Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

MONITORING AND RESEARCH DEPARTMENT

REPORT NO. 14-41

STICKNEY PHOSPHORUS TASK FORCE

TECHNICAL MEMORANDUM NO. 4

BATTERY D SOLIDS DEPOSITION SUMMARY

October 2014

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FORWARD

The Metropolitan Water Reclamation District of Greater Chicago (MWRD) recognizes the value of phosphorus as a non-renewable resource. In an effort to optimize the sustainable removal of phosphorus from its wastewater influents and the subsequent recovery of phosphorus in various forms suitable for use as an agronomic fertilizer, the MWRD initiated a Phosphorus Removal and Recovery Task Force in 2012. The Task Force initiated a study phase at several of the MWRD's Water Reclamation Plants (WRPs) to evaluate the feasibility of implementing enhanced biological phosphorus removal and to develop operational guidelines for optimizing its effectiveness. The Task Force has created WRP specific study workgroups that are focused on each of the WRPs that have been identified to participate in this initiative. As the workgroups complete various phases of their studies and evaluations they are documenting their findings and recommendations in technical memoranda. These memoranda are written by the WRP specific workgroups and vetted by the Task Force before being published. Their purpose is to capture the state of knowledge and study findings and to make recommendations for implementation of enhanced biological phosphorus removal as they are understood at the time the memoranda are published.

DISCLAIMER

The contents of this technical memorandum constitute the state of knowledge and recommendations developed by the MWRD's Phosphorus Task Force at the time of publication, and are subject to change as additional studies are completed and experience is attained, and as the full context of the MWRD's operating environment is considered.

Battery D Solids Deposition Summary

Technical Memorandum

Date: March 26, 2014

To: Phosphorus Task Force & Advisory Committee

From: Phosphorus Study/Planning Team

Subject: Battery D Solids Deposition Summary – Technical Memorandum 4

1.0. Background

Enhanced biological phosphorus (P) removal (EBPR) has been applied worldwide at full-scale wastewater treatment facilities to achieve low effluent total P (TP) levels for over 30 years through phosphate-accumulating organisms (PAOs). The growth of PAOs is traditionally encouraged by cycling them between anaerobic and aerobic conditions to promote luxury uptake, which results in biomass P content beyond growth needs.

Operations in Stickney Battery D were modified in May 2012 to accommodate EBPR. The return activated sludge channel and mixing and influent channels were set up as an anoxic zone; the first half of Pass 1 in the aeration tanks was used as an anaerobic zone; and the rest of the aeration tank was used as an aerobic zone. Coarse bubblers and fine bubbler diffusers were set at a minimum for mixing in the anoxic and anaerobic zones; no mixers were installed in these zones.

On July 24, 2013, M&O at the Stickney WRP drained Tank 1 of Battery D in order to examine the solids buildup on the bottom of the tank due to reduced air mixing, in the first half of Pass 1 in particular. As shown in Figure 1 (attached), photos upon drainage showed solids were built up on the bottom of the first half of Pass 1 in the aeration tanks after over a year of the EBPR process.

This is an operational concern, as built-up solids may clog the fine diffuser plates and reduce the tank volume. Because of this, an approach was discussed to install either actuated air valves to facilitate more frequent suspension of the settled solids or mechanical mixers to clear out the sediment in the EBPR anaerobic zones. Before installing actuated air valves or mixers, a short-term study was conducted to test the ability of the fine bubble diffusers to adequately clear these anaerobic zones through frequent opening of the air valves.

2.0. Methods

A two-month study started on August 15, 2013 with clean drainage of four test tanks (Tanks 1–4). To do this, the air valves in Battery D were fully opened in Pass 1 of the four test tanks in an attempt to resuspend all the solids seen during the initial drainage in July 2013. After fully aerating the pass, Pass 1 drains were opened first to rid the tank of as many solids as possible. This method was used to provide as clean a tank bottom as possible. Pictures were taken documenting the cleaned tanks.

After the four tanks were filled and put back into operation, Tanks 1 and 2 were operated with periodic exercising of the air valves in the anaerobic zone to resuspend and clear out any deposited material. On a daily basis, the first seven valves in Pass 1, i.e. the anaerobic zone, were fully opened for approximately 15 minutes by M&O. At the end of 15 minutes, each valve was returned to the minimal air input, i.e. anaerobic conditions. Tanks 3 and 4 were operated normally and used as a control, i.e. no exercising of the valves.

