7.40 | 7.30 |
| | P Total (mg/L P) | 0.143 | 0.217 | 0.253 | 0.218 | 0.496 | 0.758 | 0.750 | 0.483 | 0.407 | 0.395 | 0.395 | 0.152 | 0.161 | 0.235 | 0.285 | 0.283 | 0.289 | 0.228 |
| | Ortho Phosphate (mg/L P) | 0.055 | 0.072 | 0.152 | 0.117 | 0.372 | 0.648 | 0.643 | 0.385 | 0.323 | 0.248 | 0.286 | 0.112 | 0.126 | 0.192 | 0.236 | 0.207 | 0.202 | 0.144 |
| | Particulate Phosphorus (mg/L P) | 0.088 | 0.145 | 0.101 | 0.101 | 0.124 | 0.110 | 0.107 | 0.098 | 0.084 | 0.147 | 0.109 | 0.040 | 0.035 | 0.044 | 0.049 | 0.076 | 0.087 | 0.084 |
| | Temperature (°C) | 18.7 | 17.7 | 17.5 | 21.5 | 21.2 | 18.9 | 18.7 | 18.1 | 19.2 | 19.9 | 19.5 | 21.9 | 23.8 | 22.4 | 21.0 | 19.7 | 18.9 | 17.2 |
| | Pressure (Atm) | 0.9885 | 0.9835 | 1.0017 | 1.0055 | 0.9960 | 0.9933 | 0.9989 | 0.9966 | 0.9855 | 0.9940 | 0.9976 | 0.9982 | 0.9997 | 0.9946 | 0.9935 | 0.9881 | 0.9916 | 0.9973 |
| | Oxygen (mg/L) | 11.67 | 8.16 | 10.14 | 13.17 | 7.93 | 7.39 | 7.60 | 7.00 | 9.18 | 11.41 | 10.64 | 9.44 | 6.55 | 6.70 | 6.22 | 7.41 | 5.20 | 7.88 |
| | Conductivity (µS/cm) | 311.3 | 318.4 | 312.8 | 344.4 | 347.1 | 330.1 | 330.6 | 328.9 | 329.3 | 332.8 | 339.8 | 348.9 | 360.6 | 370.2 | 387.4 | 210.6 | 370.9 | 348.2 |
| | pH | 8.93 | 8.62 | 8.60 | 8.92 | 8.81 | 8.82 | 8.76 | 8.75 | 8.93 | 9.32 | 9.25 | 9.51 | 9.36 | 9.17 | 8.86 | 9.08 | 8.63 | 9.00 |
| | ORP (mV) | 113.7 | 99.0 | 64.6 | 73.4 | 60.2 | 114.7 | 137.1 | 161.7 | 129.8 | 86.6 | 86.3 | 76.6 | 82.4 | 83.9 | 219.3 | 76.6 | 73.7 | 64.3 |
| | Flow (L/s) | 137.89 | 126.37 | 108.24 | 101.08 | 85.87 | 83.29 | 103.10 | 133.21 | 318.72 | 350.19 | 153.64 | 77.79 | 70.34 | 41.52 | 26.16 | 24.21 | 43.93 | 48.81 |
| | Percentage Reduce P total (%) | -2.9 | -72.2 | -94.6 | -70.3 | -213.9 | -86.2 | -88.4 | -115.6 | -72.5 | -158.2 | -140.9 | -136.7 | -143.2 | -308.7 | -426.9 | -349.2 | -425.5 | -435.3 |
| | Percentage Réduce Ortho-Phosphate (%) | 55.28 | 31.43 | -40.74 | -4.46 | -175.56 | -69.63 | -69.66 | -120.00 | -70.90 | -166.67 | -111.85 | -110.38 | -124.11 | -275.49 | -401.06 | -279.82 | -343.96 | -294.52 |

# Appendix 12: Results Pond 4

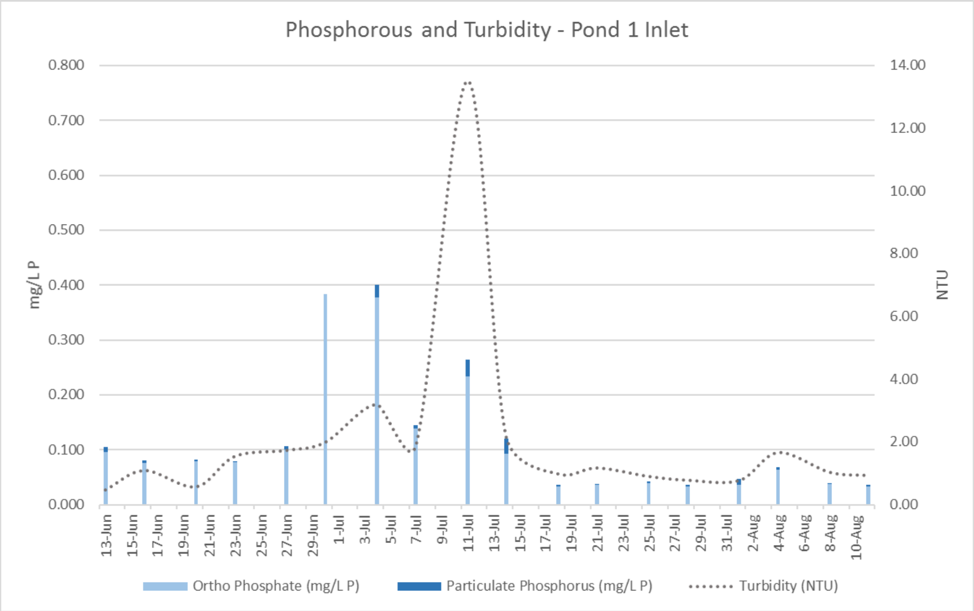
| | Date Analyses P | 14/06/16 | 17/06/16 | 20/06/16 | 23/06/16 | 27/06/16 | 30/06/13 | 7/4/2016 | 7/7/2016 | 11/7/2016 | 14/07/16 | 18/7/2016 | 21/7/2016 | 25/7/16 | 28/07/16 | 1/8/2016 | 4/8/2016 | 8/8/2016 | 11/8/2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Date Samples | 13-Jun | 16-Jun | 20-Jun | 23-Jun | 27-Jun | 30-Jun | 4-Jul | 7-Jul | 11-Jul | 14-Jul | 18-Jul | 21-Jul | 25-Jul | 28-Jul | 1-Aug | 4-Aug | 8-Aug | 11-Aug |
| 4.Out | Turbidity (NTU) | 5.23 | 4.90 | 2.20 | 1.80 | 2.24 | 2.20 | 1.75 | 2.00 | 3.30 | 5.63 | 4.10 | 3.30 | 2.56 | 2.40 | 2.00 | 1.64 | 1.72 | 1.74 |
| | P Total (mg/L P) | 0.177 | 0.334 | 0.262 | 0.249 | 0.348 | 0.679 | 0.733 | 0.478 | 0.435 | 0.436 | 0.480 | 0.203 | 0.195 | 0.241 | 0.236 | 0.214 | 0.198 | 0.184 |
| | Ortho Phosphate (mg/L P) | 0.085 | 0.105 | 0.208 | 0.196 | 0.244 | 0.628 | 0.668 | 0.397 | 0.372 | 0.290 | 0.377 | 0.164 | 0.162 | 0.208 | 0.201 | 0.179 | 0.167 | 0.154 |
| | Particulate Phosphorus (mg/L P) | 0.092 | 0.229 | 0.054 | 0.053 | 0.104 | 0.051 | 0.065 | 0.081 | 0.063 | 0.146 | 0.103 | 0.039 | 0.033 | 0.033 | 0.035 | 0.035 | 0.031 | 0.031 |
| | Temperature (°C) | 16.7 | 16.6 | 16.6 | 18.9 | 20.0 | 18.1 | 17.3 | 16.7 | 18.5 | 18.8 | 18.8 | 21.1 | 22.4 | 20.5 | 19.5 | 18.7 | 18.3 | 15.9 |
| | Pressure (Atm) | 0.9895 | 0.9844 | 1.0023 | 1.0060 | 0.9966 | 0.9939 | 0.9992 | 0.9973 | 0.9861 | 0.9947 | 0.9981 | 0.9990 | 1.0000 | 0.9952 | 0.9941 | 0.9887 | 0.9918 | 0.9977 |
| | Oxygen (mg/L) | 9.29 | 9.10 | 7.68 | 8.31 | 7.80 | 6.94 | 6.86 | 7.20 | 7.51 | 7.38 | 6.25 | 5.81 | 6.21 | 4.62 | 5.76 | 6.02 | 5.95 | 6.49 |
| | Conductivity (µS/cm) | 364.5 | 351.4 | 351.6 | 365.9 | 286.9 | 359.2 | 355.3 | 333.9 | 355.9 | 343.5 | 359.2 | 375.1 | 393.1 | 385.2 | 392.0 | 392.2 | 325.7 | 382.6 |
| | pH | 8.40 | 8.30 | 7.93 | 8.04 | 8.13 | 8.07 | 7.97 | 8.10 | 8.12 | 8.70 | 8.49 | 8.77 | 8.73 | 8.33 | 8.20 | 8.17 | 8.08 | 8.28 |
| | ORP (mV) | 121.3 | 102.3 | 89.4 | 103.9 | 102.0 | 127.6 | 150.6 | 186.3 | 131.3 | 106.9 | 91.6 | 57.8 | 73.7 | 60.0 | 115.8 | 56.1 | 58.2 | 92.4 |
| | Flow (L/s) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

