A Comparative Biological Treatment Analysis of a BioMix system and a Submersible Propeller Mixer Operating in an Anoxic zone

Renewable Water Resources

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ABSTRACT

In the summer of 2011, Renewable Water Resources pilot tested a Biomix system in a biological nutrient removal (BNR) anoxic zone reactor. The purpose of this pilot testing was to compare nutrient treatment analysis, monitor complete zone mixing, and measure potential overall energy savings between two different mixing processes. Two biological treatment trains ran in parallel operation with the exact same influent, return activated, and oxic recycle flows. The only differences between the two treatment trains during the 10 week testing protocol were the different mixing processes in the anoxic zones. One anoxic zone treatment process train operated with the typical conventional-design propeller submersible mixer and the other anoxic zone treatment train with the Biomix process. The Biomix system is a patented technology for mixing wastewater by releasing bursts of compressed air at the bottom of the water column at specific times in anaerobic, anoxic and aerated treatment zones. Mixing in anaerobic and anoxic zones with no significant oxygen transfer is a critical step in meeting BNR standards. This paper documents the results of testing performed at the Mauldin Road treatment facility, Renewable water resources, in Greenville, SC.

Results of side-by-side comparisons of Biomix with submersible propeller mixers established that:

- Biomix is fully compatible with anoxic environments based on measured oxidation reduction potential, nitrates, dissolved oxygen content, and ortho phosphates laboratory analyses. Reactors that maintain those environments are key treatment process components used to meet EPA and state-level nutrient removal limits.

- Biomix demonstrated substantial power savings compared to submersible propeller mixers based on measured horsepower and amperage.

- Biomix is effective in mixing wastewater to industry standards based on measured suspended solids analysis.

INTRODUCTION

Renewable Water Resources (f.k.a. WCRSA) is a special purpose district created as the "Greater Greenville Sewer District" by Act No. 362 of the Acts of the General Assembly of the State of South Carolina of 1925. The service area of Renewable Water Resources presently includes the major portion of Greenville County and certain areas in Anderson, Laurens, Spartanburg, and Pickens Counties. A primary function of Renewable Water Resources is to operate and maintain sewer trunk lines and treatment plants which discharge treated wastewater into the river systems of the State of South Carolina. Renewable Water Resources currently owns and operates nine facilities that treat an average of 39.4 million gallons per day (MGD) of wastewater.

Renewable Water Resources' Mauldin Road facility was the first South Carolina treatment facility permitted for effluent total phosphorus limits in 1988 due to impacts of accumulated phosphorous in downstream confined watersheds that resulted in eutrophication (excessive algae growth). The facility was upgraded for biological nutrient removal (BNR) to meet a 1.3 effluent phosphorous monthly average. The A2/O biological BNR process required a series of mixed unaerated or anaerobic/anoxic zones to create conditions suitable for biological nutrient removal. Other Renewable Water Resources facility upgrades followed over the next 10 years to add BNR processes. When designing these types of zones, typical propeller submersible mixers were utilized for capital cost savings, instead of building expensive and elaborate structural pipe galleries. Over the years, with many applications of these submersible propeller mixers, maintenance and repair costs have become substantial. The submergence of the motor also makes maintenance events more problematic for the staff, and repair times are often lengthy.

A major goal for Renewable Water Resources is to place a continual emphasis on operational efficiency, utilizing data to drive down costs and optimize operations by eliminating wasted efforts and resources, while leveraging new technology and processes to modernize the organization. With the ongoing efforts to successfully achieve this organizational goal, the new Biomix technology was considered for a pilot test at the Mauldin Road facility to demonstrate the system's energy savings potential and simplified maintenance demands compared to the submersible propeller mixer.

POTENTIAL CONCERNS

Oxygen Transfer Effects on the BNR Process

Anoxic zones promote denitrification by combining organic material, the microbiological suspension, and the nitrates, without free oxygen present. The bacteria use the nitrate as an electron acceptor during the consumption of organic material. The result is the reduction of nitrate to nitrogen gas and the growth of the bacterial population. When oxygen is present, it is the preferred electron acceptor for the microbes, so exclusion of oxygen is critical to the removal of nitrate. Dissolved oxygen concentrations less than 0.3 mg/L are considered sufficient to promote denitrification in activated sludge mixed liquor because at that concentration much of the internal parts of the flocs will be anoxic or anaerobic under typical organic loading conditions. Proper mixing in an anoxic zone permits contact of the microbial population with the carbon and nitrate to accomplish the denitrification reactions. The major concern was that any free oxygen created in the anoxic zone (BR2-1C) would cause nitrates in the overall process to increase. In such a scenario, the accumulating phosphorus organisms population would decrease because elevated nitrate levels in the anaerobic zone would allow the regular forms of organisms to have the first selection of the incoming food waste.

Effects of an Unmixed Anoxic Zone on the BNR Process

The amount of time required for denitrification to occur is largely a function of the water temperature, the degree of denitrification, and the degree of mixing. A poorly mixed anoxic zone could cause a solids inventory reduction that could in time affect the overall effluent treatment quality.

