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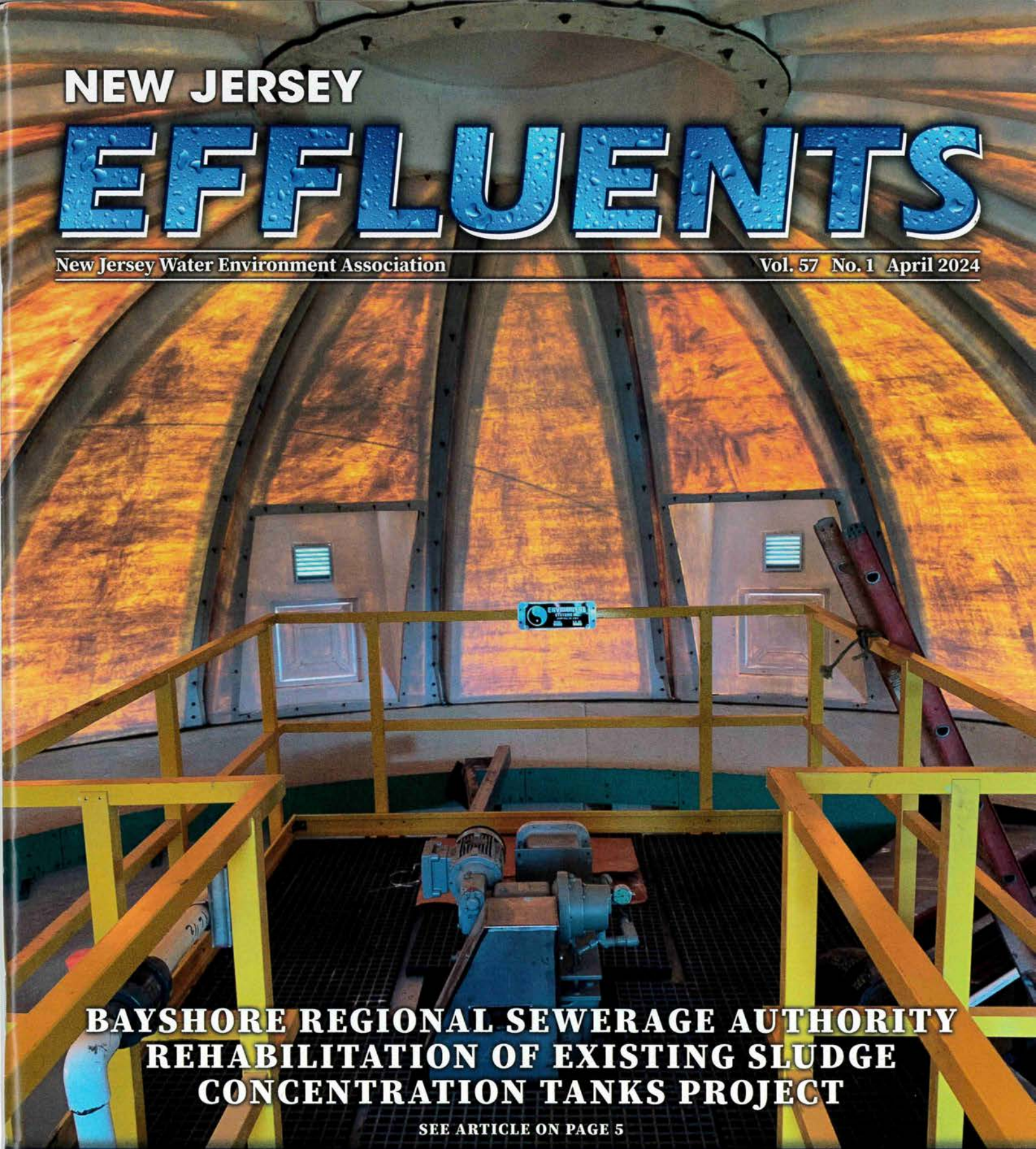

BAYSHORE REGIONAL SEWERAGE AUTHORITY REHABILITATION OF EXISTING SLUDGE CONCENTRATION TANKS PROJECT

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BAYSHORE REGIONAL SEWERAGE AUTHORITY REHABILITATION OF EXISTING SLUDGE CONCENTRATION TANKS PROJECT