Only Tanks 1 and 2 were subsequently drained on October 21, 2013, to compare solid deposition before and after the study. Tanks 3 and 4 were drained three weeks later on November 12, 2013; this delay was due to the construction contract for Tanks 1 and 2. To capture the deposited solids, the study tanks were drained by opening drains in Passes 2–4 first and maintaining the air input at minimum. Pictures were also taken documenting the end of the study tanks.

One sludge sample was taken from the bottom of Tank 1, Pass 1, after draining using a ponar grab sampler before and after the study, respectively. A total of two samples were collected. The samples were analyzed for suspended solids (SS) and volatile SS (VSS) to understand the fraction of accumulated biological solids.

M&R also measured effluent ortho P and TP from final settling tanks (FSTs) 1–6 and FSTs 7–12 of grab samples twice per week to evaluate the effect of valve exercise on EBPR performance.

3.0. Results and Discussion

The solids data of sludge sample from bottom of Tank 1 before and after study are summarized in Table 1. It shows that the VSS fraction after two months of the solids deposition study was 10 percent higher than before. This could be due to the daily exercising of air valves, which would rid the tank of old inert sludge and replace it with fresh sludge. It should be noted that the initial sludge sample taken before the study began included the accumulation of sludge from over a year of operating the EBPR process and clean drainage, while the sample after the study was the sludge from only two months and capture drainage. As the accumulation time is significantly different, it is unclear whether the ten percent difference in VSS portion is actually due to the daily re-suspension as suggested above or the timeframe difference, i.e. 16 months versus two months.

TABLE 1: SUSPENDED SOLIDS AND VOLATILE SUSPENDED SOLIDS DATA PRIOR TO DRAINAGE OF TANK 1

	SS (mg/L)	VSS (mg/L)	VSS%
Before study	27,360	15,360	56.1
After study	58,067	38,300	66.0

As shown in Figure 2 (attached), the drained bottom of the aeration tanks was relatively clean before the study. After the study, both the control and test tanks had some solids deposition in the first half of Pass 1, as shown in Figure 3 (attached). Although with daily re-suspension with air, the photo in test Tank 1, Pass 1, possibly indicates more solids deposited than in Tank 4, Pass 1. One possible reason may be because heavier solids flow into Tank 1 than to Tank 4 due to the hydraulic pathway of Battery D.

Effluent ortho-P and TP concentrations from FSTs 1–6 for Tanks 1 and 2 and FSTs 7–12 for Tanks 3 and 4 are summarized in Table 2. It was suspected that valve exercising could release more volatile fatty acids in the anaerobic zone, which could improve P release and ultimately EBPR performance. Statistical analysis of effluent ortho P and TP data indicates there was no statistical difference between the average effluent ortho P and TP concentrations from aeration Tanks 1 and 2 and Tanks 3 and 4 (Table 2).

TABLE 2: AVERAGE EFFLUENT ORTHO-PHOSPHATE AND TOTAL PHOSPHORUS FOR TANKS 1 AND 2 VERSUS 3 AND 4

	Ortho-P (mg/L)	TP (mg/L)
D2 (Tanks 1 and 2)	0.40	0.47
D4 (Tanks 3 and 4)	0.32	0.44

*Eight (8) sampling days of data.

Overall, no significant difference in solids deposition or EBPR performance was observed with daily exercise of the air valves in the test tank anaerobic zones from the two-month study.

