Cocolalla Lake, Idaho, USA

21st July 2009

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Figure 1: Cocolalla Lake, USA (Google Earth)

1. Introduction

Cocolalla Lake is located in the Northern Rockies, Idaho, USA (Figure 1). It is predominantly used for recreational activities all year round, but especially in the summer months. It is located in between the southern arm of the Pend Oreille Lake and the Pend Oreille River. The water-shed surrounding the lake is heavily forested with mountainous terrain up to 4,500 feet with slopes ranging from 15-50%.

The lake covers a total area of approximately 805 acres (325.8 ha or 3,258,000 m^2) and has an average depth of 27.7 feet (8.4 m). The total water volume is therefore on average around 27,367,200,000 L.

There are five tributaries to Cocolalla Lake: Cocolalla Creek, Fish Creek, Butler Creek, Westmond Creek, and Johnson Creek. Cocolalla Creek is the only outflow from the lake which eventually flows into the Pend Oreille River.

An excerpt from a report that was supplied to Phoslock Water Solutions Ltd (PWS) by the Cocolalla Lake Association highlights that the phosphorus in the lake is prolific; there is a continual supply. It also states that the Phase 1 Diagnostic Study (Rothrock, 1995) carried out on the lake found that 23% of the phosphorus loading was internally generated from the anoxic and aerobic sediments and macrophyte decay. Rothrock (1995) stated that:

"Reduction of internal phosphorus loads would greatly reduce the growth of algae which would in turn, reduce or eliminate the formation of anoxic conditions. To break this nutrient recycling, would likely involve an in-lake chemical treatment, combined with a concentrated effort to reduce external nutrient sources to provide a lasting benefit".

From the information that was provided to and collected by PWS, it appears that in the past there has been positive action in the form of reports and catchment management improvements; however it appears that the water quality of the lake has not improved to an acceptable standard. As Rothrock (1995) suggested, the lake needs to be treated with an in-lake product to significantly reduce the concentration of phosphorus in the sediments.

1.1. View of Phoslock Pty Ltd

An application of Phoslock® to Cocolalla Lake will target the available phosphorus contained in the sediments as well as in the water column to ensure that phosphorus is in a non-reactive, non-bioavailable form. The permeable reactive layer of Phoslock® on the sediments will ensure that any phosphorus that is released from the sediments in the future will be adsorbed before it fuels blue-green algal cells.

1.2. How Phoslock® works

Phoslock® is a bentonite clay product (modified with the active ingredient lanthanum), developed by the Land and Water Division of Australia's CSIRO (Commonwealth Scientific and Industrial Research Organisation) to significantly reduce the amount of filterable reactive phosphorus (FRP) present in the water column and in the sediment of a water body. Phoslock® is generally supplied in a granular form (in 25kg bags) and applied to the water body either as a slurry and/or as granules.

Upon application, the Phoslock® sinks through the water column (removing FRP as it falls) and settles as a permeable fine clay layer at the bottom of a water body. The free active sites (containing the rare earth element, lanthanum) continue to bind FRP that is released from the sediments at the bottom of the water body over time. The phosphate that is removed from the water binds with the lanthanum to form the insoluble mineral, Rhabdophane. By reducing phosphorus in the water body, there is less available food for alga, hence decreasing algal concentrations over time (Figures 2 & 3). The simultaneous effect is an increase in the concentration of oxygen in the water body (particularly at the bottom where the degradation of organic matter is prevalent – an oxygen consuming process).

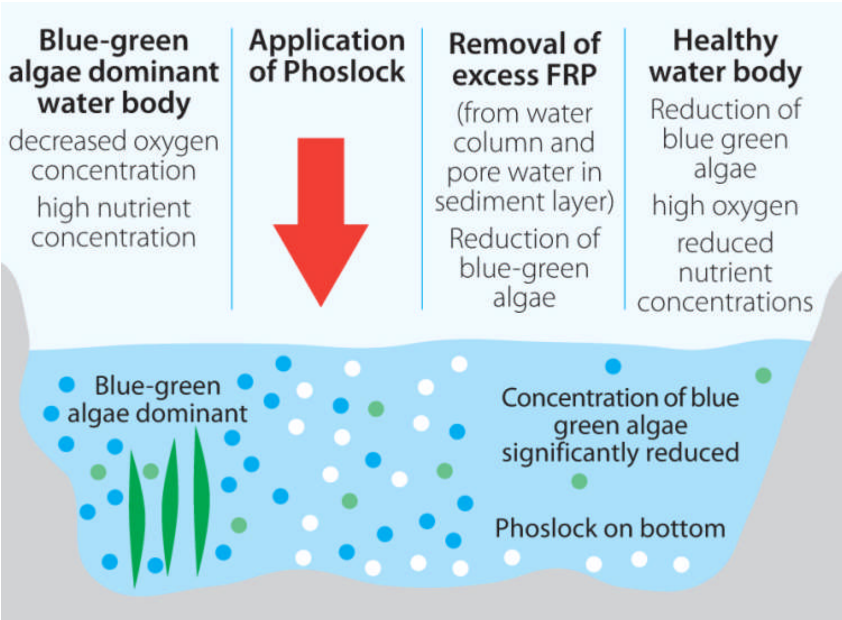

Figure 2: How Phoslock® works on a water body that is affected by blue-green algal blooms

