Removal Efficiencies of Polymer Enhanced Dewatering Systems

Presented by

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Abstract: Pond systems are routinely designed using conventional engineering methods of Stokes Law for particle settling or design based on pre-described storm event criteria. Both of these systems do not take into account the fact that colloidal activity created by clay particulate, organic material, pH, particle density and zeta-potential often renders the water quality unsuitable for discharge into sensitive riparian water bodies. The use of site-specific tailored polyacrylamide logs to treat this type of water contamination is shown to be effective in reducing turbidity and metals along with the potential for reduction of pond size in regards to water quality.

Background

Baseline data was first gathered on a major Alberta, Canada aggregate washing operation in 2003. The facility operates from April until the end of October when freeze up occurs (Fig. 1). The facility uses an "open system" where water exits the operation rather than a "closed loop". The facility takes in water from a local stream at a rate of 4000 Imp gallons/minute. Aggregate is passed over a series of screen decks and sprayed with water for the purposes of upgrading the aggregate by removing fines for specialized uses. The byproduct of the aggregate washing process is sediment-laden water, which is then pumped to a series of four settling ponds

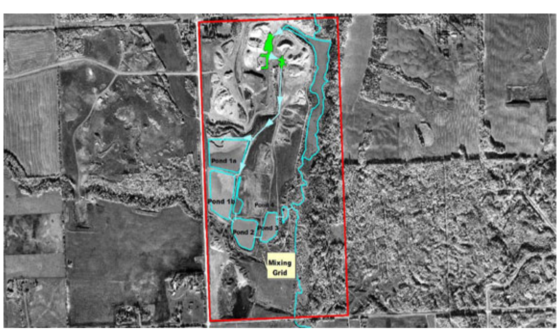

Figure 1: Project Site

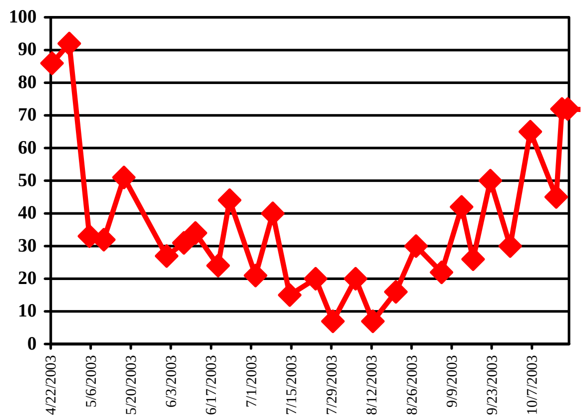

Figure 2: Discharge Turbidity (NTU) vs Date (2003)

for the removal the sediment before discharge to a fish-bearing stream. Surface area of the ponds is a massive 19.99 acres, with an overall retention time of 7 days from the time that water enters the pond to the time it is discharged into the receiving riparian environment. Weekly turbidity and TSS data is gathered when the facility is operating. It was found that both turbidity and discharge data were highest in the spring and fall and lowest in the summer, an inverse correlation with water temperature (Fig. 2).

The corresponding average Total Suspended Solids (TSS) data of the discharge for the entire year 2003 was 32.8 mg/L (Fig. 7). A particle size analysis was conducted on the discharge water. In spite of the considerable retention time it was found that <20um suspended sediment persisted in the discharge waters. It was also found that there were minimal differences found between one settling pond to the next in TSS, NTU and recoverable metals, thus indicating that additional pond capacity was not necessarily beneficial to the sediment removal process. The fact that turbidity was relatively low even during upset conditions indicated that the particle stability was likely due to Zeta-potential (Hiemenz).

Experimentation - Floc Logs

Experimentation with Floc Logs began in October 2004, to see if the polyacrylamides would facilitate flocculation and the removal of fine sediment (Green, Stott). Lab test results deemed that the 703d Floc Log was suitable for this particular application and soil type with absence of aquatic toxicity potential (Applied Polymer Systems) (Maxxam). Test results also indicated that a bridging mechanism would be the most appropriate form of flocculation technique in which to take advantage of the large pond sizes (Poirier).

