PNRS II System Modifications

Careful observation of PNRS II systems and the results of Sample Event No. 1 and 2 were used to formulate recommendations for adjustments and modifications to the test systems and the GCREC pilot facility. The recommended modifications were outlined in Data Summary Reports No. 1 and 2. The issues to be addressed, modifications that the provider will implement, and expected outcomes are presented below. All recommendations are based on the overriding PNRS II goal of providing functional specifications for modular biofiltration components for passive onsite nitrogen reducing treatment systems.

Septic Tank Effluent (STE) Quality

In PNRS II biofilter performance evaluation, the two highly important input factors are the composition of Septic Tank Effluent (STE) and the system flowrates. It has been verified in Sample Events 1 and 2 that target flow rates have been successfully achieved. Composition of STE at the GCREC site is continuing to provide a challenge. Sample Event No. 1 revealed that GCREC Septic Tank Effluent exhibited low concentrations of key parameters when compared to typical residential STE. Examination of GCREC records indicated unexpectedly high wastewater flowrates. Upon further investigation, it was found that condensate from the facility air conditioning (A/C) system was draining into the wastewater collection system and diluting the GCREC wastewater. The A/C condensate from GCREC air conditioning units was rerouted in mid July and no longer discharges to the wastewater collection system. Following removal of condensate, the influent feed to the PNRS II systems (GCREC STE) was more characteristic of typical STE from single family residences. The nitrogen level in the STE feed was at the upper end of the range for domestic STE and acceptable for PNRS II testing. However, some STE parameters continue to show relatively low values. TSS and COD were somewhat lower than for typical STE, while $CBOD_5$ was atypically low.

The provider will implement the following modifications to address STE quality issues as depicted in Figure 1:

a. A hydraulic modification will be made to the two-chamber PNRS II dosing tank (Tank 1). STE from the GCREC tank enters the first chamber of the PNRS II dosing tank and then flows to the second chamber which contains the PNRS II dosing pumps. To decrease residence time, a new pipe will be installed to direct STE from the GCREC tank directly to the second chamber in the PNRS II dosing tank.
b. Additionally, Pump 1 which withdraws STE from the GCREC septic tank will be relocated upstream of the present withdrawal tank.

The result of these efforts will be to provide influent STE to the PNRS II systems that more reasonably approximates STE characteristics typical of single family residences.