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INTRODUCTION

The Bayshore Regional Sewerage Authority (BRSA) owns and operates a 16 million gallon per day (MGD) activated sludge wastewater treatment plant in Union Beach, New Jersey. The treatment plant consists of two (2) independent parallel treatment plants referred to as Plant Number 1 and Plant Number 2, with each treatment plant rated for 8 MGD. Plant Number 1, which was constructed in the 1970s under Contract 7, consists of primary clarifier numbers 1-4, aeration tank numbers 1-4, final clarifiers 1-4, primary sludge pump station number 1 and return sludge pump station number 1. In the 1990s, under Contract 22, Plant Number 2 was constructed and consists of primary clarifier numbers 5-6, aeration tank numbers 5-8, final clarifier numbers 5-7, primary sludge pump station number 2 and return sludge pump station number 2. The typical flow split between Plant 2 and Plant 1 is 70%/30%. Final plant effluent from plant numbers 1 and 2 is combined at a junction chamber and conveyed to the Monmouth County Bayshore Outfall Authority (MCBOA), which is located adjacent to the Authority's wastewater treatment plant and is ultimately discharged one quarter of a mile off the coast of Sandy Hook in the Atlantic Ocean.

The sludge management process employed at the treatment plant is comprised of several components including primary and secondary sedimentation tanks, gravity sludge thickeners, a thickened sludge storage tank, sludge conditioning and dewatering using belt filter presses, fluidized bed incinerators for thermal destruction of solids, and ancillary and various support equipment and processes related to these components. In 2017 BRSA proceeded with a project to improve the sludge management process by rehabilitating the gravity thickeners as they were the oldest and weakest link in the sludge management process chain. This article discusses the design of the rehabilitation, the difficulties encountered during construction, and the results and lessons learned from the project.

EXISTING GRAVITY THICKENER SYSTEM OPERATION

Total primary and waste activated sludge produced from treatment plants 1 and 2 are conveyed to a sludge division box constructed in the 1980s and then to gravity thickeners known as the sludge concentration tanks. Waste activated sludge is conveyed on a continual basis while primary sludge is conveyed every 15 minutes for short pumping durations. Each Concentration Tank is thirty-five (35) feet in diameter and approximately ten (10) feet deep. Three (3) Concentration Tanks were constructed in the 1970s and the fourth Concentration Tank was constructed in the 1990s.

Each Concentration Tank is equipped with a fiberglass dome cover system to contain odors, and the headspace between the water surface and dome cover is ventilated and treated by an odor control system; Siemens LO/PRO Multistage Packaged Odor Control System installed in 2013. Underflow from each Concentration Tank is conveyed to a 127,000-gallon continually mixed, thickened sludge storage tank at an average solids concentration of 1-2% then further thickened via a Komline Sanderson 2-meter belt press system prior to being pumped to the fluidized bed incineration system as fuel. Floating grease from the Concentration Tanks is collected and conveyed to the sludge incineration facility.

The Authority employed a time-controlled pump system operation for the thickener underflow having a pumping frequency of five (5) minutes per Concentration Tank in an alternate sequence or eight (8) hours per day for each tank. The underflow from the Concentration Tanks was conveyed to the sludge storage tank via Sludge Transfer Pump Nos. 1 and 2 at a rate of 20-30 gallons per minute for twelve hours (12) hours per day except when sludge is pumped from the storage tank to the existing belt filter press where the underflow pumping rate is increased to 60-80 gallons per minute to match

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the flowrate of the sludge storage tank's pumping system. Typically, sludge was pumped from the sludge storage tank to the belt filter press at a twelve (12) hour per day cycle, Monday through Friday.

Under this operating scenario, the capacity of the sludge storage tank is insufficient, and the Concentration Tank underflow pumping system must be shut down as a function of high level in the sludge storage tank until there is sufficient volume in the sludge storage tank to accept the volume of the Concentration Tank underflow.