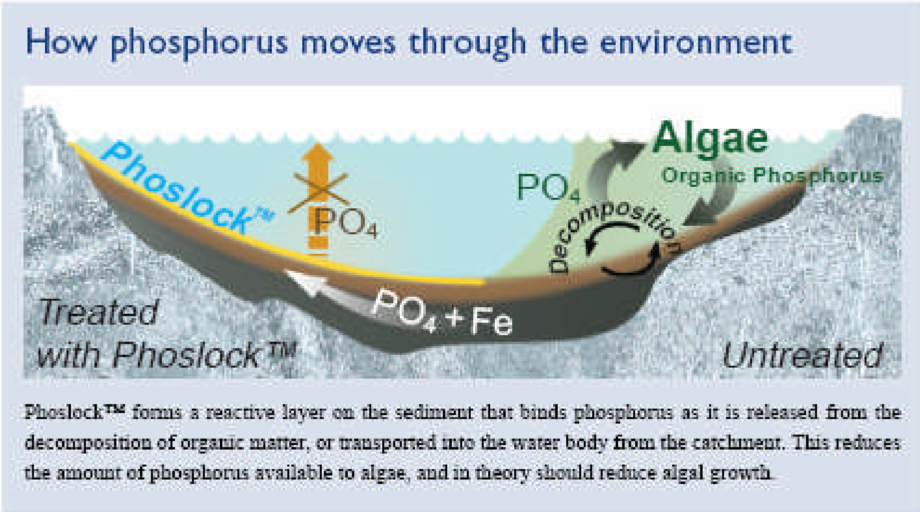

Figure 3: Continual sequestering of FRP by Phoslock® once it is applied to a water body (Swan River Trust, 2001)

2. Pre-treatment sampling, testing, analysis of results

2.1. Sampling

Before an application of Phoslock® is undertaken, PWS collects samples from:

- the water column; and
- the sediment.

Water column and sediment samples have been collected by the Cocolalla Lake Association and resulting data has been sent to PWS (for interpretation and construction of this proposal).

The water samples were collected from Cocolalla Lake on 29th June 2009 and have been analysed for Total Phosphorus (TP). Five samples were collected from within and around the lake [a surface sample taken at the secchi depth TP = 0.015 mg/L and a deep sample taken from 1m off the bottom of the lake TP = 0.134 mg/L, a sample from Westmond Creek TP = 0.076 mg/L, one from Cocolalla Creek in the south (inflow) TP = 0.032 mg/L and one from Cocolalla Creek in the north (outflow) TP = 0.022 mg/L] with the average concentration of TP in the lake of 0.075 mg/L.

These data suggest that the main sources of TP in the water column is from the sediment release as the highest concentration of TP was measured in the deep sample collected 1m off the bottom of the lake. These data also show that there is a source of TP coming into the lake in the inflow creek; however the samples collected in the outflows contain the lowest concentration of TP out of all sites sampled. This could suggest that Cocolalla Lake is retaining some of the phosphorus that enters it from the inflows over time. It is either retained in the sediment and released over time (under changing conditions such as increased temperature due to seasonal variation or oxidation of anaerobic sediment) or the phosphorus is being utilised by the algae, stored and recycled for sequential algal blooms upon cell degradation.

The sites where the sediment samples were collected are marked as red circles in Figure 4. The sediment was also analysed for Total Phosphorus (using method EPA 6010B) and the concentrations are highlighted in Figure 4 in red text.