Mauldin Road Biological Reactor Anoxic Zone in Operation

PILOT STUDY METHODS AND MATERIALS

Components and Support Provided by Enviromix:
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- Biomix NEMA 4X FRP Valve Control Panel (VCP) with Allen Bradley PLC, three MAC Series 67 solenoid valves, valve manifold, and alarm system
- Zinc-electroplated (external) carbon steel Sch5 press-technology in-tank air distribution piping with associated fittings and supports
- Sch10 carbon steel nozzle headers
- 18 Engineered carbon steel Biomix nozzles with wedge anchors

Support and Documentation Provided by Enviromix:

- System installation instructions
- System operating and maintenance instructions
- System start-up
- System operator training (up to 8 hours of instruction)
- On-site troubleshooting, if required, for the duration of the evaluation
- EnviroMix consulting, as necessary, regarding system operation for the duration of the evaluation
- Edit of report of trial findings

Components and Support Provided by Re-Wa:

- Compressor (minimum 5-HP) with receiver (minimum 80-gallon) with electrical supply located adjacent to the Biomix VCP
- 1-1/2” air supply piping and associated fittings from compressor/receiver to VCP
- System installation with supervision from EnviroMix
- Electrical power including power connection to the compressor and control unit (120V)
- Materials for collecting samples
- Sampling, evaluation, and reporting of samples
- Final report of trial findings

Evaluation Protocol

1. Test Area: The test areas consisted of two Anoxic Tanks BR2-C of the ReWa Mauldin Road WWTP, one tank operating Biomix, one tank operating an existing mechanical mixer. Each tank measures 39.9' x 30.8' x 14.6' side water depth.

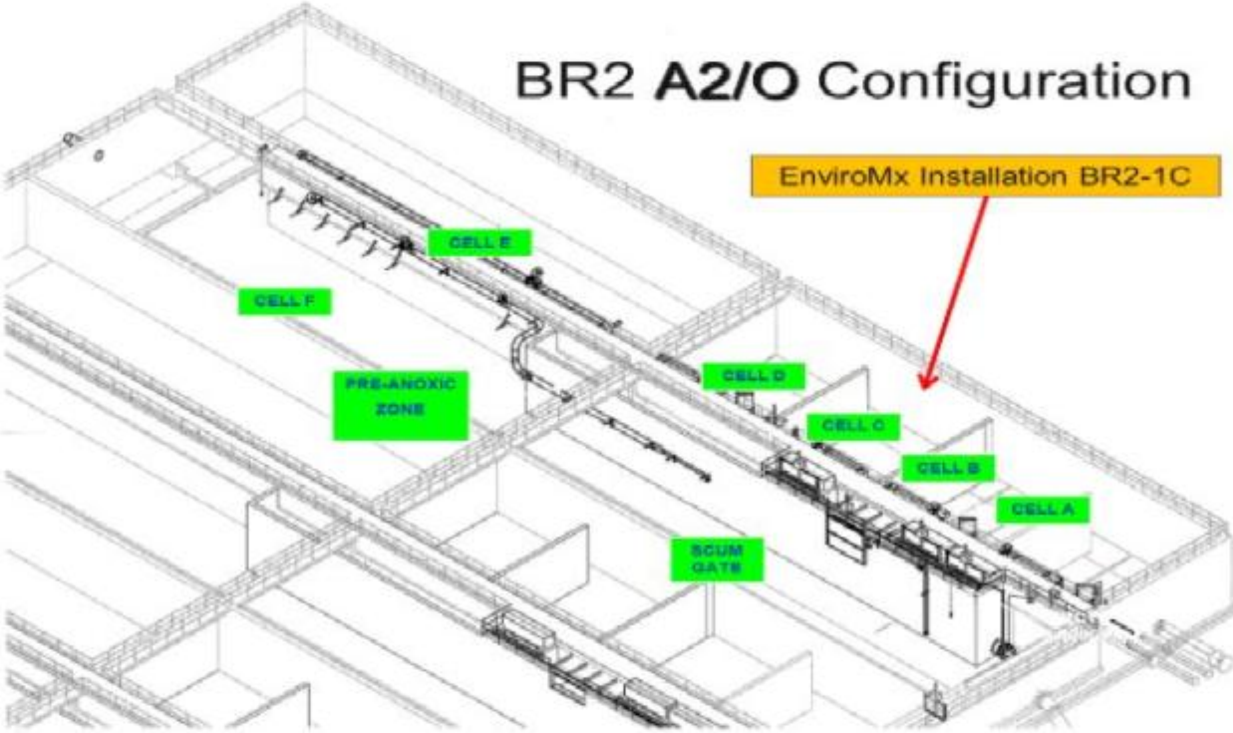
2. Test Periods: The test period for the Biomix was established as 10 weeks. ReWa committed to provide a repot to EnviroMix within 4 months of evaluation commencement.