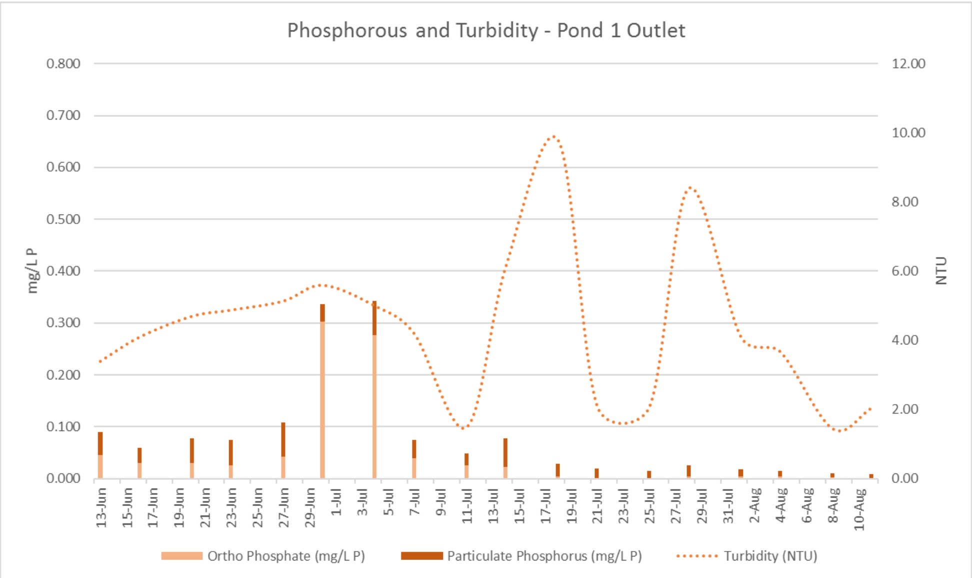
# Appendix 13: Results Pond 5

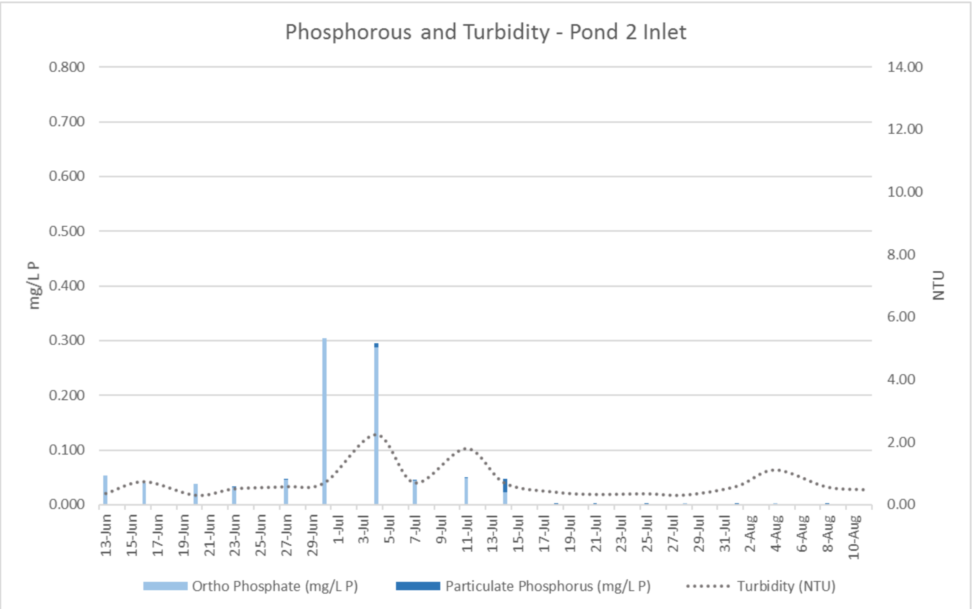
| | Date Analyses P | 14/06/16 | 17/06/16 | 20/06/16 | 23/06/16 | 27/06/16 | 30/06/13 | 7/4/2016 | 7/7/2016 | 11/7/2016 | 14/07/16 | 18/7/2016 | 21/7/2016 | 25/7/16 | 28/07/16 | 1/8/2016 | 4/8/2016 | 8/8/2016 | 11/8/2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Date Samples | 13-Jun | 16-Jun | 20-Jun | 23-Jun | 27-Jun | 30-Jun | 4-Jul | 7-Jul | 11-Jul | 14-Jul | 18-Jul | 21-Jul | 25-Jul | 28-Jul | 1-Aug | 4-Aug | 8-Aug | 11-Aug |
| 5.In | Turbidity (NTU) | 1.37 | 4.60 | 4.58 | 13.60 | 6.04 | 3.10 | 4.30 | 2.80 | 6.10 | 5.60 | 4.70 | 7.30 | 10.20 | 5.20 | 4.90 | 5.30 | 4.70 | 6.80 |
| | P Total (mg/L P) | 0.124 | 0.076 | 0.077 | 0.137 | 0.125 | 0.350 | 0.370 | 0.099 | 0.064 | 0.079 | 0.037 | 0.059 | 0.061 | 0.049 | 0.044 | 0.057 | 0.054 | 0.052 |
| | Ortho Phosphate (mg/L P) | 0.074 | 0.050 | 0.056 | 0.095 | 0.096 | 0.329 | 0.329 | 0.078 | 0.074 | 0.061 | 0.025 | 0.036 | 0.041 | 0.036 | 0.030 | 0.038 | 0.039 | 0.034 |
| | Particulate Phosphorus (mg/L P) | 0.050 | 0.026 | 0.021 | 0.042 | 0.029 | 0.021 | 0.041 | 0.021 | 0.000 | 0.018 | 0.012 | 0.023 | 0.020 | 0.013 | 0.014 | 0.019 | 0.015 | 0.018 |
| | Temperature (°C) | 12.7 | 13.7 | 18.2 | 19.1 | 17.3 | 15.8 | 14.7 | 14.8 | 15.6 | 14.4 | 16.2 | 19.4 | 21.6 | 18.6 | 16.8 | 17.6 | 18.5 | 13.1 |
| | Pressure (Atm) | 0.9899 | 0.9853 | 1.0028 | 1.0069 | 0.9975 | 0.9946 | 1.0004 | 0.9984 | 0.9869 | 0.9954 | 0.9993 | 0.9999 | 1.0008 | 0.9960 | 0.9948 | 0.9893 | 0.9926 | 0.9987 |
| | Oxygen (mg/L) | 10.26 | 9.79 | 14.83 | 8.54 | 9.06 | 9.81 | 9.51 | 9.79 | 9.52 | 9.09 | 8.89 | 7.73 | 6.50 | 6.91 | 6.88 | 6.92 | 6.52 | 8.08 |
| | Conductivity (µS/cm) | 436.0 | 432.1 | 446.5 | 482.3 | 458.8 | 440.4 | 429.4 | 431.1 | 494.4 | 471.9 | 467.4 | 498.9 | 521.0 | 503.0 | 476.2 | 495.7 | 499.8 | 443.1 |
| | pH | 8.37 | 8.24 | 8.21 | 7.98 | 8.10 | 8.22 | 8.18 | 8.26 | 8.36 | 8.44 | 8.24 | 8.28 | 8.33 | 8.25 | 8.20 | 8.19 | 8.18 | 8.30 |
| | ORP (mV) | 130.6 | 109.6 | 84.1 | 92.2 | 110.2 | 118.6 | 155.8 | 191.8 | 120.3 | 120.3 | 125.1 | 69.2 | 71.4 | 73.7 | 104.0 | 70.5 | 58.5 | 91.4 |
| | Flow (L/s) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

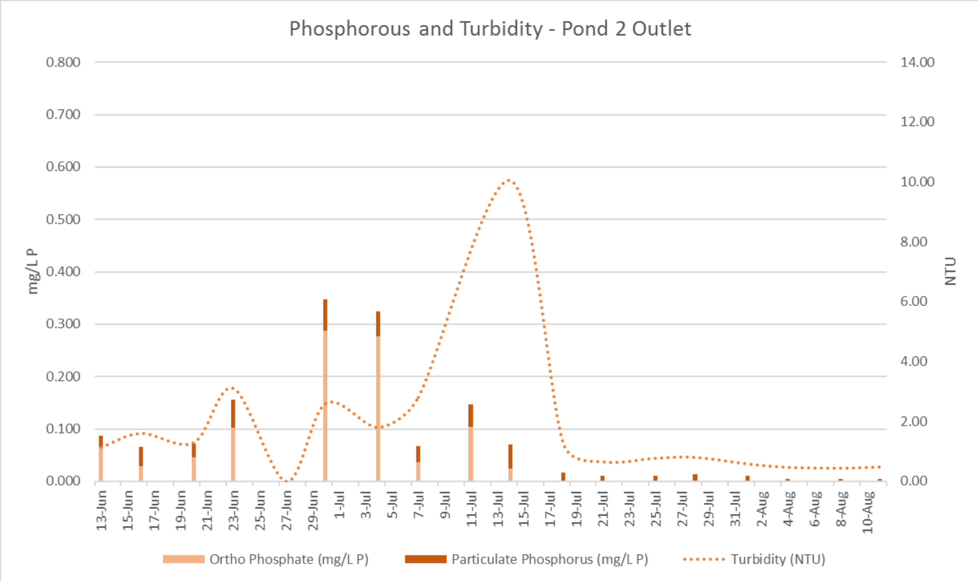
| | | 13-Jun | 16-Jun | 20-Jun | 23-Jun | 27-Jun | 30-Jun | 4-Jul | 7-Jul | 11-Jul | 14-Jul | 18-Jul | 21-Jul | 25-Jul | 28-Jul | 1-Aug | 4-Aug | 8-Aug | 11-Aug |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5.Out | Turbidity (NTU) | 0.90 | 0.82 | 0.94 | 1.16 | 1.54 | 1.70 | 1.46 | 1.70 | 1.31 | 1.91 | 1.88 | 1.40 | 1.40 | 1.40 | 1.00 | 1.25 | 1.50 | 1.10 |
| | P Total (mg/L P) | 0.12 | 0.088 | 0.104 | 0.106 | 0.141 | 0.377 | 0.377 | 0.138 | 0.102 | 0.129 | 0.055 | 0.052 | 0.050 | 0.048 | 0.037 | 0.031 | 0.032 | 0.031 |
| | Ortho Phosphate (mg/L P) | 0.086 | 0.058 | 0.069 | 0.074 | 0.097 | 0.34 | 0.337 | 0.116 | 0.093 | 0.076 | 0.037 | 0.033 | 0.031 | 0.03 | 0.022 | 0.018 | 0.019 | 0.019 |
| | Particulate Phosphorus (mg/L P) | 0.034 | 0.03 | 0.035 | 0.032 | 0.044 | 0.037 | 0.04 | 0.022 | 0.009 | 0.053 | 0.0175 | 0.019 | 0.0185 | 0.0175 | 0.015 | 0.013 | 0.013 | 0.012 |
| | Temperature (°C) | 16.1 | 17 | 17.3 | 20.9 | 20 | 17.9 | 17.7 | 16.6 | 19.6 | 19.7 | 19.1 | 22.7 | 24 | 21 | - | 19.1 | 19 | 14.9 |
| | Pressure (Atm) | 0.9898 | 0.9855 | 1.0029 | 1.0069 | 0.9975 | 0.9945 | 1.0004 | 0.9983 | 0.9869 | 0.9952 | 0.9992 | 0.9999 | 1.0008 | 0.9959 | - | 0.9895 | 0.9925 | 0.9988 |
| | Oxygen (mg/L) | 9.04 | 9.84 | 10.06 | 10.54 | 6.71 | 5.95 | 7.91 | 7.43 | 8.85 | 9.58 | 8.32 | 9.8 | 7.32 | 5.52 | - | 6.01 | 6.25 | 6.45 |
| | Conductivity (µS/cm) | 211.6 | 217.6 | 224.9 | 244.6 | 236.3 | 234.1 | 236.9 | 236.2 | 226.2 | 230.5 | 236.4 | 244.5 | 249.8 | 256.1 | - | 244.7 | 243.1 | 223.4 |
| | pH | 9.64 | 9.6 | 9.35 | 9.47 | 8.89 | 8.8 | 9.08 | 8.6 | 9.22 | 9.39 | 9.03 | 9.5 | 9.49 | 8.89 | - | 8.91 | 8.9 | 8.85 |
| | ORP (mV) | 90.1 | 84.2 | 73.7 | 35.9 | 91.9 | 94.5 | 158.5 | 202.7 | 119.2 | 100.4 | 127.9 | 54.5 | 27.3 | 51.4 | - | 43.5 | 73.5 | 68.5 |
| | Flow (L/s) | 1.29 | 1.17 | 1.33 | 1.13 | 1.12 | 1.05 | 0.84 | 1.00 | 1.33 | 1.37 | 0.99 | 0.82 | 0.56 | 0.41 | 0.23 | 0.18 | - | - |
| | Percentage Reduce P total (%) | 3.2 | -15.8 | -35.1 | 22.6 | -12.8 | -7.7 | -1.9 | -39.4 | -59.4 | -63.3 | -49.3 | 11.1 | 18.2 | 2.1 | 16.1 | 46.0 | 40.2 | 40.8 |
| | Percentage Réduce Ortho-Phosphate (%) | -16.2 | -16.0 | -23.2 | 22.1 | -1.0 | -3.3 | -2.4 | -48.7 | -25.7 | -24.6 | -48.0 | 8.3 | 24.4 | 15.5 | 28.3 | 52.6 | 50.6 | 45.6 |

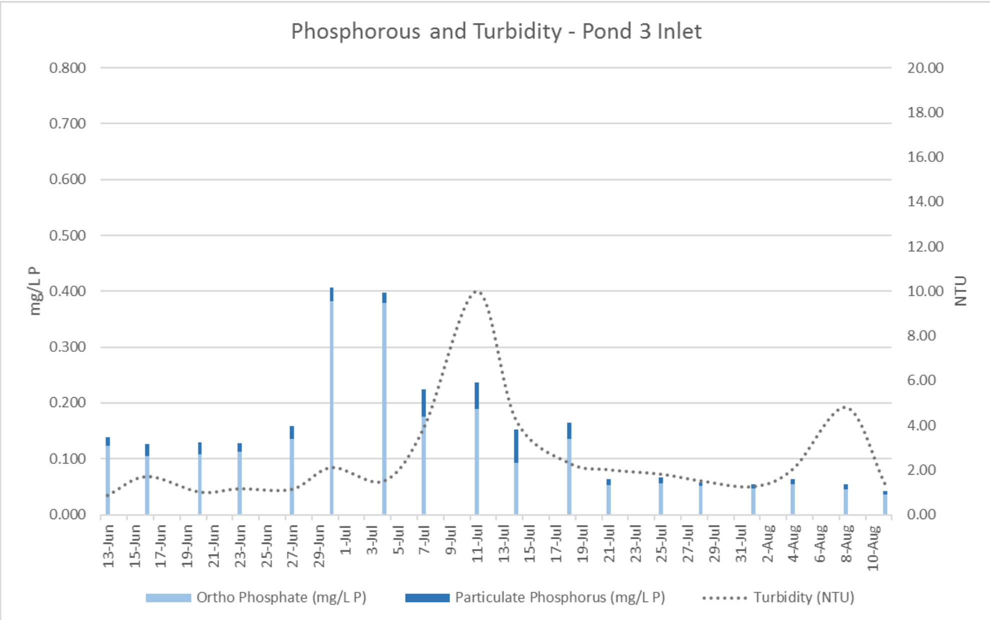
# Appendix 14: Evolution of Total phosphorus and Ortho-phosphate