FIGURE 1: PHOTO OF AERATION TANK 1-PASS 1 WITH CAPTURE DRAINAGE
ON JULY 24, 2013

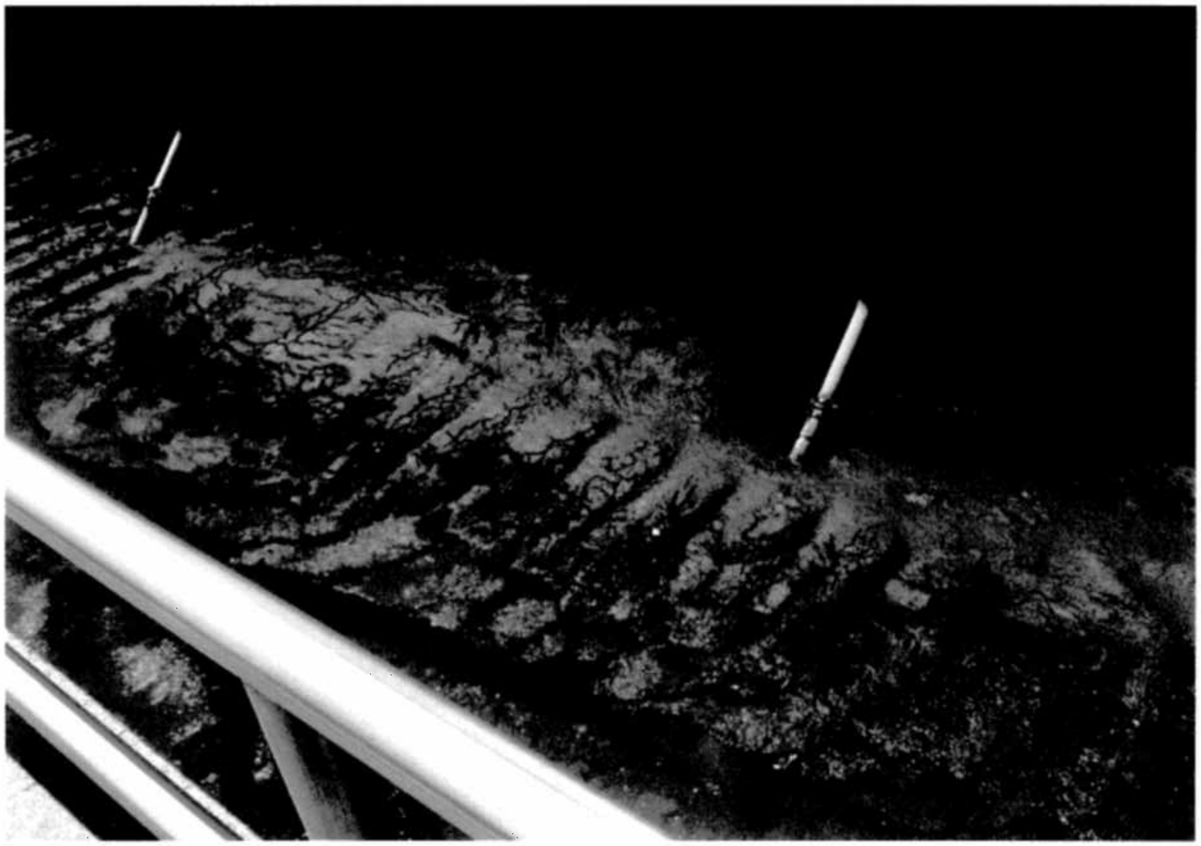
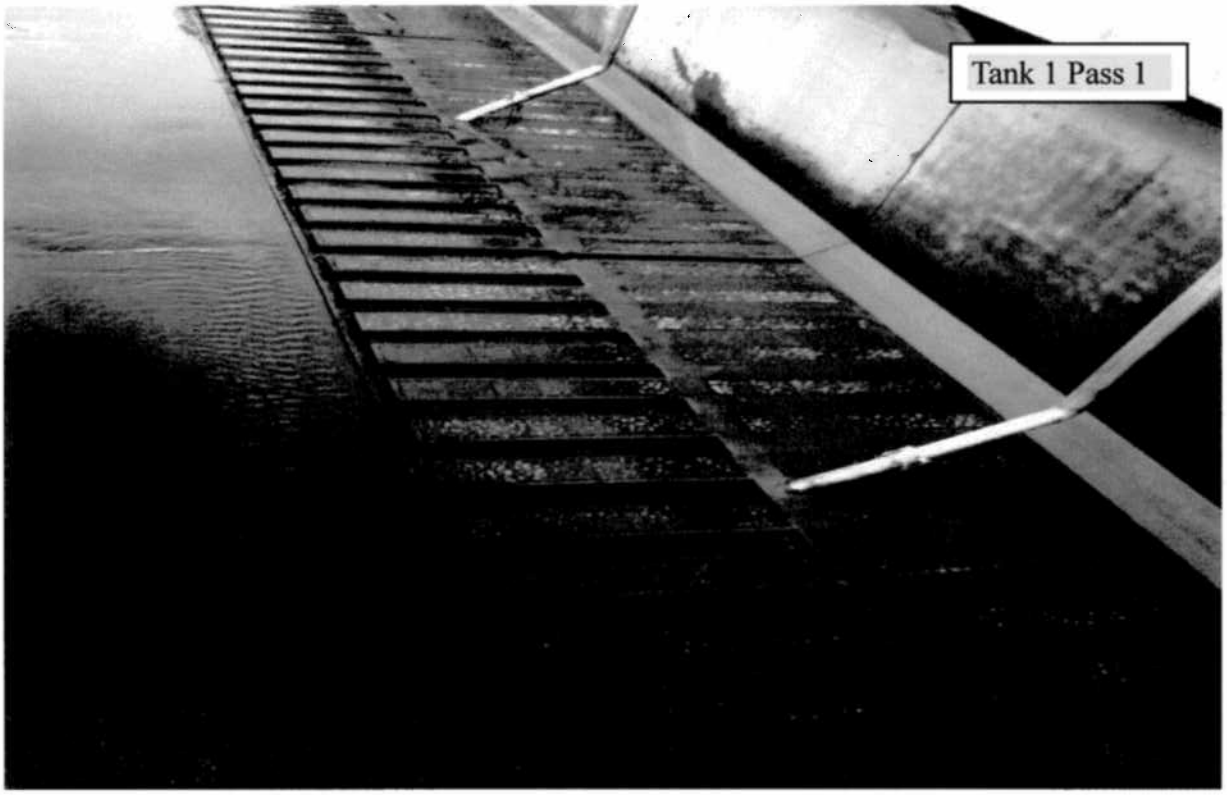