PROJECT GOALS

Because the existing Concentration Tanks and their associated equipment have exceeded their useful life, were not producing the desired underflow, and were experiencing sludge withdrawal problems, the BRSA decided to rehabilitate each tank and protect them from future potential flooding as previously experienced during Hurricane Sandy. The project goals were as follows:

- Replace existing mechanical drive mechanisms including rake and drive assemblies, catwalk, grease breeching system, baffles and effluent weir system;
- Inspect Concentration Tank No.1 to determine the relative condition of the existing concrete structure.
- Rehabilitate the internal concrete by removing all loose concrete, grout material and make necessary repairs to spalled or cracked concrete. Apply a suitable coating system to protect the concrete from hydrogen sulfide corrosion;
- Investigate alternatives to provide flood mitigation for the Concentration Tanks to the 100-year flood elevation;
- Investigate the condition of the existing fiberglass dome cover systems and make a recommendation for their replacement;
- Televise the condition of the underflow piping system and remove all noted obstructions;
- Improve upon the existing pumping scheme for the sludge storage tank to ensure that there is adequate storage capacity to improve steady state pumping operation;
- Increase the overall percent solids concentration of the combined sludges entering the Concentration Tanks;
- Increase the solids concentration of the sludge cake leaving the belt filter press to either eliminate or reduce the quantity of diesel fuel used as supplemental fuel for the fluidized bed incinerator;
- Replace the existing centrifugal primary sludge pumps in Primary Sludge Pump Stations 1 and 2 with positive displacement pumps equipped with variable frequency drives to provide operational flexibility for varying the primary sludge flow to the Concentration Tanks on a continual basis while maintaining an adequate sludge blanket within the existing primary clarifiers.

In efforts to define the scope of work for the rehabilitation of the existing Concentration Tanks and supporting systems, in accordance with the project goals, a Concentration Tank Underflow Thickening Alternatives analysis was first performed. Several alternatives were examined in efforts to provide a steady state pumping operation for the Concentration Tank Underflow to the liquid sludge storage tank. These alternatives included:

- Gravity Thickening Only
- Mechanical Thickening of Concentration Tank Underflow
- Mechanical Thickening of Waste Activated Sludge

Upon performing a detailed wastewater process analysis of each alternative, ultimately, gravity thickening was concluded to be the most cost-effective means of thickening combined primary and waste activated sludges to achieve steady state pumping conditions for the existing sludge storage tank.

CONCENTRATION TANK FLOOD MITIGATION ALTERNATIVES

Three alternatives were examined to provide flood mitigation measures for the existing Concentration Tanks by modifying the height of the external walls for each tank to an elevation of one (1) foot above the 100 year Design Flood Elevation (DFE), namely to elevation 14.00 feet. These alternatives included:

- Raising the exterior concrete walls and covering the tanks with new fiberglass dome covers;
- Raising the exterior concrete walls and covering the tanks with a flat low-profile aluminum or fiberglass cover;

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- Construct an independent reinforced concrete wall with watertight access doors around each of the Concentration Tanks to provide adequate headroom and complete access to the Concentration Tanks.

Upon performing a detailed analysis on the above alternatives, it was concluded that raising the exterior concrete walls and covering the tanks with new fiberglass dome covers was the most cost-effective alternative for providing flood mitigation measures. (We did not move forward with the raising of the walls, just the new covers).

CONCENTRATION TANK NO. 1 CONCRETE CONDITION ASSESSMENT

A detailed concrete inspection was performed on Concentration Tank No. 1 to determine the relative condition of the cast-in-place concrete structure. The concrete observation effort involved visual inspection of the interior surfaces of the walls, the top of the tank slab, and the exterior face of the exposed portions of the walls. Observations were performed in accordance with general guidelines of ASTM E-2018, Standard Guide for Property Condition Assessments: Baseline Condition Assessment Process. Because process operations of the Concentration Tank system prohibited the draining of all four (4) Concentration Tanks for inspection, it was reasoned that the results of the concrete inspection of Concentration Tank No. 1 would be representative for all remaining three (3) Concentration Tanks.

Results of the concrete inspection concluded that the bottom concrete slab for Concentration Tank No. 1 was in good condition including the inside face of the tank's vertical wall. The effluent trough located at the top of the tank and its inside wall were also found to be in good condition including the outside surface of the trough wall.

There were locations on the outside tank vertical wall projecting above grade where the concrete had varying degrees of cracks and spalls. Some locations were observed to have exposed reinforcing steel.