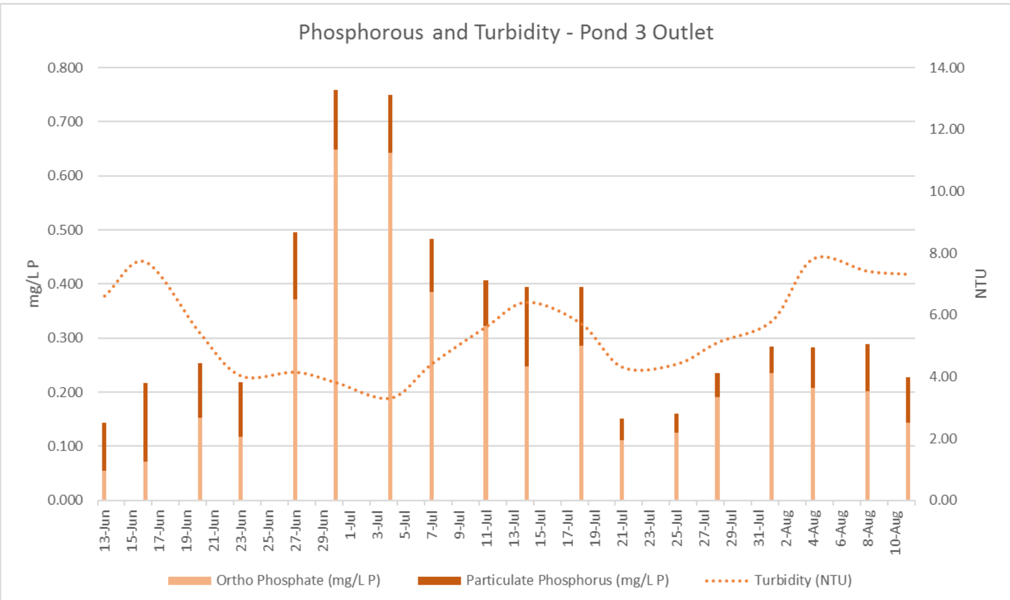


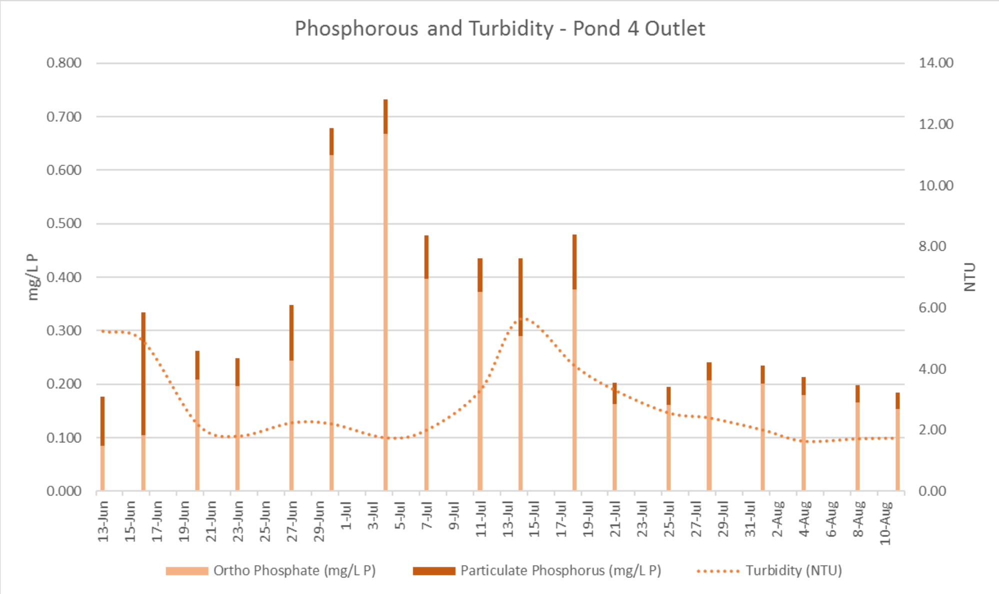



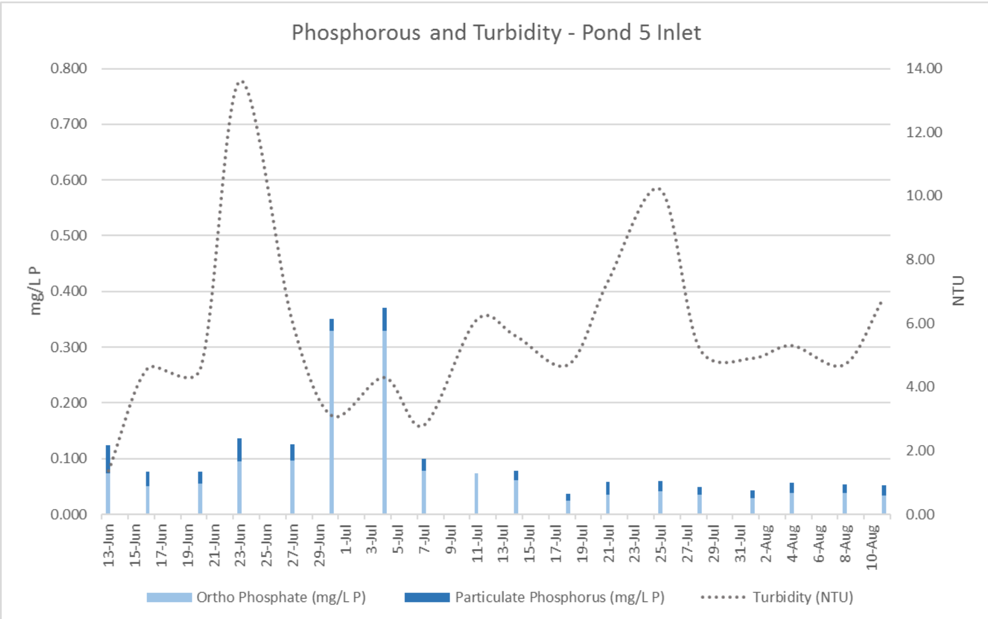



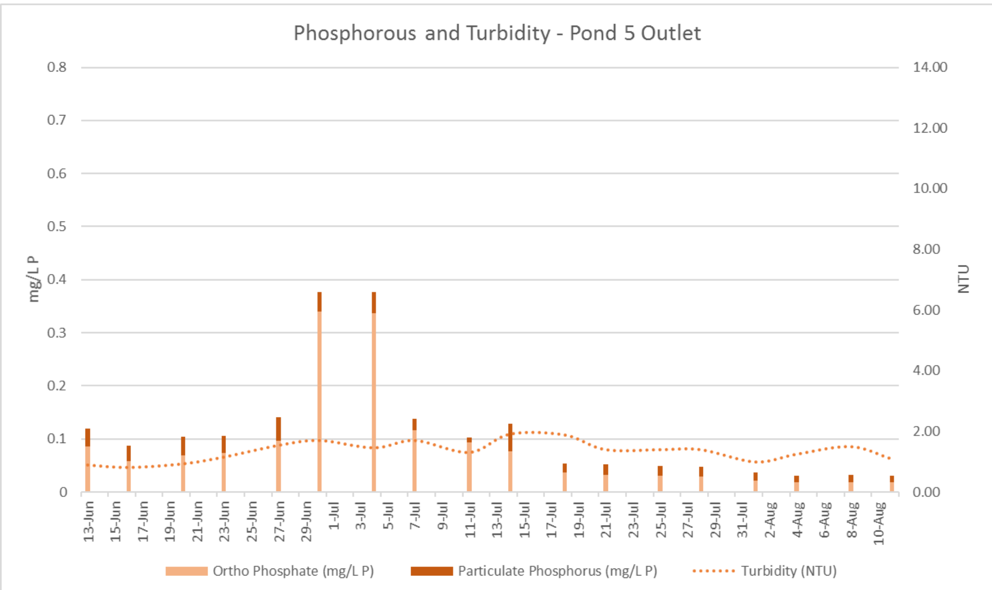

Phosphorous and Turbidity - Pond 2 Outlet
mg/L P
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
NTU
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
13-Jun 15-Jun 17-Jun 19-Jun 21-Jun 23-Jun 25-Jun 27-Jun 29-Jun 1-Jul 3-Jul 5-Jul 7-Jul 9-Jul 11-Jul 13-Jul 15-Jul 17-Jul 19-Jul 21-Jul 23-Jul 25-Jul 27-Jul 29-Jul 31-Jul 2-Aug 4-Aug 6-Aug 8-Aug 10-Aug
Ortho Phosphate (mg/L P)
Particulate Phosphorus (mg/L P)
Turbidity (NTU)


Phosphorous and Turbidity - Pond 3 Inlet
mg/L P
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
NTU
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
13-Jun 15-Jun 17-Jun 19-Jun 21-Jun 23-Jun 25-Jun 27-Jun 29-Jun 1-Jul 3-Jul 5-Jul 7-Jul 9-Jul 11-Jul 13-Jul 15-Jul 17-Jul 19-Jul 21-Jul 23-Jul 25-Jul 27-Jul 29-Jul 31-Jul 2-Aug 4-Aug 6-Aug 8-Aug 10-Aug
Ortho Phosphate (mg/L P)
Particulate Phosphorus (mg/L P)
Turbidity (NTU)

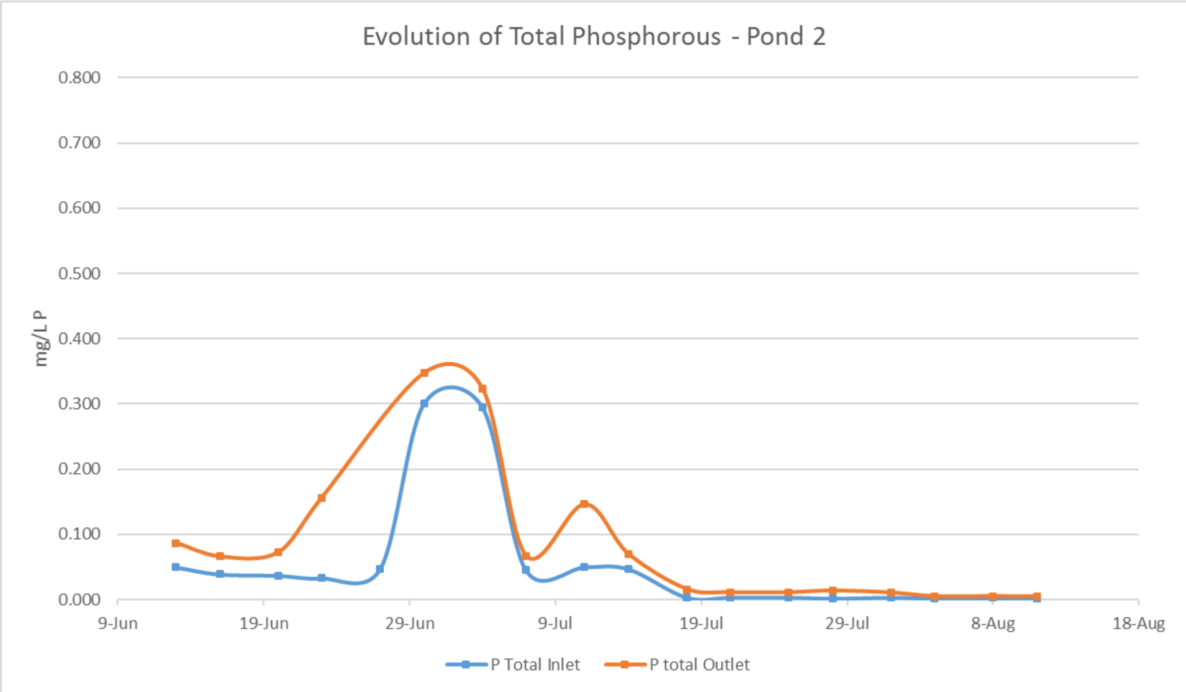

Phosphorous and Turbidity - Pond 3 Outlet
mg/L P
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
NTU
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
13-Jun 15-Jun 17-Jun 19-Jun 21-Jun 23-Jun 25-Jun 27-Jun 29-Jun 1-Jul 3-Jul 5-Jul 7-Jul 9-Jul 11-Jul 13-Jul 15-Jul 17-Jul 19-Jul 21-Jul 23-Jul 25-Jul 27-Jul 29-Jul 31-Jul 2-Aug 4-Aug 6-Aug 8-Aug 10-Aug
Ortho Phosphate (mg/L P)
Particulate Phosphorus (mg/L P)
Turbidity (NTU)

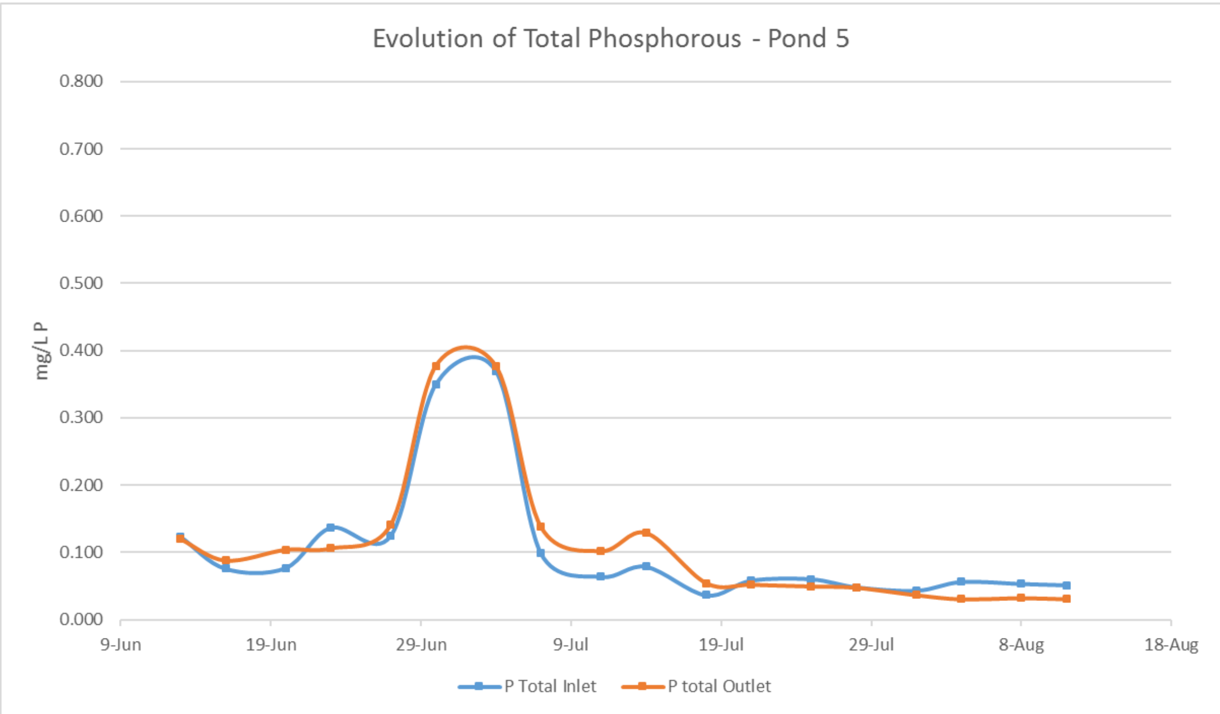

Phosphorous and Turbidity - Pond 4 Outlet
mg/L P
NTU
0.000
0.100
0.200
0.300
0.400
0.500
0.600
0.700
0.800
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
13-Jun 15-Jun 17-Jun 19-Jun 21-Jun 23-Jun 25-Jun 27-Jun 29-Jun 1-Jul 3-Jul 5-Jul 7-Jul 9-Jul 11-Jul 13-Jul 15-Jul 17-Jul 19-Jul 21-Jul 23-Jul 25-Jul 27-Jul 29-Jul 31-Jul 2-Aug 4-Aug 6-Aug 8-Aug 10-Aug
Ortho Phosphate (mg/L P)
Particulate Phosphorus (mg/L P)
Turbidity (NTU)