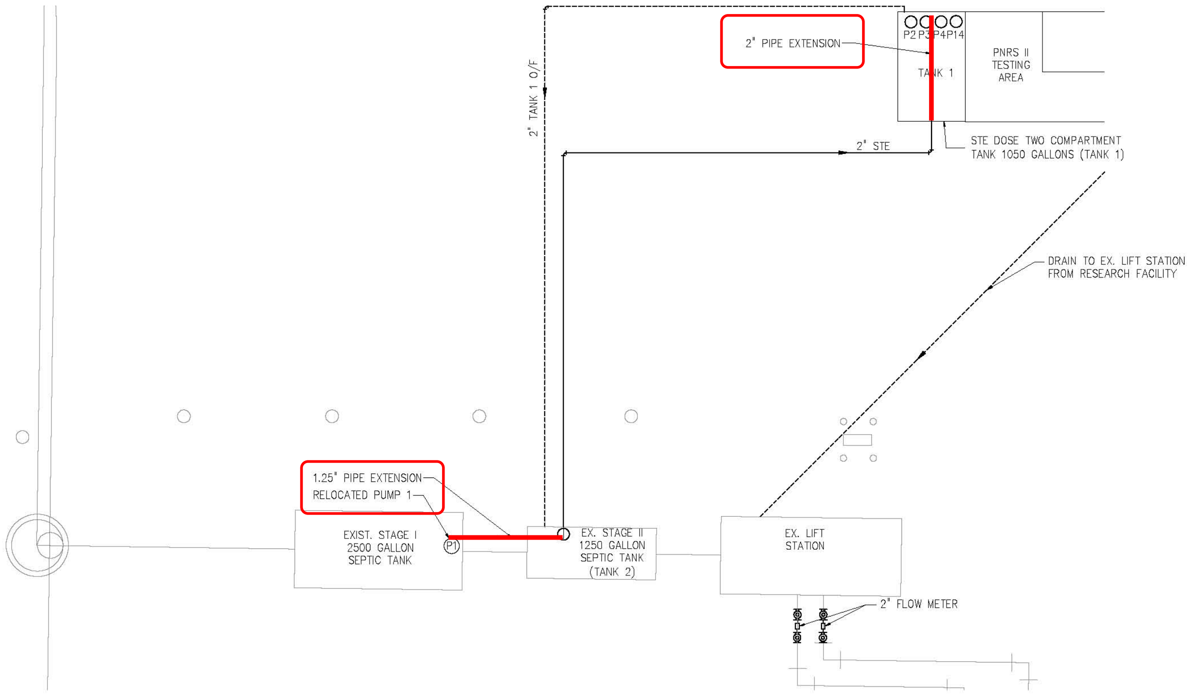

Figure 1: STE Modifications

Polystyrene Biofilter (UNSAT-PS1)

In Sample Event 1, the unsaturated single pass biofilter with polystyrene media (UNSAT-PS1) exhibited limited reduction of organic nitrogen and ammonia as well as a lower effluent dissolved oxygen concentration than the other single pass Stage 1 unsaturated biofilters. Visual observations of the media surface suggested that the STE application system resulted in a majority of dosing in the central area of the horizontal cross section of media surface. Flow monitoring confirmed that water transported rapidly through the polystyrene media following an applied STE dose, unlike the other single pass Stage 1 biofilters. This not unexpected result can be attributed to the much larger media size of polystyrene media and its limited water retention characteristics versus other Stage 1 media. The results of Sample Event 2 also showed unacceptable performance of the polystyrene biofilter as currently configured. Devices to more uniformly distribute the flow were investigated. Upon further evaluation and analyses, however, it was concluded that the properties of polystyrene media would not be compatible with a practical single pass unsaturated biofilter. It was determined that polystyrene media may be more feasibly deployed in a recirculation biofilter configuration. The polystyrene biofilter will therefore be re-configured as a recirculation biofilter.

The provider will implement the following modifications to the polystyrene biofilter system as depicted in Figure 2:

a. Addition of recirculation pump
b. ½" piping from pump to recirculation tank with flowmeter

c. Addition of recirculation tank
d. Addition of pump tank

Effluent from the re-configured polystyrene biofilter will continue to be directed to the coupled Stage 2 biofilter DENIT-LS4. The outcome of these efforts will be to provide evaluation of total nitrogen reduction using a recirculating Stage 1 biofilter with polystyrene media that is directly coupled to a Stage 2 denitrification biofilter.