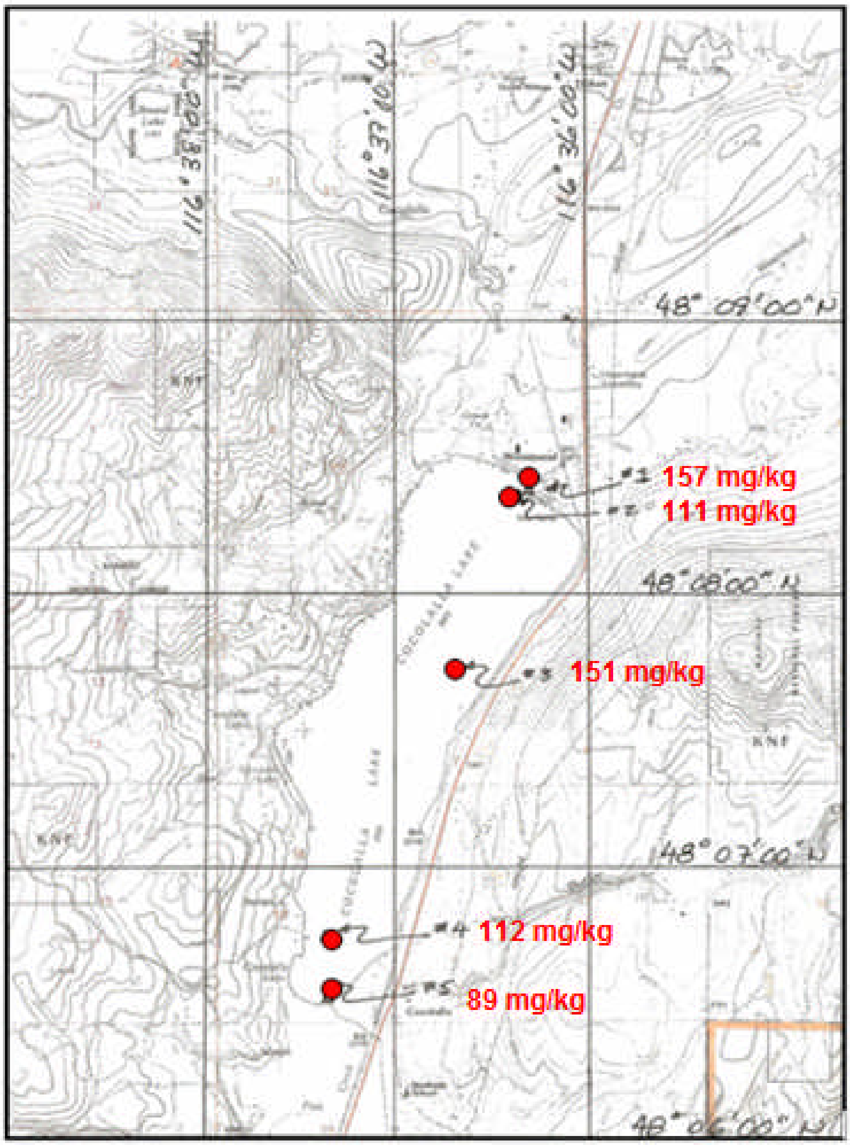

Figure 4: Adapted from Cocolalla Lake map supplied by the Cocolalla Lake Association (sediment sampling areas are located on the map as a red circle, TP concentrations are labeled in red text next to the sampling location).

The sediment data shows that the highest concentrations of TP were measured in the sediment collected from the north and centre of the lake. The lowest concentration of TP was measured in the sample taken from near the outlet point at Cocolalla Creek. It is likely that most of the TP has been deposited in the sediment near the inflow to the lake over the years and has been stored there.

2.2. Using collected data

As for most water bodies around the world, the sediment in Cocolalla Lake contains the largest pool of total phosphorus (TP).

The average total P concentration in the sediment was 124 mg/kg, in the water column 0.075 mg/L and inflow water 0.054 mg/L. These three regions are the greatest contributors to the phosphorus budget of the lake and all should be taken into account when calculating the final dosage.

In summary, there is likely a large pool of bio-available and potentially bio-available P in Cocolalla Lake that will be quickly captured by Phoslock® and bound in an insoluble mineral called Rhabdophane ($LaPO_4$). Once locked in the Rhabdophane structure it will be unavailable for use by algae and will break the current phosphorus cycle.

3. Treatment of Cocolalla Lake with Phoslock®

3.1. Aim

The aim of a potential Phoslock® application to Cocolalla Lake is to remove immediately bio-available and potentially bio-available phosphorus from both the water column and sediments. Removal of these phosphorus pools through an application of Phoslock® can be expected to reduce the trophic status of the lake, reduce the algal biomass and prevent the dominance blue green algae over green algae and other types of benign algae in future years.

Phoslock® will provide a permeable reactive layer on the sediments that interacts, adsorbs and reduces the re-release of phosphorus into the water column.

3.2. Required dosage

3.2.1. Basis for calculation

The required dosage for Phoslock® in any water body can be calculated by determining the total load of immediately and potentially bio-available phosphorus in the water body, inflows and sediments. 100 g of Phoslock® will remove 1 g of phosphorus (when in the form of phosphate).

The basis for calculating immediately bio-available and potentially bio-available phosphorus varies according the location of the phosphorus.

For the water column, Total Phosphorus is used as the basis for a dosage calculation. Total Phosphorus can be considered to be essentially the sum of immediately bio-available (i.e. ortho-phosphate or FRP) and potentially bio-available phosphorus (i.e. organic phosphorus converted to ortho-phosphate and released into the water column during the decomposition of algal cells).