3. The following parameters were measured during all testing periods for each mixing technology/tank

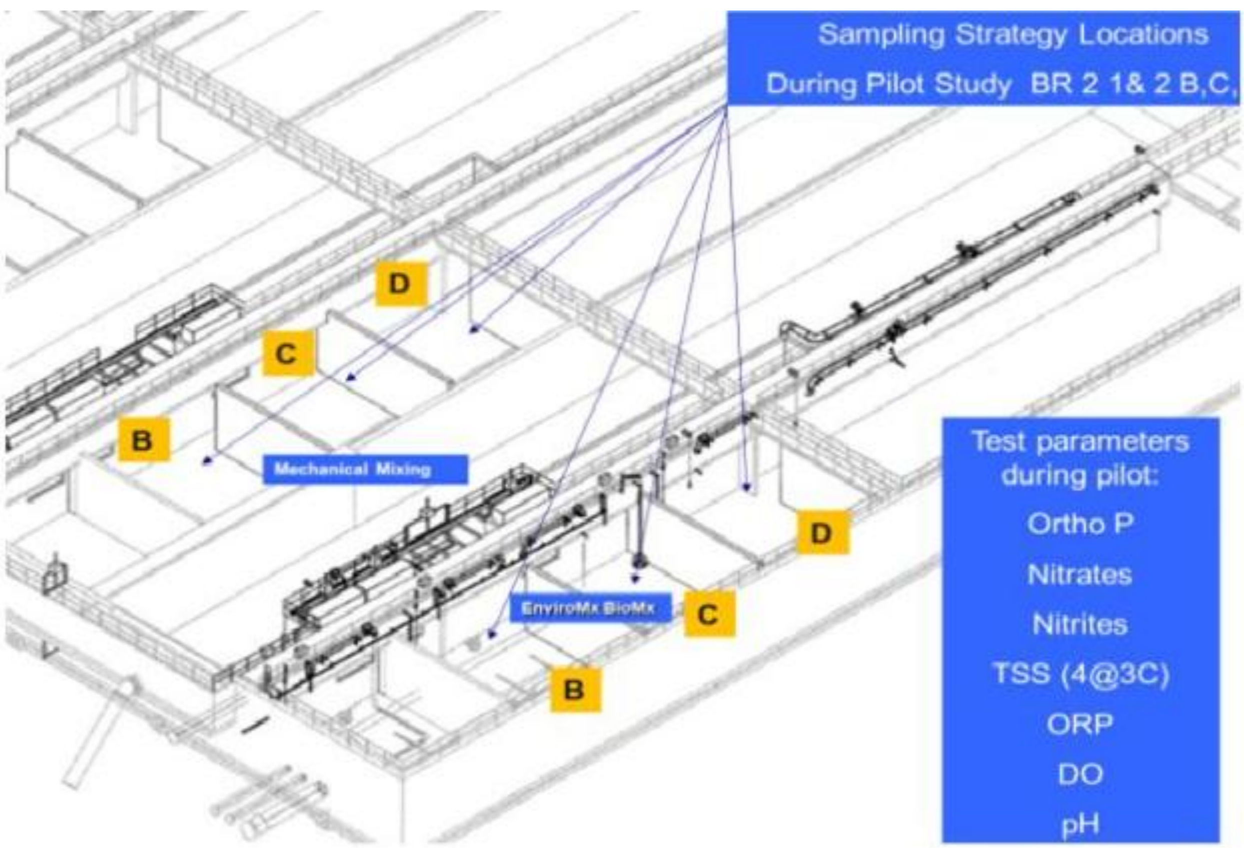
   A. Total Suspended Solids. Sampling tubes were located at a minimum of four locations distributed over the area of the respective Tank BR2-C to ensure representative sampling. At each location, sample tubes were suspended at 2 feet below the surface, at mid-depth, and at 2 feet above the floor. Sampling was performed for each mixing technology/tank as close as practicable to the same time. Sampling comparison sets were taken late morning at the same times each day.

   B. Ammonia, Nitrate, Nitrite, Ortho-Phosphorus, pH, Dissolved Oxygen, ORP. Samples were taken mid-depth at the respective center of Tanks BR2-B, BR2-C, and BR2-D. Sampling was performed for each mixing technology/tank as close as practicable to the same time. Sampling comparison sets were taken early afternoon at the same times each day.