Phosphorous and Turbidity - Pond 5 Inlet
mg/L P
NTU
0.000
0.100
0.200
0.300
0.400
0.500
0.600
0.700
0.800
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
13-Jun 15-Jun 17-Jun 19-Jun 21-Jun 23-Jun 25-Jun 27-Jun 29-Jun 1-Jul 3-Jul 5-Jul 7-Jul 9-Jul 11-Jul 13-Jul 15-Jul 17-Jul 19-Jul 21-Jul 23-Jul 25-Jul 27-Jul 29-Jul 31-Jul 2-Aug 4-Aug 6-Aug 8-Aug 10-Aug
Ortho Phosphate (mg/L P)
Particulate Phosphorus (mg/L P)
Turbidity (NTU)

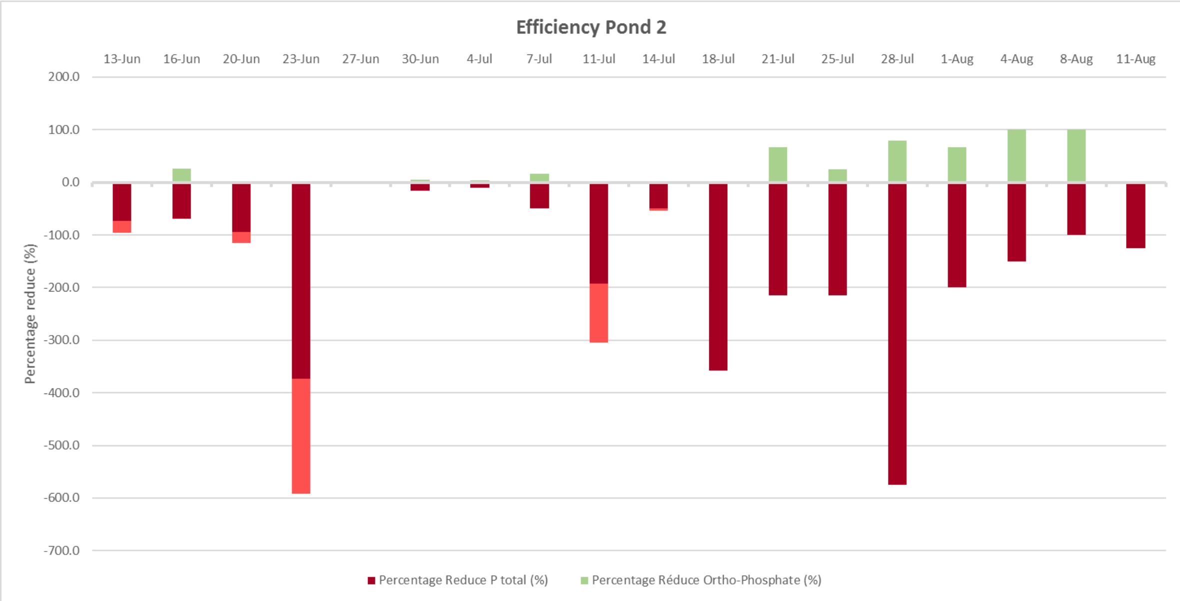

Phosphorous and Turbidity - Pond 5 Outlet
mg/L P
NTU
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
13-Jun 15-Jun 17-Jun 19-Jun 21-Jun 23-Jun 25-Jun 27-Jun 29-Jun 1-Jul 3-Jul 5-Jul 7-Jul 9-Jul 11-Jul 13-Jul 15-Jul 17-Jul 19-Jul 21-Jul 23-Jul 25-Jul 27-Jul 29-Jul 31-Jul 2-Aug 4-Aug 6-Aug 8-Aug 10-Aug
Ortho Phosphate (mg/L P)
Particulate Phosphorus (mg/L P)
Turbidity (NTU)

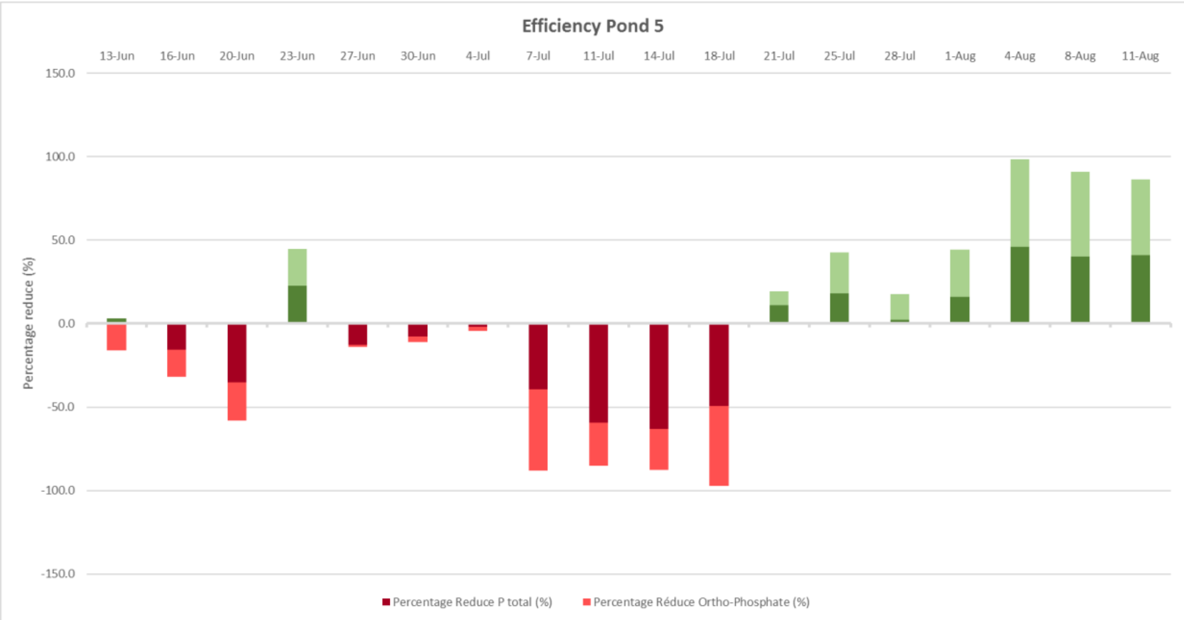
# Appendix 15: Evolution of Total Phosphorus Inlet and Outlet Ponds 2 and 5



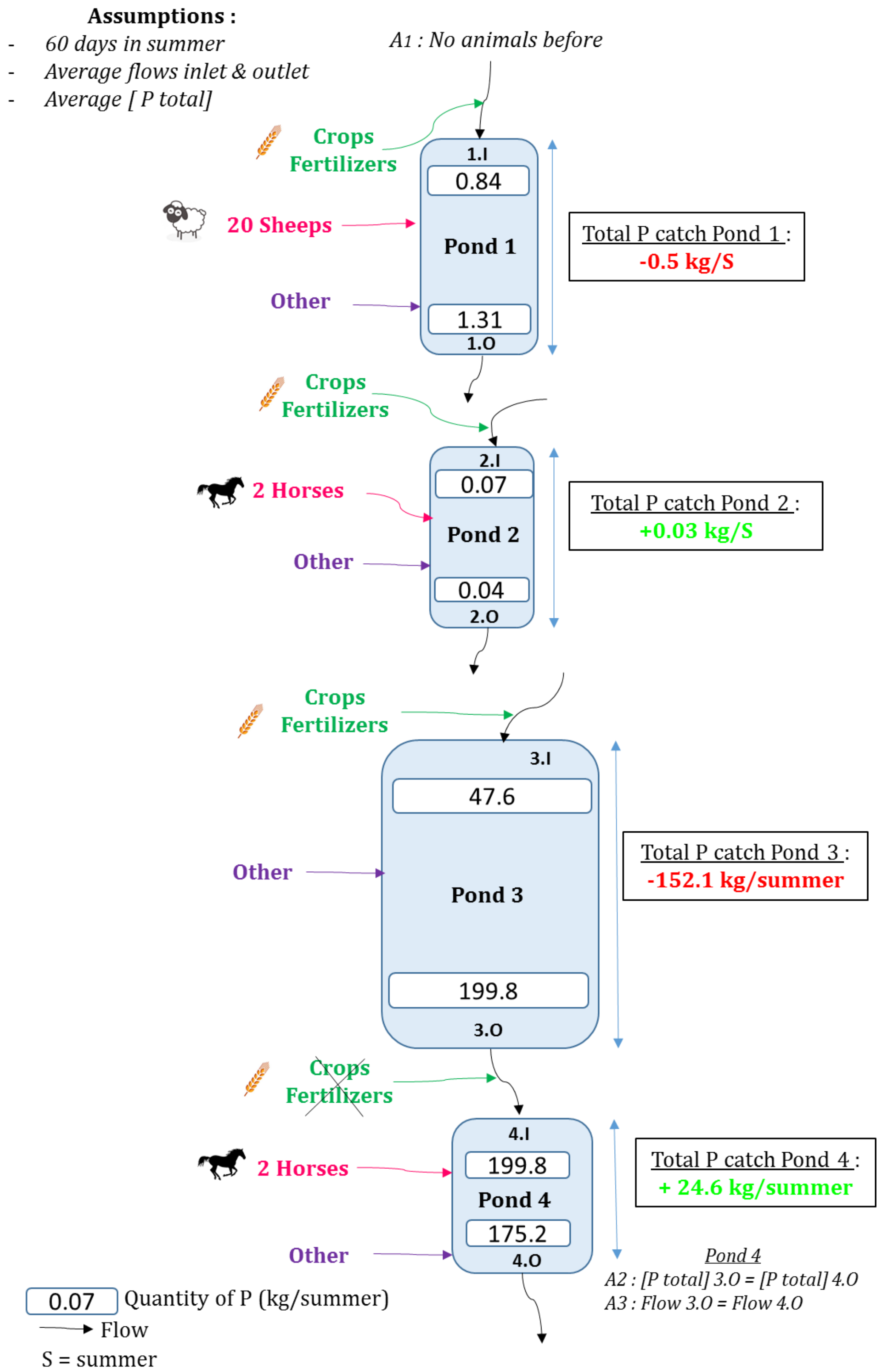
# Appendix 16: Efficiencies of Ponds 2 and 5