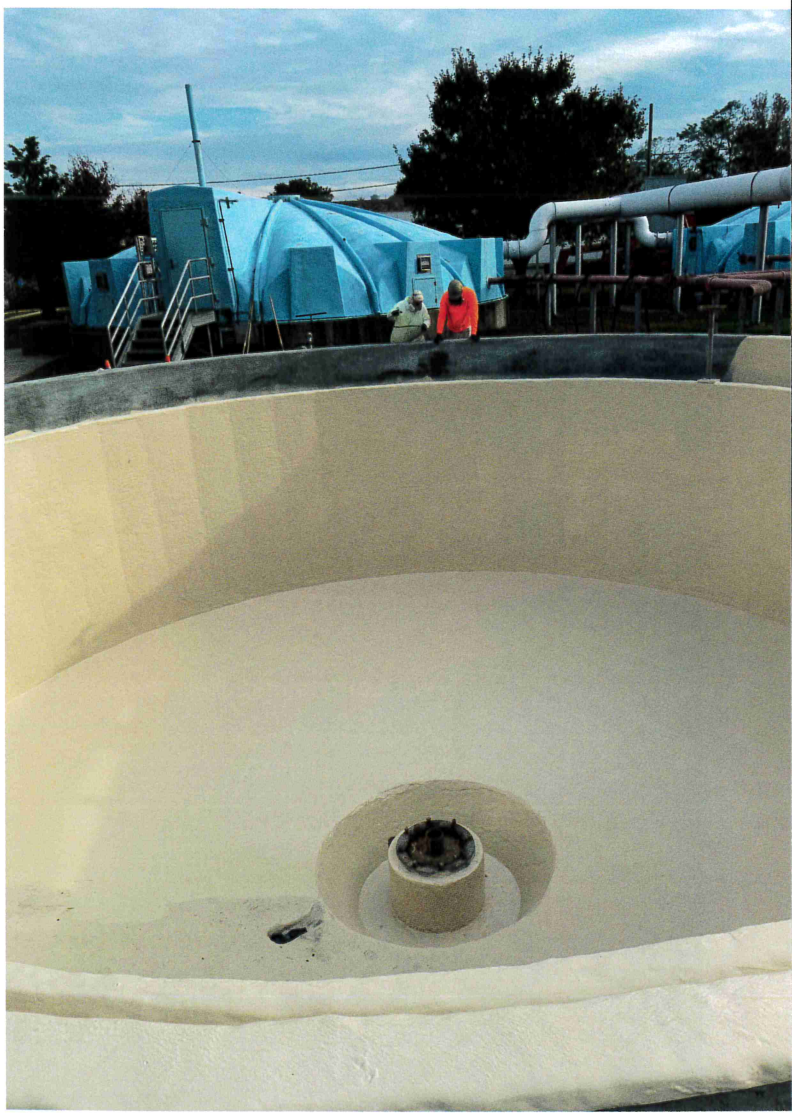
It was concluded that the rehabilitation project design documents, to extend the life of the existing concrete structure, shall include provisions for repair of concrete cracks, spalls, exposed reinforcing steel, oxidized concrete and similar conditions.

CONCENTRATION TANK CONCRETE COATING SYSTEM

To protect the concrete surfaces of each Concentration Tank from hydrogen sulfide and sulfuric acid corrosion as well Microbiologically Influenced Corrosion (MIC), it was proposed that a protective lining system manufactured by Sauereisen, SewerGard® No. 210X be applied to the concrete surfaces to provide for a chemical-resistant barrier.

Specifically, the following surfaces of the Concentration Tanks were to be protected:

- Sloped Conical Floor
- Internal tank vertical wall
- Effluent launder vertical wall
- Effluent launder channel floor



Application of the epoxy coating system in Concentration Tank #1.