   C. Plant Flow/Recycle Rates. All respective flow rates were measured and reported during the trial period.

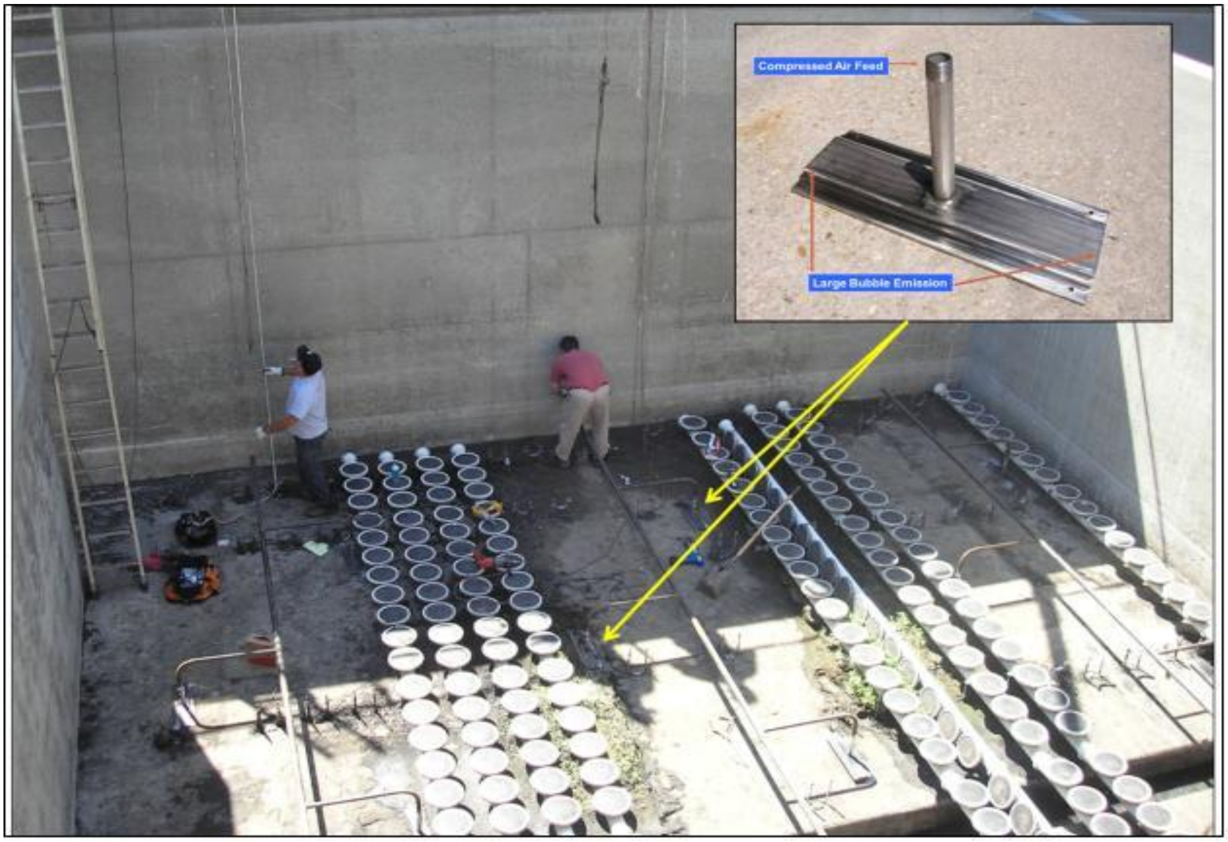


Biological Reactor #1 and #2 Testing Protocol



INSTALLATION

For the air piping installation of the equipment in BR#2-1 in took two people a little over one day. The press fit technology used to connect the air piping made the installation easy.