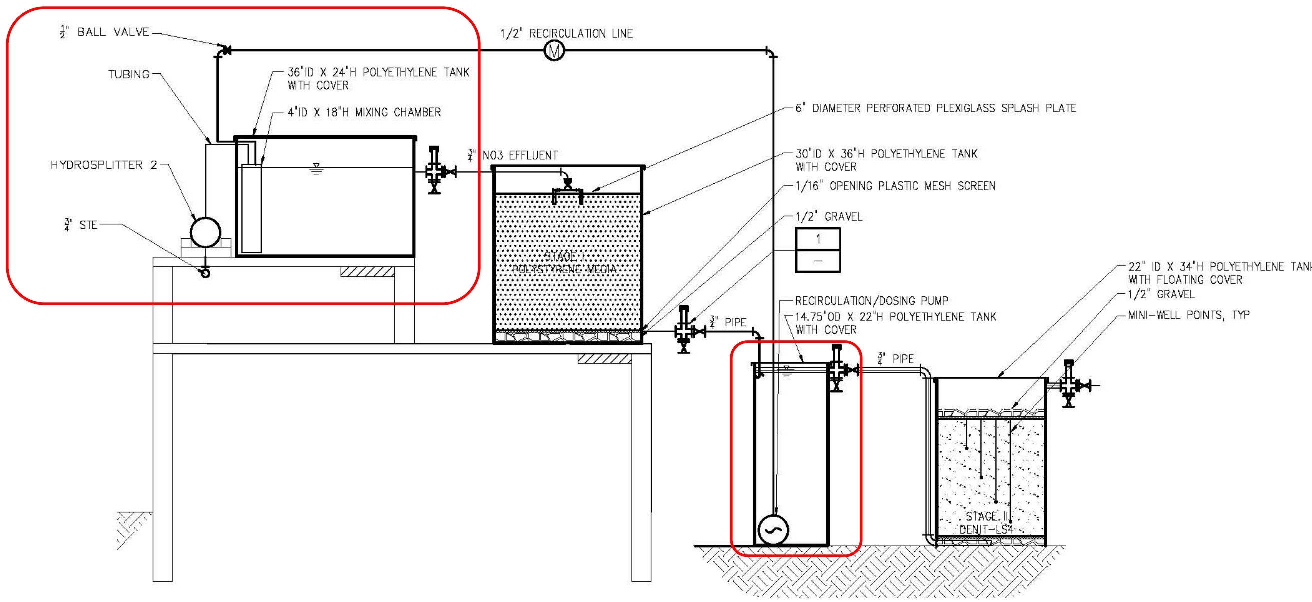

Figure 2: UNSAT-PS1 Modifications

Upflow Denitrification Biofilters (DENIT-LS2, DENIT-LS3)

Two upflow denitrification biofilters with lignocellulosic media showed limited NO_x reduction in Sample Event 2. Possible explanations were inadequate flow distribution across the biofilter area, lack of adequate electron donor release from media, and inhibition due to release of chemical constituents from the media. The project team employed dye tests to visually determine if there was a tendency for effluent to exit the biofilter media in a concentrated form at specific locations. An example is preferential flow along the biofilter walls, which would lead to low water residence times and limited contact with media. If the results indicate that flow distribution is a concern, hydraulic modification could entail reconfiguration of the underflow system beneath the biofilter media to affect more uniform follow distribution. Other options are to examine the lignocellulosic media properties.

A dye test was employed October 19th through October 25th (see Figures 3 through 13) for both DENIT-LS2 and LS3 biofilters. Fluorescent red dye (rhodamine WT) was used at a concentration of 1 mL per gallon (see Figure 3) to visually determine if there is a tendency for effluent to exit the biofilter in specific locations. At 8:00 am on October 19th, a solution of 30 mL red dye in 1 liter of distilled water was added in the sample port

Figure 3

upstream of the two biofilters. During monitoring of the biofilters, DENIT-LS-2 exhibited short-circuiting along the walls at 3:30 pm on October 19th (see Figure 5). DENIT-LS3 did not exhibit short-circuiting and began showing dye in the effluent fairly uniformly at approximately 10:00 pm on October 19th.