# Appendix 17: Model of the relation between P quantity and ponds

## Pond 1 to 4



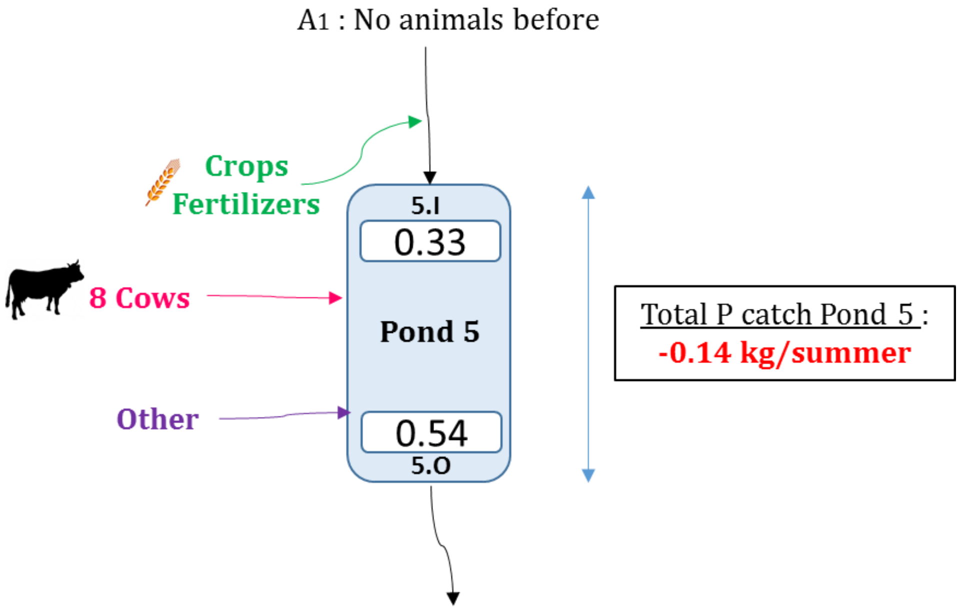

**Other :** septic tank/ fertilizers directly in the ponds/other animal wastes

# Appendix 18: Model of the relation between P quantity and ponds

## Pond 5

**Assumptions :**

- *60 days in summer*
- *Average flows inlet & outlet*
- *Average [ P total]*




0.07 Quantity of P (kg/summer)

→ Flow

S = summer

**Other :** septic tank/ fertilizers directly in the ponds/other animal wastes

# Appendix 19: Water profile Point 1 (L1)

| | | 14/06/2016 | 21/06/2016 | 28/06/2016 | 5/7/2016 | 12/7/2016 | 19/07/16 | 26/07/16 | 2/8/2016 | 9/8/2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1m | Temperature (°C) | 18.1 | 17.9 | 20.5 | 19.5 | 19.2 | 19.3 | 23.1 | 21 | 19.3 |
| | Pressure (Atm) | 0.9849 | 0.9979 | 0.9998 | 0.9972 | 0.9909 | 1.0038 | 1.0018 | 0.998 | 0.9979 |
| | Oxygen (mg/L) | 9.2 | 9.64 | 10.45 | 10.56 | 10.55 | 10.7 | 17.1 | 12.35 | 8.19 |
| | Conductivity (µS/cm) | 355.8 | 345.6 | 337.5 | 368.4 | 347 | 320.8 | 283.4 | 290.2 | 295.6 |
| | pH | 8.65 | 8.68 | 8.87 | 8.89 | 9.07 | 9.15 | 9.28 | 9.22 | 8.84 |
| | ORP (mV) | 84.4 | 89.8 | 105.2 | 95.6 | 108.8 | 115.4 | 64.6 | 122.7 | 86.4 |
| 2m | Temperature (°C) | 18 | 17.9 | 20.5 | 19.3 | 19.1 | 19.3 | 23 | 20.9 | 19.3 |
| | Pressure (Atm) | 0.9849 | 0.9979 | 0.9998 | 0.9972 | 0.9909 | 1.0038 | 1.0018 | 0.9981 | 0.9979 |
| | Oxygen (mg/L) | 7.72 | 9.44 | 10.39 | 9.16 | 10.33 | 10.86 | 17.15 | 11.56 | 8.25 |
| | Conductivity (µS/cm) | 354.5 | 346.8 | 370.8 | 367.2 | 347 | 320.8 | 284.8 | 292.7 | 295.7 |
| | pH | 8.6 | 8.59 | 8.84 | 8.91 | 9.07 | 9.18 | 9.27 | 9.17 | 8.72 |
| | ORP (mV) | 85.6 | 93.2 | 105.9 | 105.2 | 107.8 | 121.1 | 70.6 | 116.2 | 83.3 |
| 3m | Temperature (°C) | 18 | 17.9 | 20.5 | 19.3 | 19.1 | 19.3 | 22.5 | 20.8 | 19.3 |
| | Pressure (Atm) | 0.9849 | 0.9979 | 0.9998 | 0.9972 | 0.9909 | 1.0038 | 1.0019 | 0.9981 | 0.9979 |
| | Oxygen (mg/L) | 8.04 | 9.36 | 10.56 | 9.61 | 10.27 | 10.79 | 16.55 | 10.58 | 8.21 |
| | Conductivity (µS/cm) | 355.2 | 360 | 369.2 | 358.6 | 347.5 | 320 | 291.9 | 295.5 | 295.1 |
| | pH | 8.59 | 8.6 | 8.85 | 8.93 | 9.07 | 9.19 | 9.14 | 9.15 | 8.71 |
| | ORP (mV) | 86.9 | 97 | 108.5 | 110.1 | 104.6 | 120.7 | 76.2 | 111.6 | 74.3 |
| 4m | Temperature (°C) | 18 | 17.9 | 20.4 | 19.3 | 19.1 | 19.2 | 20.9 | 20.8 | 19.3 |
| | Pressure (Atm) | 0.985 | 0.9979 | 0.9998 | 0.9972 | 0.9909 | 1.0037 | 1.0017 | 0.9981 | 0.9979 |
| | Oxygen (mg/L) | 8.3 | 9.53 | 10.34 | 9.23 | 10.15 | 10.36 | 10.05 | 10.29 | 8.16 |
| | Conductivity (µS/cm) | 355.2 | 360.2 | 315.2 | 357.1 | 347.4 | 322.3 | 322 | 296.5 | 296 |
| | pH | 8.58 | 8.6 | 8.85 | 8.94 | 9.07 | 9.18 | 8.79 | 9.05 | 8.7 |
| | Alkalinity (mV) | 88.2 | 102 | 108.2 | 106.9 | 102.4 | 117.4 | 82.8 | 99.9 | 73 |
| 5m | Temperature (°C) | 17.9 | 17.9 | 20.2 | 19.3 | 19.1 | 19.2 | 19.9 | 20.8 | 19.3 |
| | Pressure (Atm) | 0.985 | 0.9979 | 0.9998 | 0.9971 | 0.991 | 1.0037 | 1.0018 | 0.998 | 0.9979 |
| | Oxygen (mg/L) | 8.28 | 9.19 | 9.45 | 9.27 | 10.28 | 10.4 | 6.29 | 10.11 | 8.19 |
| | Conductivity (µS/cm) | 355.4 | 360.4 | 376.1 | 350.2 | 347.4 | 322.7 | 332.2 | 297.2 | 296 |
| | pH | 8.58 | 8.64 | 8.79 | 8.92 | 9.07 | 9.06 | 8.45 | 9.02 | 8.7 |
| | ORP (mV) | 88.6 | 110.8 | 117.7 | 105.9 | 100.7 | 99.9 | 83.8 | 97.8 | 71.2 |
| 6m | Temperature (°C) | 17.9 | 17.9 | 19.5 | 19.3 | 19.1 | 19.2 | 19.5 | 20.1 | 19.3 |
| | Pressure (Atm) | 0.9851 | 0.998 | 0.9998 | 0.9971 | 0.991 | 1.0037 | 1.0017 | 0.9981 | 0.9977 |
| | Oxygen (mg/L) | 7.85 | 9.34 | 7.97 | 8.92 | 10.38 | 10.3 | 4.57 | 0.5 | 8.14 |
| | Conductivity (µS/cm) | 355.8 | 342.7 | 384.6 | 359.9 | 347.6 | 323 | 334.8 | 330.9 | 295.9 |
| | pH | 8.57 | 8.63 | 8.67 | 8.93 | 9.07 | 9.03 | 8.3 | 8.4 | 8.7 |
| | ORP (mV) | 89.2 | 114.4 | 128.3 | 103.7 | 99.6 | 98.4 | 82 | 113 | 71.7 |
| 7m | Temperature (°C) | 17.9 | 17.8 | 18.5 | 19.2 | 19 | 19.1 | 19.2 | 19.7 | 19.2 |
| | Pressure (Atm) | 0.9851 | 0.9979 | 0.9998 | 0.9971 | 0.991 | 1.0037 | 1.0016 | 0.998 | 0.9978 |
| | Oxygen (mg/L) | 7.56 | 8.74 | 0.97 | 6.9 | 0.34 | 8.46 | 1.41 | 0.24 | 0.54 |
| | Conductivity (µS/cm) | 356.4 | 356.7 | 363 | 358.6 | 339.5 | 324.1 | 337.6 | 335.6 | 307 |
| | pH | 8.5 | 8.61 | 8.19 | 8.85 | 8.43 | 9.12 | 8.03 | 8.04 | 8.19 |
| | ORP (mV) | -55.5 | 70.3 | -139.2 | 17.4 | -115.6 | 109.6 | -7.6 | -2 | -119.1 |