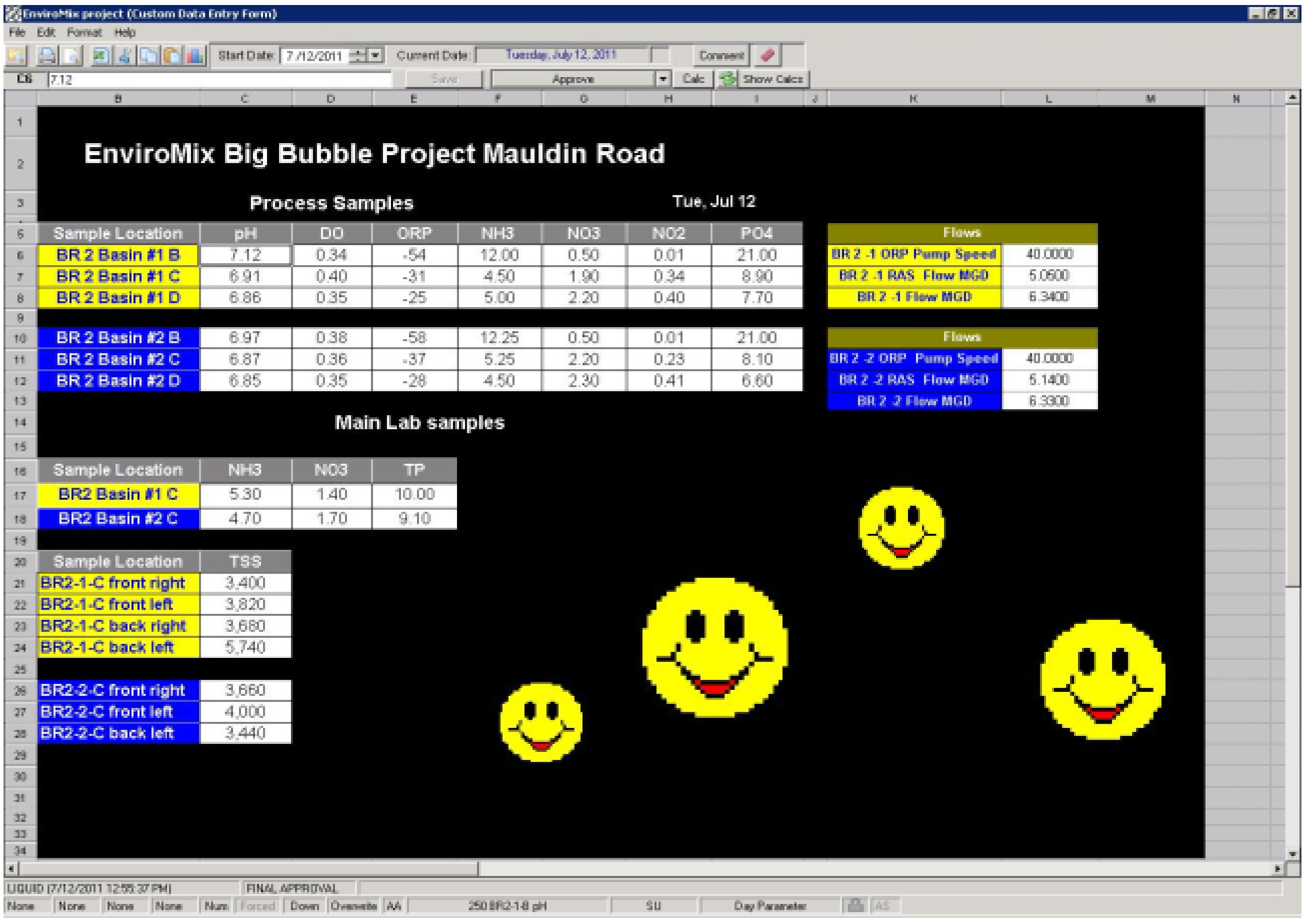


Control Cabinet Installation

Five Horse Power Compressor Utilized for the Project

Daily Sampling of Custom Tracking Sheet in Facility Database

Renewable Water Resources Mauldin Road facility staff collected samples, ran test analyses, and entered test results into the data base for tracking each requested variable. A custom daily entry sheet was created for record keeping of the pilot project for easy comparison to historical BNR performance.



EnviroMix Big Bubble Project Mauldin Road

Process Samples — Tue, Jul 12

Sample Location	pH	DO	ORP	NH3	NO3	NO2	PO4
BR 2 Basin #1 B	7.12	0.34	-54	12.00	0.50	0.01	21.00
BR 2 Basin #1 C	6.91	0.40	-31	4.50	1.90	0.34	8.90
BR 2 Basin #1 D	6.86	0.35	-25	5.00	2.20	0.40	7.70
BR 2 Basin #2 B	6.97	0.38	-58	12.25	0.50	0.01	21.00
BR 2 Basin #2 C	6.87	0.36	-37	5.25	2.20	0.23	8.10
BR 2 Basin #2 D	6.85	0.35	-28	4.50	2.30	0.41	6.60

Flows	
BR 2 -1 ORP Pump Speed	40.0000
BR 2 -1 RAS Flow MGD	5.0600
BR 2 -1 Flow MGD	6.3400

Flows	
BR 2 -2 ORP Pump Speed	40.0000
BR 2 -2 RAS Flow MGD	5.1400
BR 2 -2 Flow MGD	6.3300

Main Lab samples

Sample Location	NH3	NO3	TP
BR2 Basin #1 C	5.30	1.40	10.00
BR2 Basin #2 C	4.70	1.70	9.10

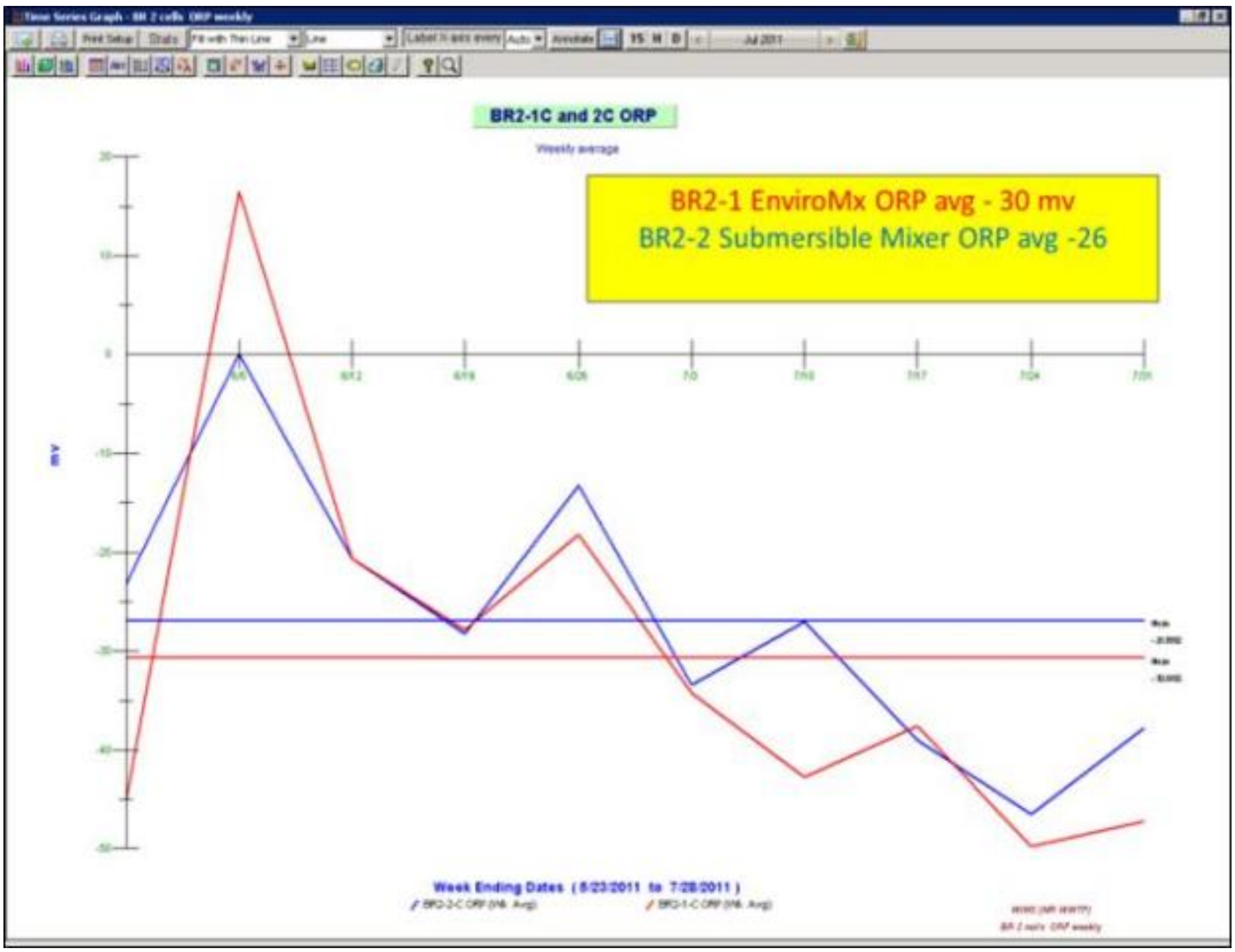
Sample Location	TSS
BR2-1-C front right	3,400
BR2-1-C front left	3,820
BR2-1-C back right	3,680
BR2-1-C back left	5,740
BR2-2-C front right	3,660
BR2-2-C front left	4,000
BR2-2-C back left	3,440