In 2005, the 703d Floc Log was applied and a noted reduction in TSS and turbidity initially occurred. However, in short order (about a week) it was found that a layer of sediment encapsulated the 703d Floc Log rendering it virtually ineffective. Analyses of water samples indicated the water to contain 260 – 340 mg/L $CaCO_3$. This hardness was most likely responsible for influencing the effectiveness of the log (Fig. 3).

Figure 3: $CaCo_3$ Blinding of the Floc Log

The Floc Logs were changed at this time with logs having the ability to resist the high level of $CaCo_3$ by taking advantage of the higher zeta-potential within the water column (Hiemenz, Poirier) and the base polymers were also modified to increase molecular weight to increase the bridging flocculation potential (Kuzkin, Nebera). The mixing system in which the Floc Logs were initially inserted was redesigned in 2006 to further increase turbulence and the formulation altered to the 703d#3 Floc Log (Erwin, Iwinski) (Fig. 4 & 5).

Figure 4: Mixing Chamber Excavation

Figure 5: Mixing Chamber completed 2006

Reduction of TSS & Turbidity

Considerable improvements in discharge water quality were noted at the facility in 2006. TSS is reduced especially in the spring and fall when water temperatures are cooler (Fig. 6). The average TSS of the discharge to the riparian environment for 2006 was 11.0 mg/L, approaching the background TSS value of 8.3 mg/L already in the stream (Fig 7).

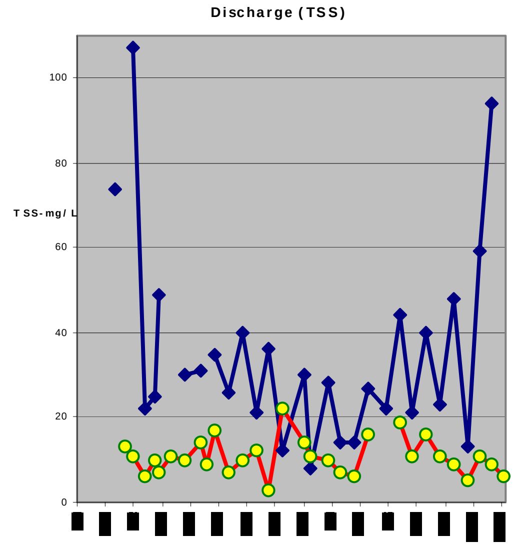

Figure 6: Reduction in TSS 2003 vs 2006

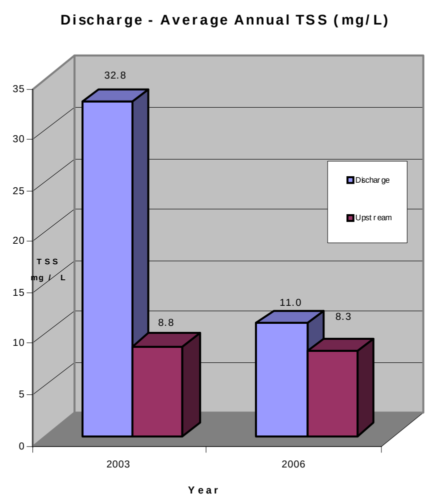

Figure 7: Average Annual TSS Discharge and Upstream (Background) – 2003 & 2006 (before and after polyacrylamide implementation)

Metals Analysis

A series of samples were taken throughout the various settling ponds as well as downstream and upstream of the operation (to establish background). A multi-element recoverable metals analysis was conducted on the samples. In general, it was found that the first and second settling ponds had very similar metals results indicating that the second pond had limited additional effect at reducing most metals (Fig. 8-12). The mixing grid and Floc Log configuration was installed between Pond 2 & Pond 3. Significant reductions of metals were noted immediately after the sediment laden water had interacted with the Floc Logs (Fig. 8–12). This resultant metal reduction has been well documented using similar treatment applications (Condon, Iwinski, Stein), (McLaughlin, Hayes, and Bartholomew) (Carter, Olice C. Jr. Schiemer, BJ.).