# Appendix 20: Water profile Point 2 (L2)

| | | 14/06/2016 | 21/06/2016 | 28/06/2016 | 5/7/2016 | 12/7/2016 | 19/07/16 | 26/07/16 | 2/8/2016 | 9/8/2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1m | Temperature (°C) | 18.2 | 18 | 20.5 | 19.9 | 19.1 | 19.3 | 23.4 | 20.9 | 19.4 |
| | Pressure (Atm) | 0.9849 | 0.9985 | 1.0002 | 0.9955 | 0.9912 | 1.0037 | 1.002 | 0.9982 | 0.998 |
| | Oxygen (mg/L) | 7.81 | 9.03 | 10.9 | 11.2 | 10.82 | 10.85 | 17.74 | 11.06 | 8.03 |
| | Conductivity (µS/cm) | 346.2 | 361.6 | 370.6 | 353 | 348.6 | 307.1 | 286.1 | 295.2 | 295.8 |
| | pH | 8.58 | 8.47 | 8.82 | 8.98 | 9.05 | 8.97 | 9.19 | 9.04 | 8.66 |
| | ORP (mV) | 183.4 | 135 | 60.3 | 29.7 | 126.5 | 68.4 | 88.2 | 85.5 | 61 |
| 2m | Temperature (°C) | 18.1 | 18 | 20.5 | 19.5 | 19 | 19.3 | 22.4 | 20.9 | 19.4 |
| | Pressure (Atm) | 0.9849 | 0.9985 | 1.0002 | 0.9955 | 0.9913 | 1.0038 | 1.0019 | 0.9982 | 0.998 |
| | Oxygen (mg/L) | 7.8 | 9.29 | 10.95 | 10.25 | 10.4 | 10.52 | 14.82 | 10.97 | 8.08 |
| | Conductivity (µS/cm) | 346.9 | 351 | 371.3 | 358.8 | 346.8 | 324 | 299.7 | 295.5 | 295.7 |
| | pH | 8.56 | 8.5 | 8.85 | 9.01 | 9.12 | 8.97 | 8.96 | 9.03 | 8.66 |
| | ORP (mV) | 176.4 | 139.2 | 62.3 | 58.3 | 137.3 | 68.3 | 86.9 | 86.2 | 61.8 |
| 3m | Temperature (°C) | 18 | 18 | 20.4 | 19.3 | 19 | 19.2 | 21.2 | 20.8 | 19.4 |
| | Pressure (Atm) | 0.9849 | 0.9985 | 1.0001 | 0.9955 | 0.9912 | 1.0038 | 1.002 | 0.9982 | 0.998 |
| | Oxygen (mg/L) | 7.87 | 9.18 | 10.89 | 9.53 | 10.44 | 10.47 | 8.56 | 10.69 | 8.16 |
| | Conductivity (µS/cm) | 347.4 | 334.3 | 374.5 | 357.3 | 347.2 | 327.2 | 325 | 296.6 | 295.8 |
| | pH | 8.56 | 8.53 | 8.86 | 8.97 | 9.1 | 8.96 | 8.55 | 9.01 | 8.65 |
| | ORP (mV) | 171.9 | 143.9 | 66.5 | 67.5 | 136.1 | 68.1 | 89.5 | 86.7 | 63.5 |
| 4m | Temperature (°C) | 18 | 18 | 20.4 | 19.3 | 19 | 19.2 | 19.9 | 20.8 | 19.4 |
| | Pressure (Atm) | 0.9849 | 0.9985 | 1.0002 | 0.9955 | 0.9912 | 1.0038 | 1.002 | 0.9981 | 0.998 |
| | Oxygen (mg/L) | 7.76 | 9.06 | 10.8 | 9.44 | 10.44 | 10.34 | 5.69 | 10.74 | 8.13 |
| | Conductivity (µS/cm) | 348.2 | 375.2 | 376.3 | 356.3 | 347.3 | 327.5 | 333.8 | 296.4 | 295.9 |
| | pH | 8.55 | 8.56 | 8.88 | 8.96 | 9.11 | 8.95 | 8.33 | 9.01 | 8.64 |
| | ORP (mV) | 167.2 | 151.8 | 74 | 72.3 | 131.7 | 68 | 89.3 | 86.5 | 65.1 |
| 5m | Temperature (°C) | 17.9 | 18 | 20.2 | 19.3 | 19 | 19.2 | 19.8 | 20.8 | 19.4 |
| | Pressure (Atm) | 0.9849 | 0.9985 | 1.0002 | 0.9955 | 0.9913 | 1.0039 | 1.0021 | 0.9981 | 0.9981 |
| | Oxygen (mg/L) | 7.62 | 8.85 | 10.51 | 9.36 | 10.58 | 10.16 | 5.42 | 10.09 | 8.05 |
| | Conductivity (µS/cm) | 349.2 | 351.7 | 369.4 | 355.4 | 347.5 | 327.7 | 333.7 | 297.9 | 296 |
| | pH | 8.54 | 8.6 | 8.91 | 8.96 | 9.13 | 8.95 | 8.27 | 8.98 | 8.65 |
| | ORP (mV) | 164.8 | 153.7 | 77.1 | 73 | 127.8 | 67.3 | 85.4 | 87.2 | 65.5 |
| 6m | Temperature (°C) | 17.9 | 18 | 20.2 | 19.3 | 19 | 19.2 | 19.6 | 20.8 | 19.4 |
| | Pressure (Atm) | 0.9849 | 0.9985 | 1.0002 | 0.9954 | 0.9911 | 1.0039 | 1.0021 | 0.9981 | 0.9981 |
| | Oxygen (mg/L) | 7.43 | 8.86 | 10.39 | 9.14 | 10.56 | 10.04 | 5.14 | 10.47 | 8.21 |
| | Conductivity (µS/cm) | 350.1 | 357.3 | 369.9 | 357.5 | 347.6 | 327.6 | 334 | 297.4 | 295.8 |
| | pH | 8.54 | 8.6 | 8.93 | 8.97 | 9.13 | 8.95 | 8.24 | 8.97 | 8.66 |
| | ORP (mV) | 161.3 | 154.5 | 79.7 | 74 | 125.3 | 66.7 | 82.2 | 85.1 | 66.6 |
| 7m | Temperature (°C) | 17.9 | 18 | 20.2 | 19.3 | 19 | 19.2 | 19.5 | 20.6 | 19.4 |
| | Pressure (Atm) | 0.9849 | 0.9985 | 1.0002 | 0.9955 | 0.9911 | 1.0039 | 1.002 | 0.9981 | 0.9979 |
| | Oxygen (mg/L) | 7.54 | 8.96 | 10.14 | 9.41 | 10.47 | 10 | 4.63 | 7.27 | 8.13 |
| | Conductivity (µS/cm) | 350.8 | 356.5 | 364.9 | 357 | 347.5 | 327.7 | 335 | 309.5 | 296.2 |
| | pH | 8.54 | 8.61 | 8.91 | 8.96 | 9.12 | 8.94 | 8.19 | 8.62 | 8.63 |
| | ORP (mV) | 158.7 | 152.5 | 86.1 | 74.7 | 123.3 | 66 | 80.3 | 85.5 | 67.5 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 8m | Temperature (°C) | 17.9 | 18 | 19.4 | 19.2 | 19 | 19.1 | 19.3 | 19.6 | 19.4 |
| | Pressure (Atm) | 0.9849 | 0.9986 | 1.0003 | 0.9953 | 0.9912 | 1.0038 | 1.002 | 0.998 | 0.9979 |
| | Oxygen (mg/L) | 7.23 | 9.07 | 8.05 | 9.58 | 10.26 | 10.09 | 3.31 | 0.04 | 8.01 |
| | Conductivity (µS/cm) | 351.4 | 357.1 | 367.9 | 356.9 | 347.7 | 327.9 | 336.8 | 337.2 | 296.2 |
| | pH | 8.52 | 8.6 | 8.62 | 8.94 | 9.12 | 8.93 | 8.09 | 8.08 | 8.62 |
| | ORP (mV) | 156.7 | 151.6 | 91.5 | 76.5 | 120.6 | 66 | 77.8 | 91.8 | 66.9 |
| 9m | Temperature (°C) | 17.8 | 17.9 | 18.7 | 19.2 | 19 | 19.1 | 19.2 | 19.4 | 19.4 |
| | Pressure (Atm) | 0.9848 | 0.9986 | 1.0002 | 0.9953 | 0.9912 | 1.0039 | 1.0021 | 0.998 | 0.9979 |
| | Oxygen (mg/L) | 7.51 | 8.6 | 6.63 | 9.56 | 10.33 | 9.95 | 2.43 | 0.01 | 8.09 |
| | Conductivity (µS/cm) | 351.7 | 356.6 | 365.8 | 356.8 | 348.4 | 327.8 | 337.2 | 338 | 296.3 |
| | pH | 8.55 | 8.58 | 8.39 | 8.94 | 9.12 | 8.92 | 8.01 | 7.92 | 8.62 |
| | ORP (mV) | 152.9 | 150.6 | 95.2 | 77.1 | 108.6 | 66.4 | 75.8 | 78 | 66.8 |
| 10m | Temperature (°C) | 17.8 | 17.9 | 18.5 | 19.2 | 19 | 19.1 | 19 | 19.4 | 19.3 |
| | Pressure (Atm) | 0.9849 | 0.9986 | 1.0001 | 0.9954 | 0.9911 | 1.0039 | 1.002 | 0.998 | 0.9979 |
| | Oxygen (mg/L) | 7.77 | 8.56 | 5.61 | 9.35 | 10.34 | 9.64 | 1 | 0.02 | 9.04 |
| | Conductivity (µS/cm) | 352 | 356.4 | 365.2 | 356.6 | 347.7 | 327.7 | 338.6 | 338.6 | 296.3 |
| | pH | 8.56 | 8.59 | 8.23 | 8.96 | 9.09 | 8.91 | 7.93 | 7.88 | 8.6 |
| | ORP (mV) | 150.8 | 147.7 | 96.1 | 76.2 | 116.3 | 67.5 | 75.2 | 67.9 | 65.6 |
| 11m | Temperature (°C) | 17.8 | 17.9 | 18.3 | 19.2 | 19 | 19.1 | 19 | 19.3 | 19.3 |
| | Pressure (Atm) | 0.9849 | 0.9985 | 1.0002 | 0.9953 | 0.9912 | 1.0039 | 1.002 | 0.998 | 0.9979 |
| | Oxygen (mg/L) | 7.97 | 8.8 | 5 | 9.02 | 10.4 | 9.94 | 0.85 | 0.01 | 8.06 |
| | Conductivity (µS/cm) | 351.9 | 355.7 | 366.1 | 356.5 | 348.6 | 327.6 | 338.4 | 339 | 296.3 |
| | pH | 8.58 | 8.54 | 8.15 | 8.96 | 9.04 | 8.91 | 7.87 | 7.86 | 8.62 |
| | ORP (mV) | 148.3 | 145.7 | 98.7 | 76.3 | 102.1 | 67.1 | 72.5 | 47.1 | 63.9 |
| 12m | Temperature (°C) | 17.8 | 17.8 | 18.2 | 19.1 | 19 | 19.1 | 19 | 19.3 | 19.3 |
| | Pressure (Atm) | 0.9848 | 0.9986 | 1.0002 | 0.9953 | 0.9911 | 1.0038 | 1.0021 | 0.998 | 0.9978 |
| | Oxygen (mg/L) | 7.86 | 8.44 | 5.35 | 7.41 | 10.2 | 9.95 | 0.42 | 0.01 | 8.18 |
| | Conductivity (µS/cm) | 352.2 | 356.7 | 363.7 | 361 | 347.8 | 327.5 | 338.4 | 339.3 | 296.2 |
| | pH | 8.58 | 8.53 | 8.13 | 8.79 | 9.1 | 8.92 | 7.82 | 7.85 | 8.61 |
| | ORP (mV) | 146.3 | 145.1 | 97.4 | 79.5 | 101 | 66.5 | 71.4 | 32 | 62.9 |
| 13m | Temperature (°C) | 17.7 | 17.7 | 18.1 | 18.4 | 18.9 | 19.1 | 18.8 | 19.2 | 19.3 |
| | Pressure (Atm) | 0.9848 | 0.9986 | 1.0002 | 0.9952 | 0.9912 | 1.0039 | 1.0021 | 0.998 | 0.9978 |
| | Oxygen (mg/L) | 7.83 | 8.34 | 4.61 | 2.37 | 10.03 | 9.64 | 0.01 | 0.01 | 8.1 |
| | Conductivity (µS/cm) | 352.7 | 356.1 | 365.1 | 369.8 | 347.7 | 327.7 | 342.1 | 341.4 | 296.4 |
| | pH | 8.56 | 8.49 | 8.09 | 8.26 | 9.1 | 8.91 | 7.81 | 7.86 | 8.58 |
| | ORP (mV) | 145.1 | 143.6 | 99.6 | -86.2 | 111.3 | 66.3 | 71 | -16.8 | 61.9 |
| 14m | Temperature (°C) | 17.7 | 17.6 | 17.8 | 18.4 | 18.8 | 18.9 | 18.8 | 19.1 | 19.3 |
| | Pressure (Atm) | 0.9848 | 0.9986 | 1.0002 | 0.9952 | 0.9911 | 1.0039 | 1.0021 | 0.9979 | 0.9978 |
| | Oxygen (mg/L) | 7.79 | 7.44 | 0.28 | 0.12 | 9.89 | 3.32 | 0.02 | 0.01 | 8.13 |
| | Conductivity (µS/cm) | 353.5 | 356.5 | 356.1 | 371.9 | 347.3 | 329 | 343.4 | 343.8 | 296.4 |
| | pH | 8.54 | 8.46 | 7.84 | 8.08 | 9.01 | 8.06 | 7.81 | 7.87 | 8.58 |
| | ORP (mV) | 138.5 | 137 | -133.8 | -163.2 | 89.2 | -147.8 | 0.9 | -78.3 | 61 |

# Appendix 21: Water profile Point 3 (L3)

| | | 14/06/2016 | 21/06/2016 | 28/06/2016 | 5/7/2016 | 12/7/2016 | 19/07/16 | 26/07/16 | 2/8/2016 | 9/8/2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1m | Temperature (°C) | - | 18.1 | 20.7 | 19.9 | 19.2 | 19.4 | 23.3 | 21.1 | 19 |
| | Pressure (Atm) | - | 0.9985 | 1.0002 | 0.995 | 0.9913 | 1.0039 | 1.0022 | 0.9979 | 0.9979 |
| | Oxygen (mg/L) | - | 9.4 | 10.8 | 11.25 | 11.16 | 11.35 | 18.76 | 10.85 | 8.12 |
| | Conductivity (µS/cm) | - | 352.1 | 376.9 | 332 | 347.1 | 323.1 | 283 | 292.3 | 294.7 |
| | pH | - | 8.49 | 8.84 | 9.01 | 9.07 | 9 | 9.18 | 9.05 | 8.61 |
| | ORP (mV) | - | 128.3 | 71.1 | 90.3 | 97.2 | 54.2 | 54.5 | 19.6 | 91.6 |
| 2m | Temperature (°C) | - | 18.1 | 20.7 | 19.6 | 19.2 | 19.4 | 23.3 | 21 | 19.1 |
| | Pressure (Atm) | - | 0.9985 | 1.0001 | 0.995 | 0.9913 | 1.004 | 1.0021 | 0.9978 | 0.9977 |
| | Oxygen (mg/L) | - | 9.59 | 10.87 | 11.27 | 11.13 | 11.11 | 18.32 | 11.32 | 8.22 |
| | Conductivity (µS/cm) | - | 370.2 | 375.9 | 358 | 346.9 | 323.5 | 283.1 | 292.7 | 294.6 |
| | pH | - | 8.51 | 8.85 | 9.04 | 9.08 | 9.02 | 9.23 | 9.1 | 8.63 |
| | ORP (mV) | - | 130.6 | 71.7 | 97.1 | 95 | 56 | 59.7 | 34.2 | 84.2 |
| 3m | Temperature (°C) | - | 18.1 | 20.5 | 19.3 | 19.2 | 19.3 | 22.8 | 21 | 19.1 |
| | Pressure (Atm) | - | 0.9985 | 1.0001 | 0.995 | 0.9913 | 1.0039 | 1.0022 | 0.9979 | 0.9977 |
| | Oxygen (mg/L) | - | 9.54 | 10.84 | 9.98 | 11.16 | 10.73 | 16.68 | 10.86 | 8.32 |
| | Conductivity (µS/cm) | - | 377.5 | 373.9 | 356.5 | 346.7 | 324.9 | 294.3 | 292.7 | 294.7 |
| | pH | - | 8.56 | 8.88 | 9.01 | 9.09 | 9.02 | 9.13 | 9.11 | 8.62 |
| | ORP (mV) | - | 135.4 | 74.2 | 96.9 | 92.7 | 56.9 | 64.9 | 42.1 | 80.8 |
| 4m | Temperature (°C) | - | 18.1 | 20.5 | 19.3 | 19.2 | 19.3 | 21.1 | 21 | 19.1 |
| | Pressure (Atm) | - | 0.9986 | 1.0001 | 0.995 | 0.9912 | 1.0039 | 1.0022 | 0.9978 | 0.9976 |
| | Oxygen (mg/L) | - | 9.86 | 10.78 | 9.49 | 11.28 | 10.59 | 12.82 | 10.78 | 8.18 |
| | Conductivity (µS/cm) | - | 364.1 | 369.6 | 356.3 | 346.7 | 324.9 | 313.6 | 293.1 | 294.6 |
| | pH | - | 8.59 | 8.91 | 9 | 9.09 | 9.02 | 8.92 | 9.11 | 8.63 |
| | ORP (mV) | - | 143.8 | 87.1 | 95.1 | 101.5 | 57.2 | 71.9 | 45.5 | 76.5 |
| 5m | Temperature (°C) | - | 18.1 | 20.5 | 19.3 | 19.2 | 19.3 | 20 | 20.9 | 19 |
| | Pressure (Atm) | - | 0.9987 | 1.0002 | 0.995 | 0.9912 | 1.004 | 1.0021 | 0.9977 | 0.9978 |
| | Oxygen (mg/L) | - | 9.22 | 10.09 | 9.53 | 10.99 | 10.55 | 6.95 | 10.18 | 8.21 |
| | Conductivity (µS/cm) | - | 347.6 | 381.8 | 355.8 | 346.8 | 325.4 | 332.5 | 294.4 | 294.7 |
| | pH | - | 8.62 | 8.94 | 9.01 | 9.08 | 9 | 8.54 | 9.05 | 8.62 |
| | ORP (mV) | - | 145.5 | 89.4 | 92.3 | 88.6 | 57.2 | 78 | 55.4 | 74.7 |
| 6m | Temperature (°C) | - | 18.1 | 20.4 | 19.3 | 19.2 | 19.2 | 19.4 | 20.5 | 19 |
| | Pressure (Atm) | - | 0.9985 | 1.0001 | 0.9949 | 0.9913 | 1.0039 | 1.0022 | 0.9978 | 0.9978 |
| | Oxygen (mg/L) | - | 9.41 | 10.35 | 9.36 | 10.62 | 10.27 | 4.21 | 5.24 | 8.12 |
| | Conductivity (µS/cm) | - | 358.2 | 367.8 | 357 | 346.6 | 325.8 | 336.2 | 315.5 | 294.7 |
| | pH | - | 8.62 | 8.95 | 9.01 | 9.08 | 8.98 | 8.32 | 8.35 | 8.6 |
| | ORP (mV) | - | 146.9 | 88.4 | 89.6 | 87.4 | 56.3 | 79.6 | 55.6 | 72.3 |