Various methods exist for the calculation of the immediately bio-available, potentially bio-available and non bio-available fractions of phosphorus in sediments. A reliable estimate of the immediately and potentially bio-available P load can also be obtained by analyzing the chemical composition of the sediment, examining its physical characteristics and comparing these parameters with those from previously analysed samples from other comparable water bodies.

The inflow water entering from the surrounding creeks, such as Westmond Creek, are also important sources of phosphorus contributing to the Cocolalla Lake phosphorus budget. These creeks allow nutrients that are draining from the catchment area to accumulate in Cocolalla Lake. Phoslock® mechanical dosers could be constructed in the creeks, so the water entering the lake is previously treated. This would significantly reduce or nullify the concentration of phosphorus entering Cocolalla Lake from the inflows.

3.2.2. Volume of Phoslock® required

Based on the data collected during the sampling, the dosage of Phoslock® required to remove all immediately and potentially bio-available phosphorus currently (without the addition of treating inflows) in Cocolalla Lake (as measured in the June 2009 sampling) has been calculated as follows:

Calculations

P load in the water column = 2,041.59 kg P
(= 27,367,200 m^3 * 0.075 g P/m^3)

Releasable P per liter of sediment = 18.85 mg/L
(= 124 mg P/kg DW * 0.380 kg DW/L * 0.4 releasable P/ total P)

Total releasable P in top 4 cm = 2,456.27 kg P
(= 3,258,000 m^2 * 0.04 m * 18.85 g/m^3)

Total P load to be removed = 4,498 kg P (= 2,042 kg P + 2,456 kg P)
Total Phoslock® dosage required = 449.8 MT (4,498*100)

For calculations pertaining to the neutralization of phosphorus entering the Lake from inflows, further data relating to flow rates, creek volume and chemistry over time (to see the seasonal affects) would need to be provided before calculations can be made for treatment of these areas.

4. Projected outcomes

Phoslock Water Solutions Ltd believe that an application of Phoslock® to Cocolalla Lake will provide an effective in-lake nutrient management strategy that will significantly reduce the concentrations of bio-available phosphorus in the lake, its sediment (via the permeable capping layer) and reduce the impact of in-flows to prevent the re-occurrence of major algal blooms such as those experienced in recent times.

The calculations above have been determined by using data provided by the Cocolalla Lake Association. Before an application of Phoslock®, PWS would need current water chemistry data to ensure that certain chemical parameters (such as TP) haven’t changed.

The most favourable strategy for the lake is to apply an entire lake application of Phoslock®, to treat the current and potentially releasable phosphorus, with small follow up maintenance applications every 2-3 years. However if it is not economically possible to treat the entire lake (due to budgetary restrictions), PWS is happy to work with the Cocolalla Lake Association to design a management plan to reduce the concentration of phosphorus over time (as depicted in Figure 5).

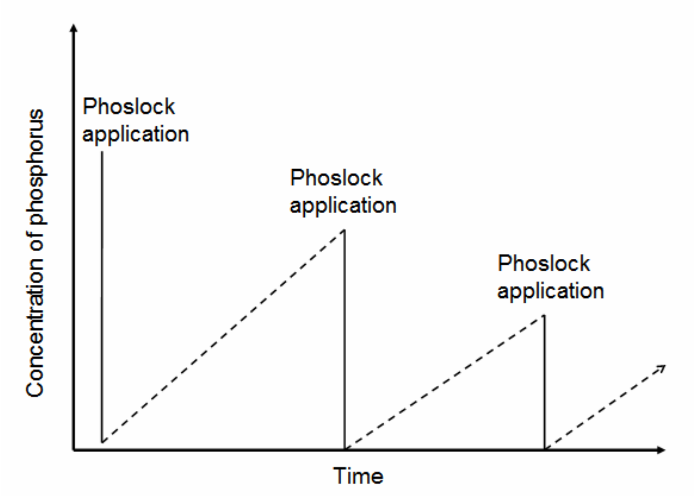

Figure 5: Reducing the trophic status of a lake with staged multiple, but decreasing applications of Phoslock® over time.

5. Application

The application of Phoslock® is a quick and simple process even in large lakes such as Cocolalla Lake. Due to the lakes size, the best way of applying Phoslock® to the lake is from a barge configuration, outlined in Figure 6.

Figure 6: Phoslock® barge application on a large reservoir in New Zealand (LHS) and in a large recreational lake in the Netherlands (RHS).

6. Next Steps

We would be happy to answer any questions you should have or provide further information as appropriate.

7. References

Rothrock, G. 1995. Phase 1 Diagnostic and Feasibility Analysis Cocolalla Lake. Bonner County, Idaho, 1990-1992. Idaho Department of Health and Welfare, Division of Environmental Quality. Coeur d'Alene, Idaho.

8. Phoslock® Contacts

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