RESULTS

During the pilot testing all effluent BNR compliance parameters from the Enviromix basin were exceptional. The total phosphorus averaged 0.34 mg/l with only biological treatment using no chemical in the sidestream or mainstream treatment processes. The Mauldin Road facility has averaged 0.50 mg/l total phosphorus year to date. The effluent ammonia nitrogen averaged 0.10 mg/l during the trial as compared to a year to date average of 0.19 mg/l.

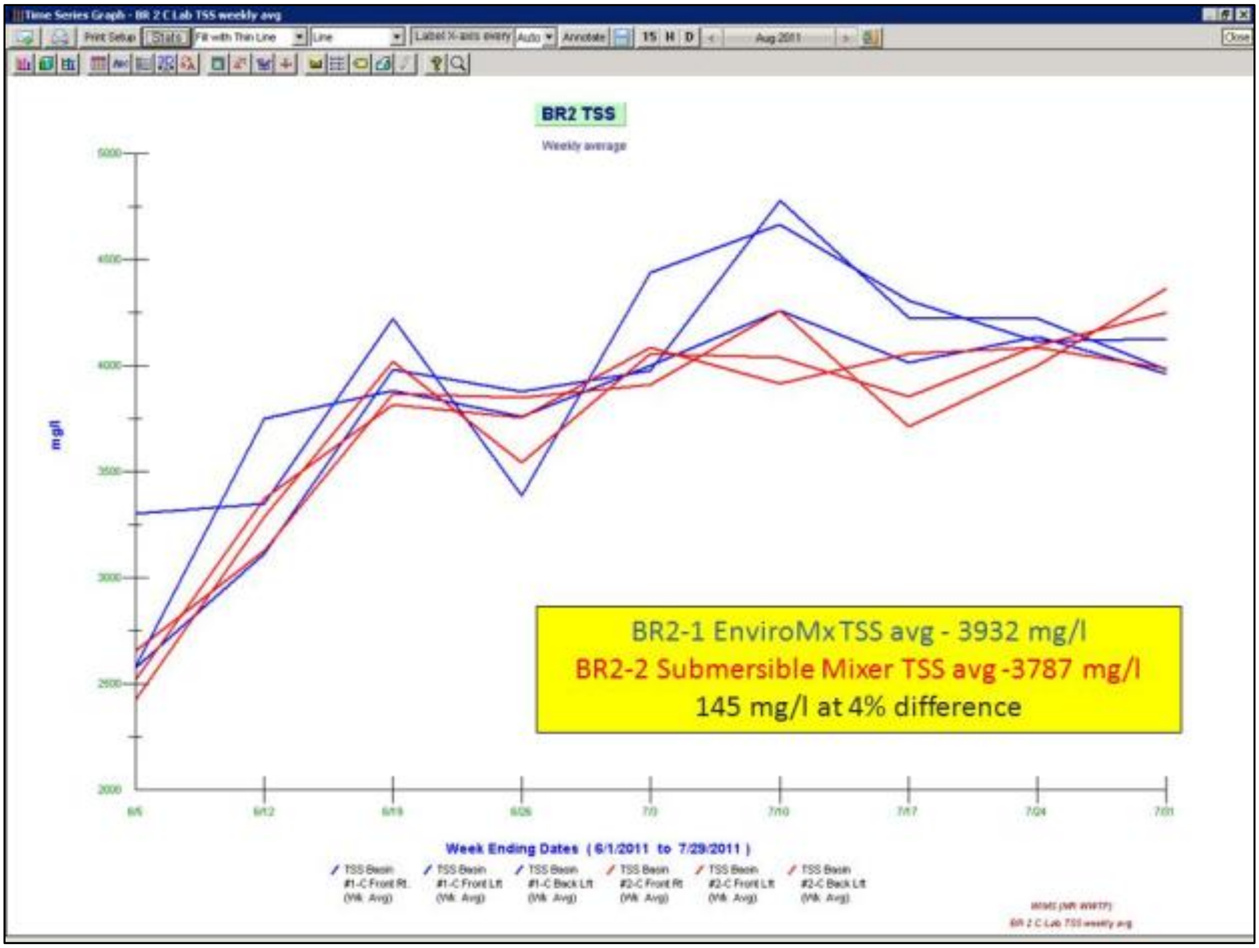
ORP Test Comparisons Biomix BR2-1 verses Propeller Submersible Mixer BR2-2

Both reactors' ORP test analysis tracked very closely. The weekly average test results were actually lower for the Enviromix basin at -30 mv versus -26 mv for the control basin with the submersible mixer. Lower (more negative) ORP numbers indicate a better environment for the denitrification and phosphorus removal processes. These test results indicated that the oxygen transfer rate for large bubble mixing was insignificant toward disrupting the denitrifcation and phosphorus process.