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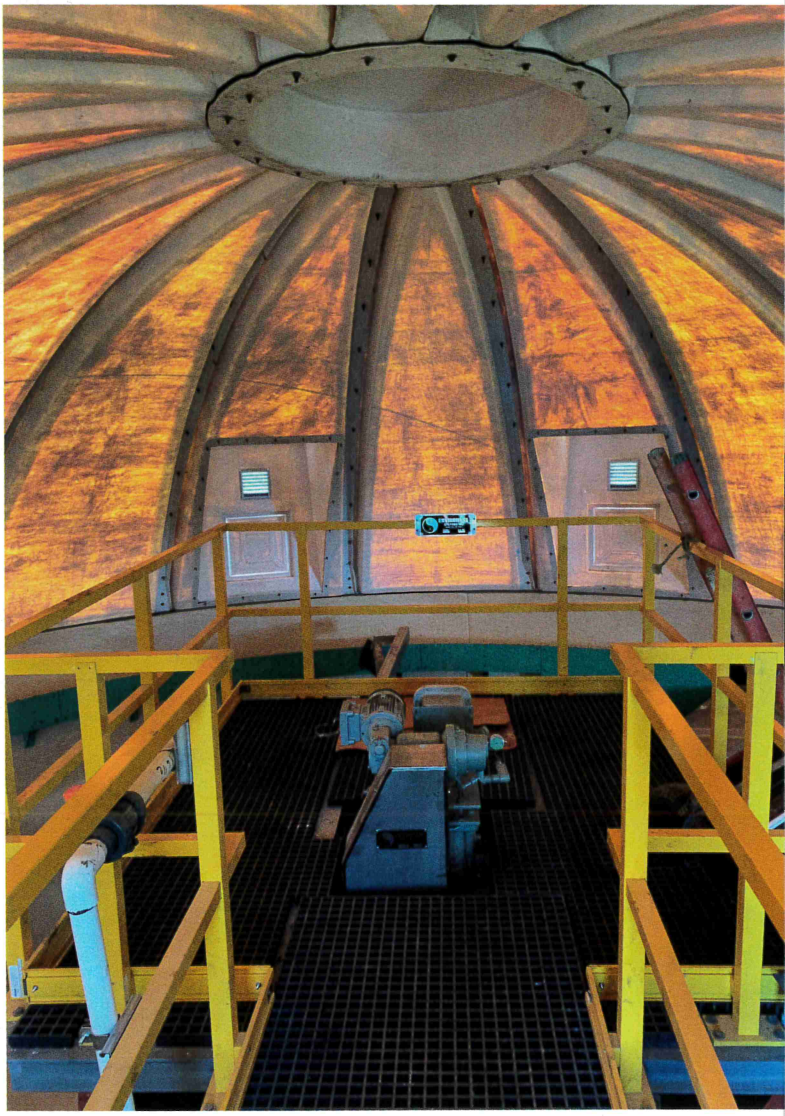
THICKENER COLLECTION MECHANICAL MECHANISM

The existing thickener collection mechanical systems were investigated and found to be heavily corroded and in various areas the "V" notch effluent weirs and scum baffles were severely deteriorated resulting in a negative process performance on the existing Concentration Tank collection system. In addition, the mechanical collection equipment had been in service for 20-30 years, thus exceeding its useful life.

The scope of replacement for the Thickener Collection Mechanical Mechanism included the following mechanical and structural components for each Concentration Tank:

1. One (1) 35-foot column supported sludge collection mechanism system to include two (2) steel rake arms with thickening pickets and plow blades with 304 stainless steel squeegees;
2. Motor drive including sprockets, drive chain and chain guard;
3. Electromechanical torque overload device with a backup mechanical shear pin;
4. Local Control panels;
5. Two (2) separate influent piping feed points:
   - Bypass feed pipe;
   - Primary feed pipe with a submerged discharge and "tee" outlet to evenly distribute the influent flow into the sludge feed well
6. 4-foot-wide full radius steel walkway bridge spanning from the tank wall to one side of the drive platform with 1-1/4inch aluminum grating and toe board;
7. Enlarged motor drive maintenance platform to facilitate maintenance activities;
8. Fiberglass Reinforced Plastic (FRP) handrail system for walkway bridge;
9. Steel box truss center cage;
10. Influent feed well with supports and baffled scum ports;
11. Scum box with automatic flush valve assembly and full radius scum skimmer assembly;
12. FRP scum baffle and effluent V notch weirs.
13. Improve the odor control duct collection system layout to increase the capture efficiency of hydrogen sulfide gas.



Completion of the mechanical equipment installation, catwalk, and access platform in Concentration Tank #4.

FIBERGLASS DOME COVERS

The existing fiberglass dome covers were investigated, and it was noted that the covers for Concentration Tank Nos. 1, 2, 3, and 4 were found to be in poor condition. A financial analysis comparing the cost to repair the existing covers versus replacing the covers with new fiberglass dome covers was performed and it was concluded that replacement of the existing covers was the most financially attractive alternative.

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PRIMARY SLUDGE PUMP REPLACEMENT

There were two (2) primary sludge pump stations located within the wastewater treatment plant facility, namely, Primary Sludge Pump Station No. 1 which conveys primary sludge from plant 1, and Primary Sludge Pump Station No. 2 which conveys primary sludge from plant 2 to the Concentration Tanks.