# Appendix 22: Water profile Point 4 (L4)

| | | 14/06/2016 | 21/06/2016 | 28/06/2016 | 5/7/2016 | 12/7/2016 | 19/07/16 | 26/07/16 | 2/8/2016 | 9/8/2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1m | Temperature (°C) | 17.7 | 18 | 20.5 | 19.4 | 19.1 | 19.3 | 23.9 | 20.8 | 19.4 |
| | Pressure (Atm) | 0.9851 | 0.9982 | 0.9999 | 0.9967 | 0.9911 | 1.0038 | 1.0019 | 0.9976 | 0.9977 |
| | Oxygen (mg/L) | 8.48 | 9.43 | 10.13 | 10.55 | 10.43 | 10.63 | 16.3 | 10.14 | 8.08 |
| | Conductivity (µS/cm) | 353.5 | 358.9 | 369.3 | 363.7 | 347 | 326.6 | 285.2 | 292.9 | 296.1 |
| | pH | 8.63 | 8.5 | 8.88 | 8.89 | 9 | 9.11 | 9.14 | 8.9 | 8.63 |
| | ORP (mV) | 130.1 | 150.9 | 54.4 | 86 | 106 | 115.7 | 58.3 | 70.3 | 47.9 |
| 2m | Temperature (°C) | 17.7 | 18 | 20.5 | 19.3 | 19.1 | 19.2 | 23.4 | 20.8 | 19.4 |
| | Pressure (Atm) | 0.9851 | 0.9982 | 0.9999 | 0.9967 | 0.9912 | 1.0038 | 1.0019 | 0.9977 | 0.9976 |
| | Oxygen (mg/L) | 8.61 | 9.56 | 10.61 | 9.3 | 10.43 | 10.57 | 16.42 | 9.48 | 8.07 |
| | Conductivity (µS/cm) | 354.2 | 358.1 | 370.5 | 362.3 | 345.6 | 331.3 | 292 | 296.3 | 296.3 |
| | pH | 8.62 | 8.51 | 8.92 | 8.91 | 9.04 | 9.02 | 9.13 | 8.94 | 8.64 |
| | ORP (mV) | 125.7 | 148.1 | 62.6 | 90.7 | 101.4 | 101.6 | 69 | 72.5 | 53.8 |
| 3m | Temperature (°C) | 17.7 | 18 | 20.4 | 19.2 | 19.1 | 19.2 | 20.9 | 20.7 | 19.4 |
| | Pressure (Atm) | 0.985 | 0.9981 | 0.9999 | 0.9967 | 0.9912 | 1.0037 | 1.0018 | 0.9977 | 0.9977 |
| | Oxygen (mg/L) | 8.45 | 9.19 | 10.93 | 8.63 | 10.41 | 10.12 | 10.54 | 9.1 | 8.15 |
| | Conductivity (µS/cm) | 354.1 | 363.1 | 371.8 | 356.9 | 347.5 | 328.2 | 321.2 | 297.2 | 296.4 |
| | pH | 8.62 | 8.54 | 8.89 | 8.98 | 9.05 | 9.11 | 8.75 | 8.85 | 8.64 |
| | ORP (mV) | 122.6 | 148.2 | 68.8 | 92.6 | 98.5 | 103.6 | 79.1 | 75.1 | 56.5 |
| 4m | Temperature (°C) | 17.6 | 17.9 | 20.4 | 19.2 | 19.1 | 19.2 | 19.7 | 20.5 | 19.4 |
| | Pressure (Atm) | 0.985 | 0.9982 | 0.9999 | 0.9965 | 0.9911 | 1.0038 | 1.0019 | 0.9978 | 0.9978 |
| | Oxygen (mg/L) | 8.4 | 9.53 | 10.09 | 8.73 | 10.54 | 10.05 | 6.17 | 8.18 | 7.99 |
| | Conductivity (µS/cm) | 354 | 343.5 | 375.4 | 356.2 | 347.4 | 328.1 | 333.4 | 301.7 | 296.3 |
| | pH | 8.6 | 8.56 | 8.95 | 8.91 | 9.06 | 9.11 | 8.47 | 8.7 | 8.65 |
| | ORP (mV) | 119.7 | 163.6 | 79.2 | 88.8 | 95.8 | 105.2 | 82.2 | 74.1 | 58.6 |
| 5m | Temperature (°C) | 17.6 | 17.9 | 19.7 | 19.2 | 19.1 | 19.2 | 19.5 | 20.3 | 19.4 |
| | Pressure (Atm) | 0.985 | 0.9982 | 1 | 0.9965 | 0.9911 | 1.0038 | 1.0018 | 0.9979 | 0.9977 |
| | Oxygen (mg/L) | 8.18 | 9.29 | 8.09 | 8.4 | 10.48 | 9.68 | 4.73 | 9.63 | 8.02 |
| | Conductivity (µS/cm) | 354.2 | 340.5 | 371.5 | 355.2 | 347.6 | 328 | 334.7 | 293.7 | 296.4 |
| | pH | 8.57 | 8.58 | 8.82 | 8.91 | 9.06 | 9.1 | 8.32 | 8.9 | 8.64 |
| | ORP (mV) | 118.5 | 158.7 | 94 | 87.1 | 94.2 | 102.5 | 80.2 | 71.4 | 59.4 |
| 6m | Temperature (°C) | 17.5 | 17.9 | 19.3 | 19.2 | 19.1 | 19.2 | 19.3 | 19.7 | 19.3 |
| | Pressure (Atm) | 0.985 | 0.9981 | 1 | 0.9965 | 0.9911 | 1.0039 | 1.0019 | 0.9978 | 0.9977 |
| | Oxygen (mg/L) | 8.12 | 9.08 | 7.83 | 8.31 | 10.47 | 9.57 | 3.15 | 1.7 | 7.99 |
| | Conductivity (µS/cm) | 354.7 | 356.5 | 352.4 | 358.7 | 347.8 | 328.2 | 335.4 | 328.1 | 295.9 |
| | pH | 8.53 | 8.56 | 8.66 | 8.9 | 9.04 | 9.1 | 8.13 | 8.19 | 8.64 |
| | ORP (mV) | 117.6 | 160.8 | 99.9 | 84.9 | 93.4 | 100 | 78.2 | 83.5 | 59.8 |
| 7m | Temperature (°C) | 17.5 | 17.7 | 19.3 | 19.2 | 19 | 19.1 | 19 | 19.6 | 19.2 |
| | Pressure (Atm) | 0.985 | 0.9982 | 1 | 0.9965 | 0.9911 | 1.0038 | 1.0019 | 0.9978 | 0.9978 |
| | Oxygen (mg/L) | 7.76 | 8.34 | 7.46 | 7.87 | 10.16 | 8.98 | 0.92 | 0.95 | 7.92 |
| | Conductivity (µS/cm) | 354.9 | 356.3 | 367 | 357.3 | 347.9 | 328.7 | 337.6 | 343 | 295.6 |
| | pH | 8.49 | 8.52 | 8.62 | 8.89 | 9.04 | 9.08 | 7.95 | 7.97 | 8.63 |
| | ORP (mV) | 116.9 | 161.6 | 100.6 | 83.1 | 92.3 | 99.1 | 76.4 | -88.3 | 60.2 |

# Appendix 23: Water profile Point 5 (L5)

| | | 14/06/2016 | 21/06/2016 | 28/06/2016 | 5/7/2016 | 12/7/2016 | 19/07/16 | 26/07/16 | 2/8/2016 | 9/8/2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1m | Temperature (°C) | 17.7 | 18.1 | 20.4 | 19.6 | 18.9 | 19.3 | 24.5 | 20.5 | 19.2 |
| | Pressure (Atm) | 0.9849 | 0.9982 | 1.000 | 0.9965 | 0.9911 | 1.0037 | 1.0019 | 0.9977 | 0.9977 |
| | Oxygen (mg/L) | 8.57 | 9.55 | 10.66 | 9.61 | 9.98 | 11.18 | 16.93 | 9.72 | 8.27 |
| | Conductivity (µS/cm) | 353.9 | 372.9 | 373.8 | 368.6 | 348.7 | 325.3 | 287.6 | 302.4 | 294.8 |
| | pH | 8.67 | 8.48 | 8.79 | 8.89 | 8.99 | 9.11 | 9.15 | 8.82 | 8.64 |
| | ORP (mV) | 171.1 | 174 | 61 | 63.7 | 90.5 | 86.6 | 68.5 | 87.3 | 59.4 |
| 2m | Temperature (°C) | 17.7 | 18.1 | 20.3 | 19.1 | 18.9 | 19.2 | 23.3 | 20.4 | 19.2 |
| | Pressure (Atm) | 0.985 | 0.9983 | 1.0000 | 0.9966 | 0.9912 | 1.0037 | 1.0019 | 0.9977 | 0.9978 |
| | Oxygen (mg/L) | 8.71 | 9.87 | 10.19 | 8.86 | 9.98 | 10.3 | 15.22 | 8.48 | 8.21 |
| | Conductivity (µS/cm) | 353.8 | 358.8 | 372.4 | 357.6 | 348.1 | 324.9 | 295.8 | 305.3 | 295.1 |
| | pH | 8.66 | 8.52 | 8.84 | 8.9 | 8.99 | 8.98 | 9.07 | 8.73 | 8.64 |
| | ORP (mV) | 166.9 | 173 | 61.4 | 76.2 | 89.4 | 84.5 | 68.7 | 88.7 | 60.5 |
| 3m | Temperature (°C) | 17.7 | 18.1 | 20.3 | 19.1 | 18.9 | 19.1 | 20.2 | 20.2 | 19.2 |
| | Pressure (Atm) | 0.9849 | 0.9983 | 1 | 0.9965 | 0.9912 | 1.0037 | 1.0019 | 0.9978 | 0.9978 |
| | Oxygen (mg/L) | 8.62 | 9.86 | 9.86 | 7.89 | 9.85 | 9.77 | 6.17 | 7.27 | 8.24 |
| | Conductivity (µS/cm) | 353.4 | 283.6 | 372.8 | 356.8 | 348.2 | 327.1 | 331.3 | 310.4 | 295.1 |
| | pH | 8.66 | 8.54 | 8.85 | 8.89 | 8.99 | 8.96 | 8.54 | 8.55 | 8.64 |
| | ORP (mV) | 162.4 | 174.4 | 65.8 | 75.8 | 87.3 | 86.7 | 77.1 | 89.1 | 60.9 |
| 4m | Temperature (°C) | 17.6 | 18.1 | 20.2 | 19.1 | 18.9 | 19.1 | 19.5 | 20.1 | 19.2 |
| | Pressure (Atm) | 0.9849 | 0.9983 | 1 | 0.9966 | 0.9912 | 1.0037 | 1.0019 | 0.9978 | 0.9978 |
| | Oxygen (mg/L) | 8.6 | 9.8 | 9.43 | 7.74 | 9.84 | 9.47 | 2.43 | 5.81 | 8.23 |
| | Conductivity (µS/cm) | 352.9 | 360.6 | 368.4 | 356.3 | 348.3 | 326.7 | 335.4 | 313.8 | 295.1 |
| | pH | 8.65 | 8.57 | 8.85 | 8.89 | 9 | 8.91 | 8.22 | 8.42 | 8.65 |
| | ORP (mV) | 159.3 | 175.4 | 69 | 74.9 | 85.8 | 83.7 | 79.9 | 86.5 | 59.6 |
| 5m | Temperature (°C) | - | - | 20 | 19 | 18.9 | 19 | 19.4 | 19.9 | 19.2 |
| | Pressure (Atm) | - | - | 1 | 0.9965 | 0.9911 | 1.0037 | 1.0019 | 0.9978 | 0.9978 |
| | Oxygen (mg/L) | - | - | 7.94 | 6.19 | 8.72 | 8.11 | 0.81 | 4.06 | 7.23 |
| | Conductivity (µS/cm) | - | - | 236.5 | 357.6 | 348 | 328.3 | 337.9 | 316 | 294 |
| | pH | - | - | 8.83 | 8.86 | 8.98 | 8.79 | 8 | 8.24 | 8.59 |
| | ORP (mV) | - | - | 74.1 | 73 | 52.5 | 70.5 | -70.8 | 27.4 | -103.3 |