Total Suspended Solids Comparisons Biomix BR2-1 verses Propeller Submersible Mixer BR2-2

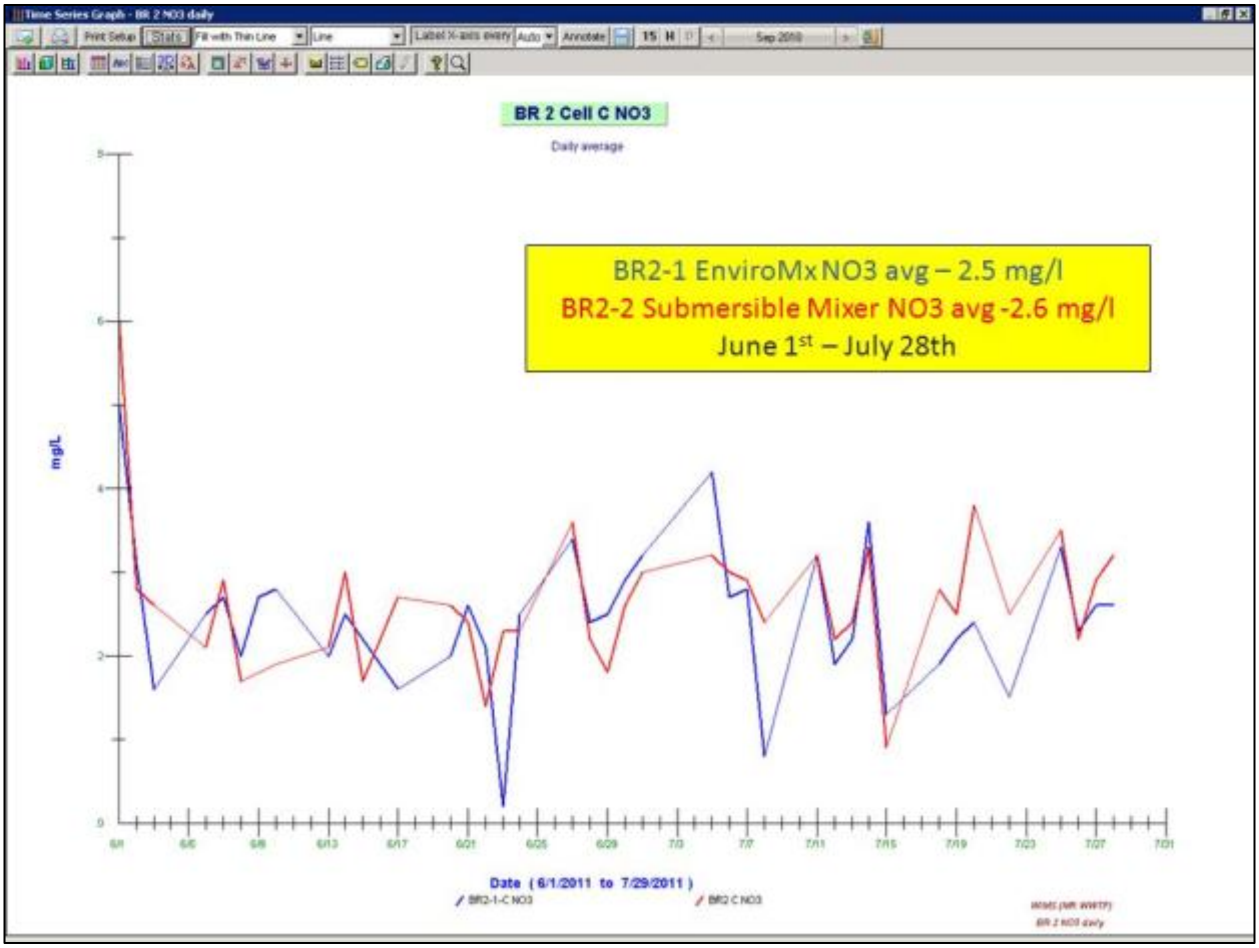
Both reactors total suspend solids test analyses were within 4% difference. The Enviromix basin averaged 3932 mg/l versus 3787 mg/l the control basin with the submersible mixer.



Nitrate Comparisons Biomix BR2-1C verses Propeller Submersible Mixer BR2-2C

Both reactors' nitrate test analyses tracked very closely. The daily average test results were actually lower for the Enviromix basin at 2.5 mg/l versus 2.6 mg/l for the control basin with the submersible mixer. Once again, these test results indicate the oxygen transfer rate for large bubble mixing was insignificant toward disrupting the denitrifcation process.