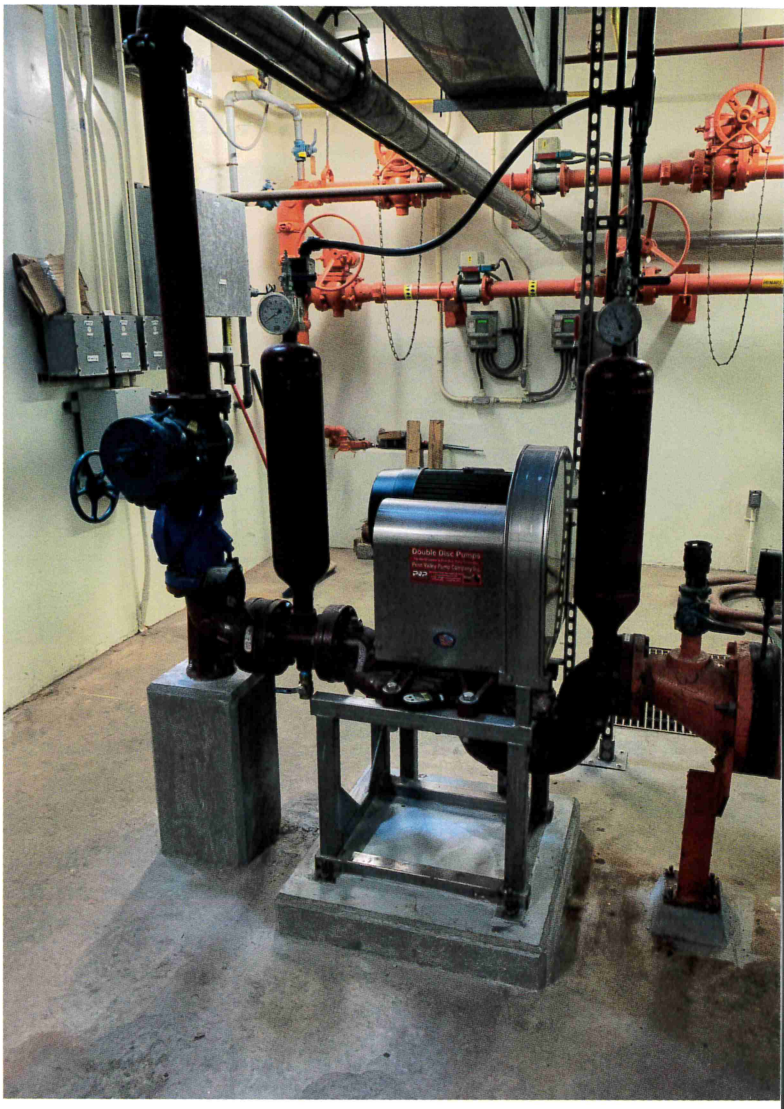
The existing pumps were recessed impeller centrifugal pumps, approximately 25-30 years old, exceeding their useful life, and spare parts were difficult to obtain. Furthermore, the high flow capacity of the centrifugal primary sludge pumps made it extremely difficult to maintain a sludge blanket in the primary clarifiers, and therefore, the primary sludge pump control system has been set to pump primary sludge for five (5) minutes every hour. It was noted that conveying primary sludge to the Concentration Tanks on an intermittent basis had a negative impact on the overall solid concentration of the combined sludges (primary and waste activate sludge) entering the Concentration Tanks leading to a negative impact on the ability of the combined sludges to settle by gravity. Although the primary sludge pumps were equipped with a Reeve adjustable speed drive system, mechanically adjusting pump speed was proven to be cumbersome and therefore an electronic variable speed drive system was recommended for the new proposed primary sludge pumping equipment.

BID DOCUMENT PREPARATION AND RESULTS

Bid Documents entitled "Sludge Concentration Tanks Rehabilitation Project-Contract Number 106" were prepared during October 2018.

On December 5, 2018, the Authority received and opened bids ranging between $3,439,000.00 to $3,912,445.00 as compared to the Engineer's Opinion of Probable Construction Cost Estimate of $4,443,250.00.

The similarities between the bids results (a 4.5% spread separated the 1st and 4th bidders) indicates clearly written plans and specifications and barring unforeseen field conditions, suggests minimal change orders. As will be explained further, there were field conditions that were unforeseen leading to changes, however, the change orders were kept low overall.



The new positive displacement pumps in the Primary Sludge Pumping Station #2.