# Appendix 24: Water profile Point 6 (L6)

| | | 14/06/2016 | 21/06/2016 | 28/06/2016 | 5/7/2016 | 12/7/2016 | 19/07/16 | 26/07/16 | 2/8/2016 | 9/8/2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1m | Temperature (°C) | 18 | 17.9 | 20.6 | 19.3 | 19.2 | 19.3 | 23.9 | 20.9 | 19.3 |
| | Pressure (Atm) | 0.9851 | 0.998 | 0.9997 | 0.997 | 0.991 | 1.0038 | 1.0018 | 0.998 | 0.9978 |
| | Oxygen (mg/L) | 8.28 | 9.22 | 10.64 | 9.5 | 10.69 | 10.69 | 17.87 | 11.33 | 7.95 |
| | Conductivity (µS/cm) | 349.7 | 358.7 | 373.5 | 369.6 | 347.5 | 321.4 | 283.8 | 289.8 | 294.6 |
| | pH | 8.6 | 8.53 | 8.82 | 8.88 | 9.06 | 9.11 | 9.22 | 9.07 | 8.64 |
| | ORP (mV) | 141 | 148.9 | 88.1 | 77.9 | 80.7 | 125.3 | 80.9 | 85.7 | 49.6 |
| 2m | Temperature (°C) | 17.9 | 17.9 | 20.5 | 19.3 | 19.1 | 19.3 | 22.9 | 20.9 | 19.3 |
| | Pressure (Atm) | 0.9851 | 0.998 | 0.9998 | 0.9969 | 0.991 | 1.0037 | 1.0018 | 0.998 | 0.9978 |
| | Oxygen (mg/L) | 8.38 | 9.03 | 10.72 | 8.86 | 10.79 | 10.29 | 16.95 | 11.22 | 8.03 |
| | Conductivity (µS/cm) | 350.2 | 357.9 | 294 | 307.5 | 347.3 | 322.3 | 297.1 | 289.8 | 295.2 |
| | pH | 8.59 | 8.82 | 8.87 | 8.89 | 9.06 | 9.18 | 9.08 | 9.12 | 8.65 |
| | ORP (mV) | 135.9 | 147.9 | 88.4 | 85.6 | 79.8 | 126.3 | 82.2 | 84.5 | 49.8 |
| 3m | Temperature (°C) | 17.9 | 17.9 | 20.4 | 19.3 | 19.1 | 19.3 | 21.3 | 20.7 | 19.3 |
| | Pressure (Atm) | 0.9851 | 0.998 | 0.9998 | 0.9969 | 0.991 | 1.0037 | 1.0018 | 0.9981 | 0.9977 |
| | Oxygen (mg/L) | 8.44 | 9.3 | 10.75 | 8.64 | 10.45 | 10.34 | 12.55 | 10.11 | 7.97 |
| | Conductivity (µS/cm) | 351 | 354.4 | 366.5 | 354.9 | 347.4 | 324.3 | 316.4 | 292.8 | 295.6 |
| | pH | 8.58 | 8.54 | 8.87 | 8.93 | 9.06 | 9.17 | 8.84 | 9.06 | 8.66 |
| | ORP (mV) | 132 | 150.6 | 101.3 | 87.6 | 78.3 | 123.6 | 85.3 | 91 | 52 |
| 4m | Temperature (°C) | 17.9 | 17.9 | 20.3 | 19.3 | 19.1 | 19.2 | 19.8 | 20.6 | 19.3 |
| | Pressure (Atm) | 0.9851 | 0.998 | 0.9997 | 0.9969 | 0.9909 | 1.0037 | 1.0018 | 0.9981 | 0.9977 |
| | Oxygen (mg/L) | 8.23 | 9.19 | 10.71 | 8.91 | 10.22 | 10.52 | 5.57 | 9.37 | 8.03 |
| | Conductivity (µS/cm) | 351.5 | 361.5 | 361.4 | 353.5 | 347.5 | 325 | 333.5 | 296.4 | 295.5 |
| | pH | 8.58 | 8.56 | 8.94 | 8.93 | 9.05 | 9.06 | 8.41 | 9.03 | 8.74 |
| | ORP (mV) | 129.6 | 152.4 | 95.2 | 85.8 | 78.2 | 118.4 | 88.4 | 105.6 | 55.6 |
| 5m | Temperature (°C) | 17.8 | 17.9 | 19.6 | 19.2 | 19 | 19.2 | 19.6 | 20.6 | 19.3 |
| | Pressure (Atm) | 0.9851 | 0.998 | 0.9997 | 0.9968 | 0.9909 | 1.0036 | 1.0019 | 0.998 | 0.9978 |
| | Oxygen (mg/L) | 8.52 | 9.05 | 8.34 | 8.68 | 10.31 | 9.63 | 4.71 | 9.48 | 8.11 |
| | Conductivity (µS/cm) | 351.5 | 369.7 | 383.3 | 353.4 | 347.6 | 325.9 | 334 | 296.5 | 295.5 |
| | pH | 8.58 | 8.57 | 8.68 | 8.92 | 9.07 | 9.13 | 8.28 | 8.98 | 8.66 |
| | ORP (mV) | 127.3 | 154.5 | 104.2 | 81.9 | 78.6 | 118.7 | 85 | 92.1 | 54.8 |
| 6m | Temperature (°C) | 17.8 | 17.9 | 19.2 | 19.2 | 19 | 19.2 | 19.5 | 20.2 | 19.3 |
| | Pressure (Atm) | 0.9851 | 0.9981 | 0.9998 | 0.9969 | 0.9911 | 1.0036 | 1.0018 | 0.998 | 0.9978 |
| | Oxygen (mg/L) | 8.43 | 8.87 | 7.67 | 8.61 | 10.33 | 9.66 | 4.37 | 5.62 | 8.11 |
| | Conductivity (µS/cm) | 351.5 | 360 | 367.8 | 355.4 | 347.7 | 326.2 | 334.4 | 313.3 | 295.5 |
| | pH | 8.59 | 8.59 | 8.59 | 8.91 | 9.05 | 9.13 | 8.2 | 8.6 | 8.66 |
| | ORP (mV) | 125 | 158.3 | 111.3 | 78.9 | 77 | 115.5 | 81.1 | 104.1 | 56.3 |
| 7m | Temperature (°C) | 17.7 | 17.8 | 19.2 | 19.2 | 19 | 19.2 | 19.4 | 19.8 | 19.3 |
| | Pressure (Atm) | 0.9851 | 0.998 | 0.9998 | 0.9968 | 0.9911 | 1.0037 | 1.0019 | 0.9979 | 0.9977 |
| | Oxygen (mg/L) | 8.43 | 8.86 | 7.57 | 8.71 | 10.17 | 9.6 | 4.29 | 1.85 | 7.81 |
| | Conductivity (µS/cm) | 351.7 | 356.3 | 366.2 | 355 | 347.1 | 326.4 | 334.5 | 329 | 295.5 |
| | pH | 8.58 | 8.6 | 8.53 | 8.9 | 9.05 | 9.12 | 8.17 | 7.95 | 8.67 |
| | ORP (mV) | 123.6 | 158.4 | 108.3 | 75.8 | 78.1 | 109.6 | 77.5 | 78 | 56.2 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **8m** | **Temperature (°C)** | 17.6 | 17.8 | 18.9 | 19.2 | 18.9 | 19.2 | 19.3 | 19.7 | 19.3 |
| | **Pressure (Atm)** | 0.9852 | 0.9981 | 0.9998 | 0.9969 | 0.9912 | 1.0038 | 1.0019 | 0.9979 | 0.9978 |
| | **Oxygen (mg/L)** | 8.29 | 9.12 | 6.77 | 8.04 | 9.87 | 9.76 | 3.17 | 1.81 | 8.03 |
| | **Conductivity (µS/cm)** | 351.3 | 360.8 | 365.2 | 355.4 | 345.6 | 326.8 | 335.4 | 329.7 | 295.4 |
| | **pH** | 8.57 | 8.58 | 8.52 | 8.89 | 9.01 | 9.11 | 8.07 | 7.98 | 8.66 |
| | **ORP (mV)** | 122.3 | 158.4 | 113.6 | 72.5 | 77.5 | 108.1 | 77 | 80 | 56 |
| **9m** | **Temperature (°C)** | 17.6 | 17.8 | 18.5 | 19.1 | 18.8 | 19.2 | 19.1 | 19.4 | 19.3 |
| | **Pressure (Atm)** | 0.9851 | 0.9981 | 0.9999 | 0.9968 | 0.9911 | 1.0038 | 1.0019 | 0.9979 | 0.9977 |
| | **Oxygen (mg/L)** | 8.11 | 8.61 | 5.37 | 7.8 | 9.68 | 9.59 | 1.11 | 0.26 | 7.77 |
| | **Conductivity (µS/cm)** | 351.6 | 375.2 | 365.1 | 356.7 | 346.7 | 327 | 337.2 | 337.8 | 295.3 |
| | **pH** | 8.56 | 8.56 | 8.26 | 8.82 | 8.99 | 9.12 | 7.94 | 7.9 | 8.64 |
| | **ORP (mV)** | 121.1 | 157.4 | 110 | 71.9 | 77.4 | 105.8 | 77.2 | 70.1 | 54.8 |
| **10m** | **Temperature (°C)** | 17.4 | 17.7 | 18.3 | 18.8 | 18.8 | 19.2 | 18.9 | 19.4 | 19.3 |
| | **Pressure (Atm)** | 0.9852 | 0.9981 | 0.9998 | 0.9968 | 0.9911 | 1.0038 | 1.0019 | 0.9979 | 0.9977 |
| | **Oxygen (mg/L)** | 8.16 | 8.28 | 4.39 | 5.14 | 7.65 | 9.67 | 0.19 | 0.17 | 7.64 |
| | **Conductivity (µS/cm)** | 351.5 | 353.6 | 364.9 | 357.5 | 346.7 | 327.4 | 339.7 | 338.5 | 296.6 |
| | **pH** | 8.53 | 8.51 | 8.13 | 8.49 | 8.89 | 8.93 | 7.88 | 7.85 | 8.6 |
| | **ORP (mV)** | 120.4 | 132.9 | 112.7 | 71.5 | 12.4 | 84.4 | 64.5 | 55.9 | -96.2 |

## Abstract

Vomb's lake, situated in Scania (Sweden), is an important tank of drinkable water managed by the company Sydvatten AB. For fifty years, intensive agriculture forces farmers to use fertilizers, rich in phosphorus, which then enters in Vombsjön waters and causes a premature eutrophication of the lake. To avoid this problem, Sydvatten AB has set up artificial ponds, called Phosphorus Ponds (P Ponds) which goal is to catch phosphorus. The first aim of this study is to determinate the retention capacity of those ponds and also, quantities of P which are cached or not. Thanks to this study, it can lead to Sydvatten a better knowledge about the ponds efficiency and phosphorus volume arriving in Vombsjön.

The second study consists in looking at the evolution of different parameters depending on the lake depth. Mainly parameters studied are dissolved oxygen and temperature which are useful to know the possible phosphorus release by sediments at the bottom of the lake. This second study is done each summer in order to follow the evolution of chemicals and physical parameters in Vombsjön faces to a premature eutrophication.



## Résumé

Le lac de Vomb situé en Scanie (Suède) est un important réservoir d'eau potable de Sydvatten AB. Depuis une cinquantaine d'années, l'agriculture intensive oblige les agriculteurs à utiliser des engrais, riche en phosphore, qui se retrouve dans les eaux de Vombsjön et provoques une eutrophisation prématurée du lac. Pour pallier à ce problème, Sydvatten AB a mis en place des étangs artificiels qui ont pour rôle de retenir le phosphore. Le premier but de cette étude est de déterminer la capacité de rétention de ces étangs ainsi que les quantités qui y sont retenues ou non. Cela permet ainsi à Sydvatten de connaitre l'efficacité réelle de ces étangs et le volume de phosphore qui arrive dans les eaux du lac de Vomb.

La deuxième étude consiste à tracer l'évolution de différents paramètres en fonction de la profondeur du lac. Les paramètres principalement étudiés sont l'oxygène et la température qui permettent ainsi de déterminer un éventuel largage du phosphore par les sédiments situés au fond du lac. Cette deuxième étude est menée chaque année afin de suivre l'évolution chimique et physique de Vombsjön qui fait face à une eutrophisation prématurée.