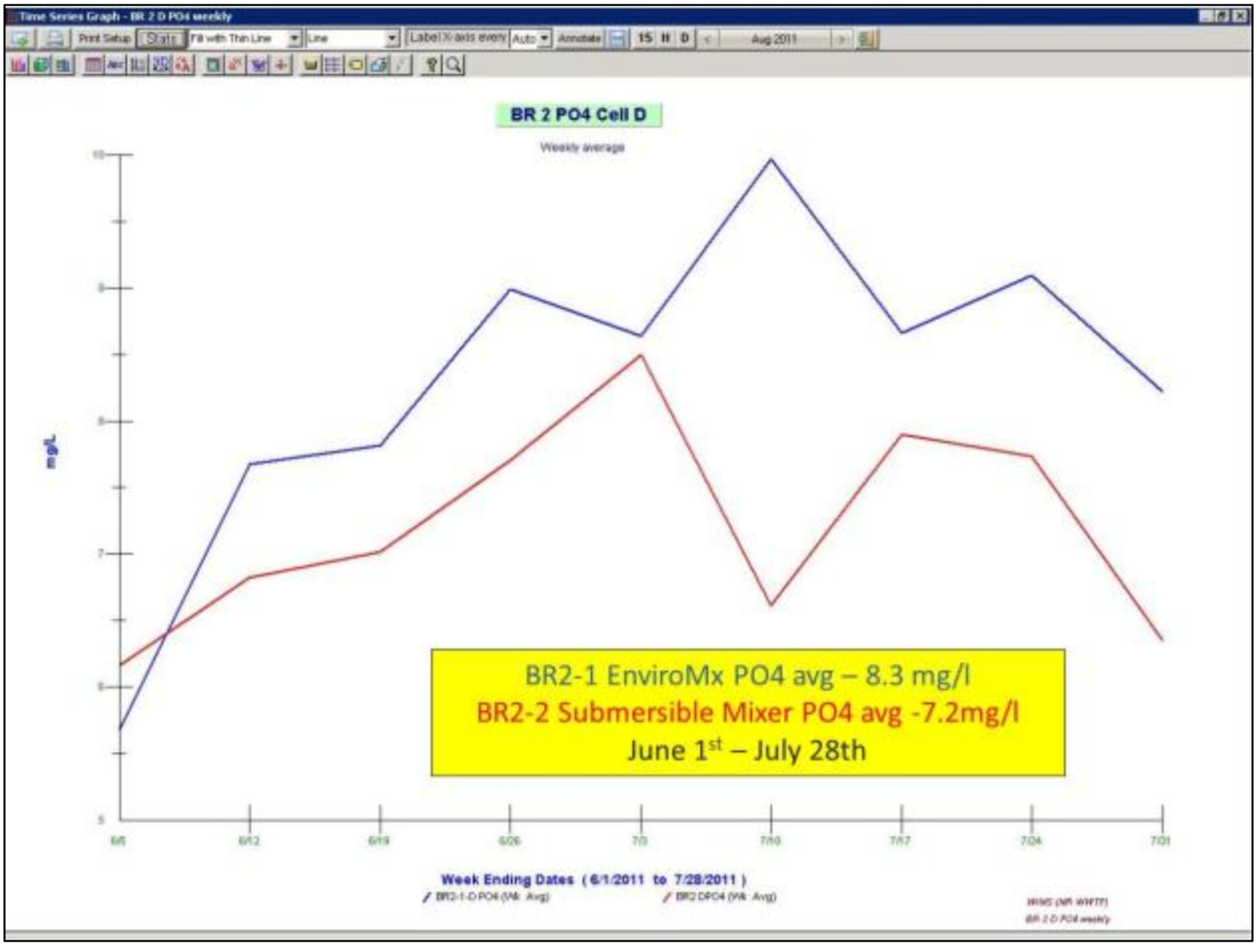
Nitrate Comparisons Biomix BR2-1C verses Propeller Submersible Mixer BR2-2C
Nitrate graph



Phosphorous Comparisons Biomix BR2-1D verses Propeller Submersible Mixer BR2-2D

A major key process indicator in the biological phosphorous removal system is the ability to release and uptake phosphorous. Before the trial, one of the main process concerns was the additional oxygen transfer generated from the Enviromix system effects on the phosphors release. To our pleasant surprise, at the end of the anerobic and anoxic zones the phosphorous release in the Enviromix mixing basin had higher release test results. The daily average phosphorous test results were Enviromix basin at 8.3 mg/l versus 7.2 mg/l for the control basin with the submersible mixer.

Phosphorous Comparisons Biomix BR2-1D verses Propeller Submersible Mixer BR2-2D
Phosphorus Graph



Electrical Usage Comparisons Biomix BR2-1 verses Propeller Submersible Mixer BR2-2

Field tests indicated that the 5 hp compressor used to mix the EniroMx system measured 5 amps versus the 20 amps that the 15 hp mixer required. These monitored results indicate a 75% energy reduction with the Enviromix system.

CONCLUSION

1. The Enviromix system did not affect the BNR system. All key test indicators showed positive results for the two mixing comparisons. The surprise factor was the higher beneficial release tests Phosphorous test results at the end of BR2-1D.

2. The energy demands versus the systems show the potential of a 75% savings with the Enviromix system in the Mauldin Road BR2-1C anoxic zone.