CONSTRUCTION

The project encountered a few difficulties during construction due to workmanship as well as unforeseen field conditions. The workmanship issues were minor in magnitude and overall, the contractor performed very well on this project. The issues encountered during construction included:

1. Poor bonding of the specified Sauereisen Sewerguard epoxy coating system in two (2) Concentration Tanks due to surface preparation deficiencies.
2. Loss of Struvicide chemical solution for the removal of struvite due to cracked sludge withdrawal pipelines.
3. Failure of the pipelining subcontractor to adequately install and cure a new CIPP liner in sludge withdrawal line to Concentration Tank 2.

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POOR BONDING OF THE SAUEREISEN SEWERGUARD DUE TO SURFACE PREPARATION DEFICIENCIES

Prior to the application of the protective epoxy membrane system, Sauereisen Sewerguard 210X, the tank walls and floors had a ½ inch thick concrete mortar underlayment applied. The existing concrete surfaces were abrasive blasted for better adherence of the Sewerguard coating. Weeks after application of the epoxy membrane system, the Authority drained one of the newly upgraded tanks to inspect the rake assembly and squeegee blades. Upon draining the tank, the Authority discovered peeling of the Sewerguard coating from the concrete in certain areas. The contractor remobilized the painting subcontractors, cleaned and scoured the peeling areas, and re-applied the Sewerguard 210X product successfully. The process was repeated in one other tank and continues to provide protection without further failure.

CRACKED SLUDGE WITHDRAWAL LINES LEADS TO LOSS OF STRUVICIDE CHEMICAL SOLUTION

Magnesium ammonium phosphate, commonly known as struvite, is a hard crystalline substance that can cause damage to sludge processing pipelines and equipment. At the BRSA, struvite formation created problems in the sludge withdrawal pipelines from the concentration tanks by reducing their diameter and physically obstructing the removal of sludge. The blockage created by struvite formation within the sludge pipelines was estimated at up to 75% of the pipe's flow area. To address this problem, a struvicide chemical solution circulation system with pumps and chemical solution reservoir was provided by Grignard, the manufacturer of the chemical solution. It was installed and placed into operation adjacent to the sludge Concentration Tanks. The Struvicide chemical solution was introduced into each Concentration Tank's sump pit piping located at the center of each emptied Concentration Tank and removed at the downstream end of the tanks' sludge withdrawal piping. At the downstream end of the sludge removal piping, flexible hoses returned the chemical solution back into the circulation system reservoir. This process ran for several days continually dissolving struvite in the process. Early in the process, struvicide chemical solution loss was detected which alerted the contractor to a possible crack in the sludge withdrawal pipeline. Upon televising the pipeline, a six-(6) foot long crack was located and the application of struvicide chemical solution halted until a repair solution of the sludge withdrawal pipeline was identified and installed.

Cured in Place Piping (CIPP) subcontractors were mobilized to line the sludge withdrawal pipeline, but the process took months of work and three-(3) different CIPP liner installers. The sludge withdrawal line for this tank had three-(3) forty-five-degree fittings, two of which being fifteen-(15) feet apart. The lining subcontractor was unable to create enough pressure to invert the liner more than ten-(10) feet past the 2nd fitting. In the first attempt, the liner was cured just past the midpoint in the pipeline and the subcontractor had to grind the cured liner out of the pipe using a mechanical grinder, a process that took two-(2) months to complete. In the second attempt, a different epoxy was used, one with a longer cure time to prevent a repeat of the first attempt. This liner also did not make it past the second fitting, but fortunately did not cure, and the subcontractor was able to pull the liner back out of the pipe. On the third attempt, the subcontractor used a pre-liner to reduce the friction and facilitate an easier inversion process. This attempt failed as well. A subsequent fourth attempt was similarly applied, and that attempt failed.

The fifth and most successful attempt used a completely different method. Realizing the inversion process was not going to be successful, a new linier subcontractor installed a winch system at the center of the Concentration Tank and pulled the liner the entire distance of the pipeline into place and using specialty fittings, inflated and cured the liner, successfully lining and repairing the pipeline and ending a nightmare of a repair.

SLUDGE BLANKET MEASUREMENTS USING NEW METERS WERE UNRELIABLE.