Little of no benefit was yielded as well by the fourth settling pond (after treatment). In many instances, increases in metals TSS & turbidity were observed, indicating that the addition of subsequent pond capacity did little to further improve the water chemistry, after the polymer interaction.

Element	% Change in metals Pond 1 - 2	% Change in metals Pond 2 - 3 (Polymers Inserted)	% Change in metals Pond 3 - 4
Th	12%	-86%	39%
Ti	-1%	-74%	67%
Al	-1%	-73%	25%
Fe	9%	-73%	8%
Be	-4%	-71%	-14%
Pb	-3%	-70%	-3%
Cr	0%	-68%	9%
Bi	-14%	-65%	-15%
Co	8%	-63%	-2%
V	-7%	-61%	9%
Ag	-8%	-58%	23%
Ni	9%	-46%	4%
Zn	27%	-41%	-5%
Cd	-8%	-37%	-9%
Cu	-2%	-28%	-2%
As	10%	-25%	-2%
Mn	-4%	-22%	5%
Tl	-3%	-21%	-1%
Sn	-3%	-18%	-5%
Sb	-11%	-12%	-1%

Represents Increase in Metals Values

Figure 8: Percentage Reduction/Increase in metals in settling ponds, sample date Oct 6, 2006

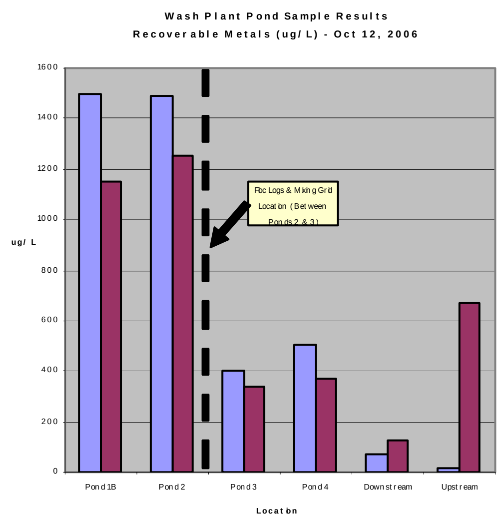

Figure 9: Ponds 1 – 4 & Downstream / Upstream
Aluminum & Iron

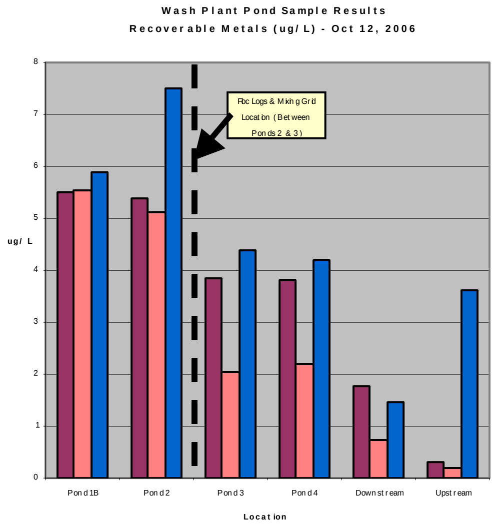

Figure 10: Ponds 1 – 4, Downstream / Upstream Copper, Vanadium & Zinc

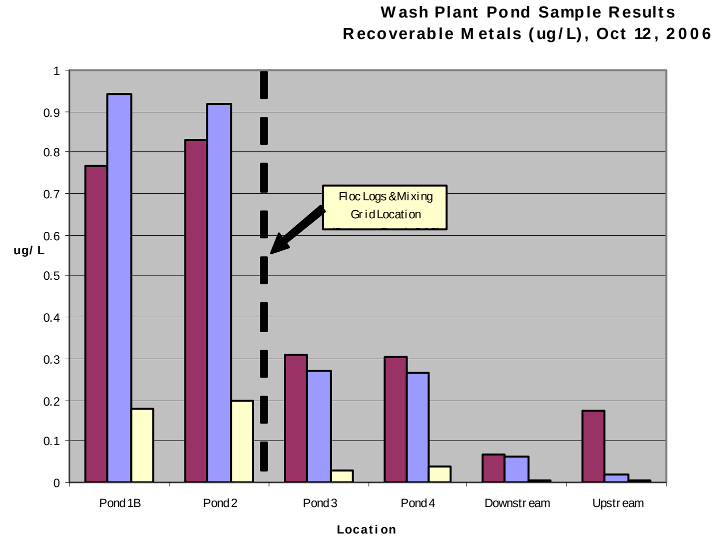

Figure 12: Ponds 1-4, Downstream / Upstream Cobalt, Lead & Thorium

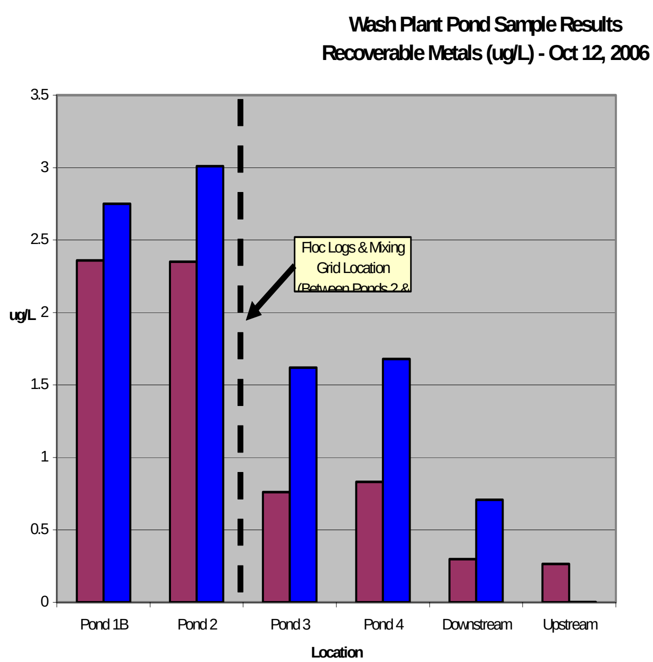

Figure 11: Ponds 1 – 4, Downstream / Upstream Chromium & Nickel

Conclusions

- Smaller particle sizes (10-20um or smaller) do not readily settle by mechanical means. Various efforts and changes at the operation were successful at lowering TSS, turbidity, however polyacrylamide based flocculent was required to substantially improve the surface water discharge quality
- Polyacrylamides are effective at reducing a number of metals in surface water discharge although site specific testing and application is essential.
- Temperature has a direct effect on turbidity, TSS and metals levels.
- Increasing settling pond size does not necessarily on its own result in a decrease in metal values, turbidity and TSS, and in some situations can result in increases of some values (picking up sediment).
- Polyacrylamide blends may have to be altered to formulations having the ability to resist the high level of $CaCO_3$ by taking advantage of the higher zeta-potential within the water column along with altering the molecular weight.

Implications

- A smaller footprint can be designed for settling ponds when used in conjunction with site specific polyacrylamide achieving more effective results.
- Construction costs can potentially be reduced significantly for storm water pond design.
- More useable land can be left available for uses other than being occupied by settling ponds (may still have a civil engineering requirement for flood protection).
- Polyacrylamides are simple and cost effective at bringing surface water quality to levels that aid in achieving requirements for municipal stormwater and environmental regulations and guidelines. Three or four installations (for a six month operation) at this facility suffice for the operating year.
- Polyacrylamides are site-specific and optimal performance requires applications of the appropriate formulation for the specific location.

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