FIGURE 2: PHOTOS OF AERATION TANKS 1 AND 4-PASS 1 BEFORE DEPOSITION STUDY WITH CLEAN DRAINAGE



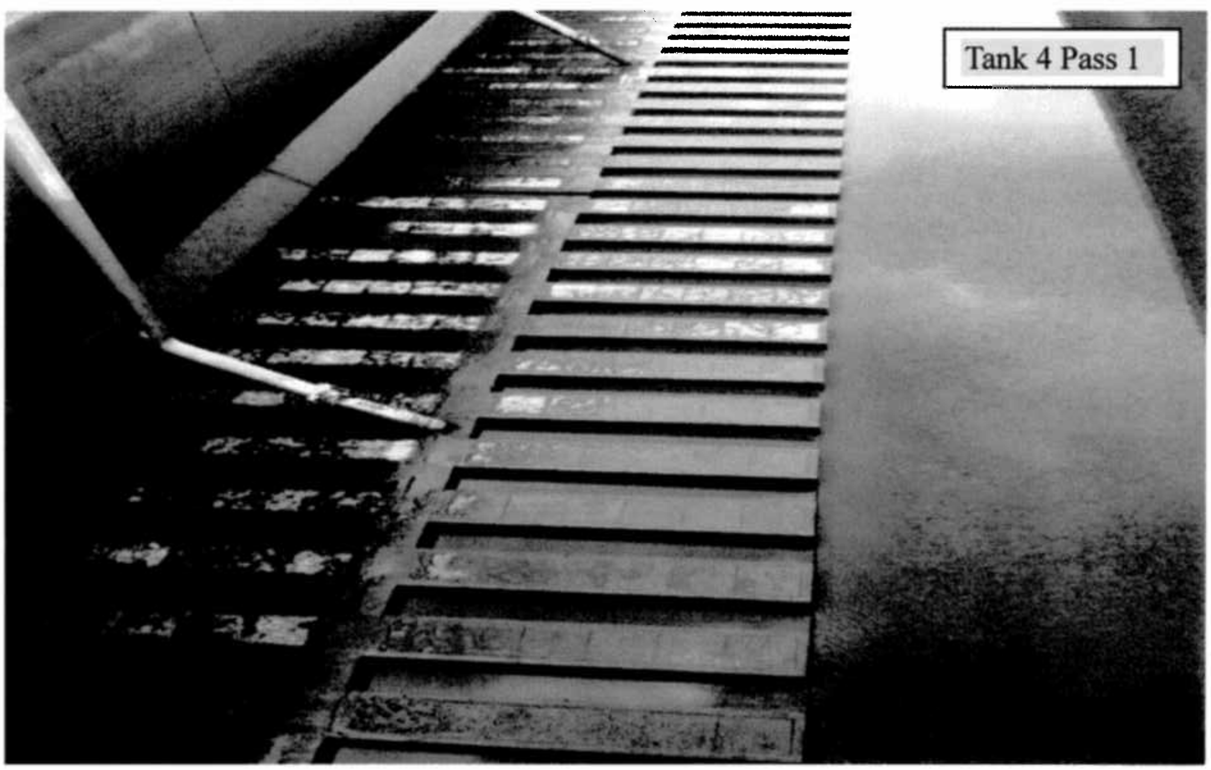


FIGURE 3: PHOTOS OF AERATION TANKS 1 AND 4 - PASS 1 AFTER DEPOSITION STUDY WITH CAPTURE DRAINAGE