To promote a more efficient thickening of sludge prior to dewatering on the belt filter presses, the Authority requested electronic sludge blanket meters be installed in the Concentration Tanks with the intention of using measured sludge blanket depth to activate the primary sludge pumping cycles. However, the sludge blanket meters within

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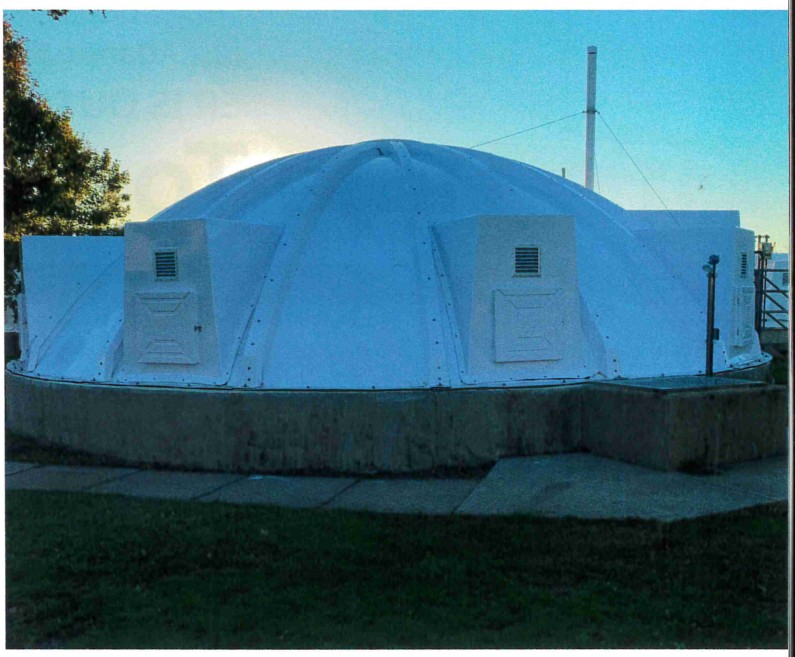
the Concentration Tanks were unable to detect the interface between sludge blanket depth and supernatant zones within the tanks. In addition, the meters could not provide a consistent blanket depth indication matching the manual measurements taken by the operators. After several unsuccessful attempts to remedy the problem, the Authority decided to relocate the sludge blanket meters to the primary clarifiers where a clearer sludge blanket interface forms. The sludge blanket meters were then used to measure sludge blanket depth in the primary clarifiers to control primary sludge pumping operation. However, after several months of use, the Authority decided to revert to intermittent sludge withdrawal based on time rather than sludge blanket depth. The sludge blanket meters were kept in use and provide an accurate measurement of blanket depth.



Completion of work in Concentration Tank #3, with the new fiberglass dome cover.

CONCLUSION

The Rehabilitation of the Existing Concentration Tanks Project at the Bayshore Regional Sewerage Authority was a successful construction project providing a significant improvement in gravity thickening process performance. The solid concentration of the thickener underflow increased from 1-2% solids to 3-5% solids which provides for a much-improved fuel source to the fluidized bed sludge incinerators. The new fiberglass dome covers provide greater head space, and the improved lighting coupled with odor control duct modifications have provided for a safer working environment for plant operators when performing maintenance activities within the tanks. The sludge withdrawal lines are clear of struvite formation and no longer clogged with debris and the new sludge collection mechanisms have restored the useful life of the sludge collection system. The change from the existing centrifugal primary sludge pumps to positive displacement pumps has resulted in a 62% decrease in volume of sludge pumped per day from 178,000 gpd to 68,000 gpd, a significant energy savings to the Authority, and the sludge blanket meters provide an instantaneous reading of blanket depth in each clarifier to facilitate primary settling tank operation.

Notwithstanding the unforeseen field conditions, the final project cost was $3,538,600 which was only 2.9% above the awarded bid price of $3,439,000. Additional information about this project can be obtained from Thomas Petti, Principal Engineer at BRSA at tpetti@bayshorersa.com.

MESSAGE FROM THE PRESIDENT

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for their tolerance and understanding. Their support and encouragement helped me keep moving forward. Finally, my thanks go out to the members of the NJWEA. You are a great bunch and I truly appreciate all of your well-wishing and assistance.

But, with all the appreciation put aside, I'm not gone yet. We have a number of initiatives in the works that I will continue to help with even after I'm out of this position. One of many examples is the operator's training initiative. Operator training has always been near and dear to my heart. Over the long term, I will continue to be involved with that and other topics. Over the shorter term, we have a great Conference coming in May. The information is out there – in the mail, electronically, and in this issue. I look forward to seeing you all in Atlantic City to personally express my thanks. Thank you again and see you at Harrah's.