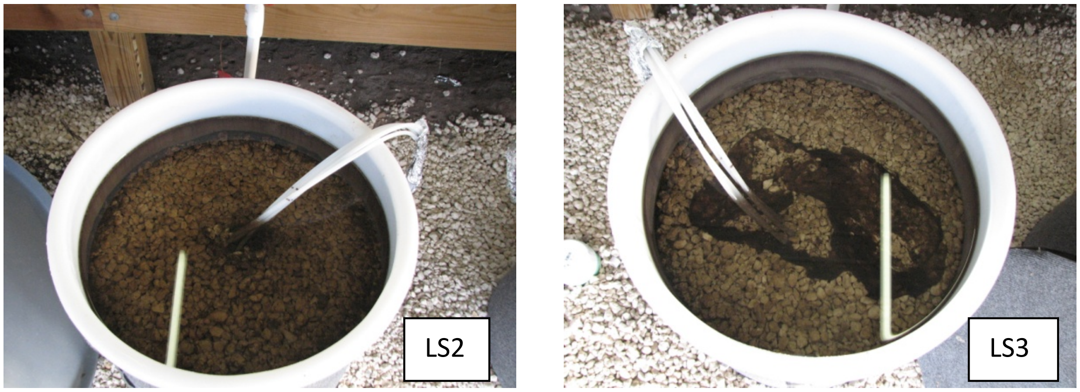

Figure 4: UNSAT-LS2 and LS3 at 8:22 am, October 19th

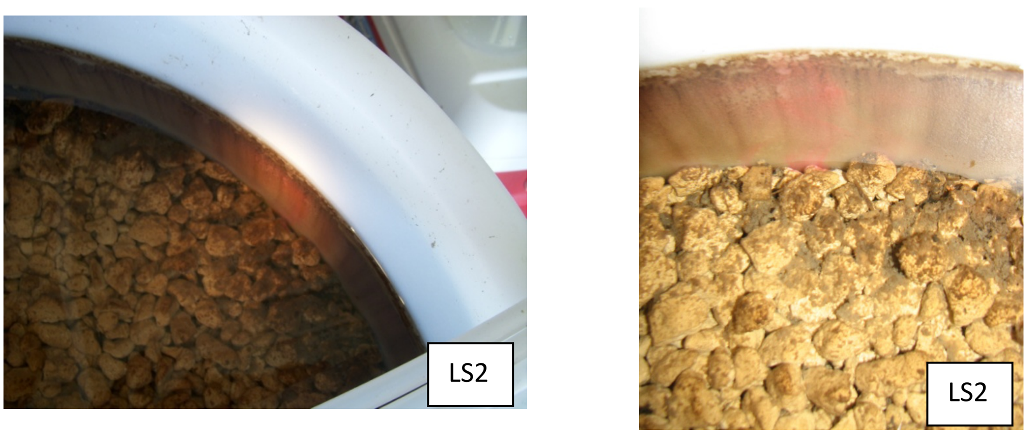

Figure 5: LS2 at 3:56 pm, October 19th

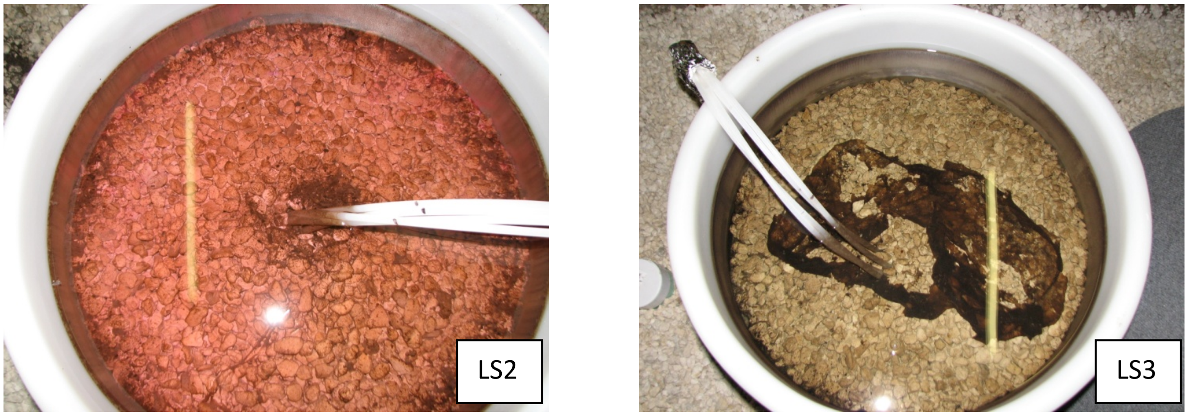

Figure 6: LS2 and LS3 at 7:26 pm, October 19th

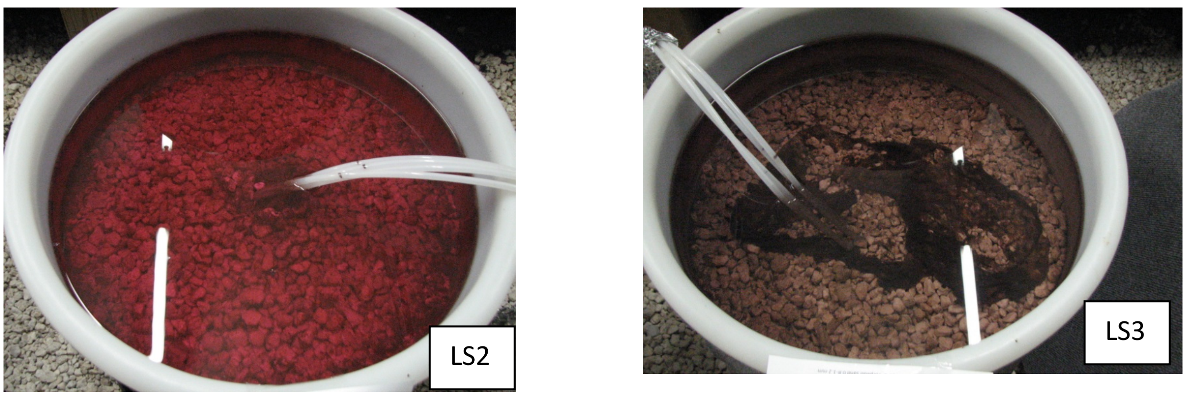

Figure 7: LS2 and LS3 at 12:00 am, October 20th

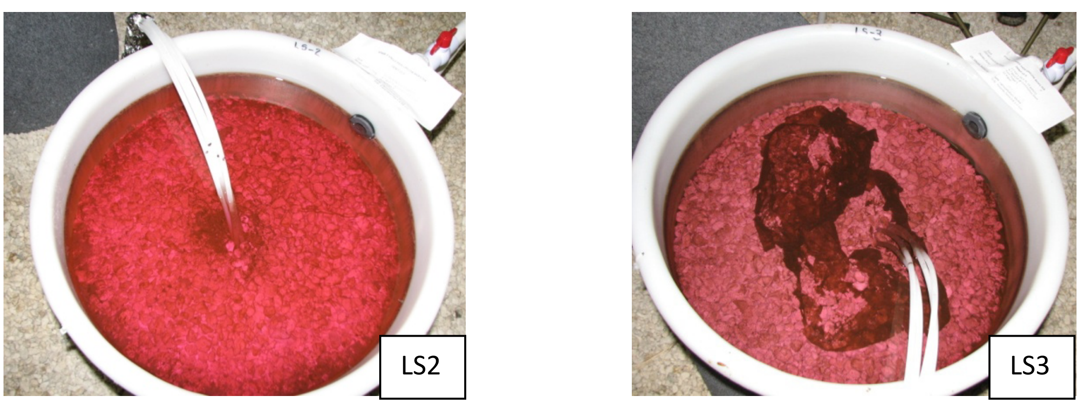

Figure 8: LS2 and LS3 at 7:00 am, October 20th

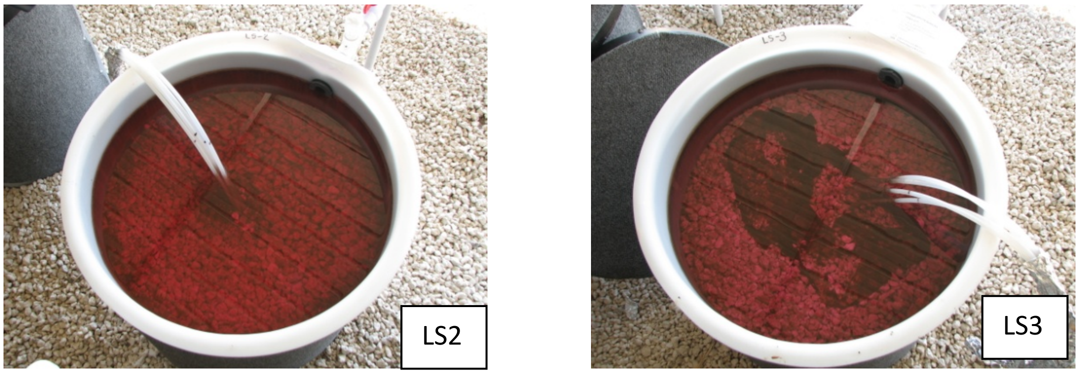

Figure 9: LS2 and LS3 at 12:00 pm, October 20th

Figure 10: LS2 and LS3 effluent at 12:00 pm, October 20th, relative to influent dye solution on right

Figure 11: LS2 and LS3 effluent at 9:00 am, October 21st

Figure 12: LS2 and LS3 effluent at 9:27 am, October 22nd

Figure 13: LS2 and LS3 effluent at 8:39 am, October 25th

The provider will implement the following modifications as depicted in Figure 14:

a. Replace media within DENIT-LS2 biofilter
    i. Media mix = 25% Lignocellulosic, 75% Expanded Clay >1.13 mm
b. Glue expanded clay fines to sides of walls to prevent wall creep
c. Add perforated discharge pipe to bottom inlet along entire length of bottom of tank

The outcome of these modifications will be to achieve more efficient NO_x reduction in the DENIT-LS2 upflow lignocellulosic biofilter.

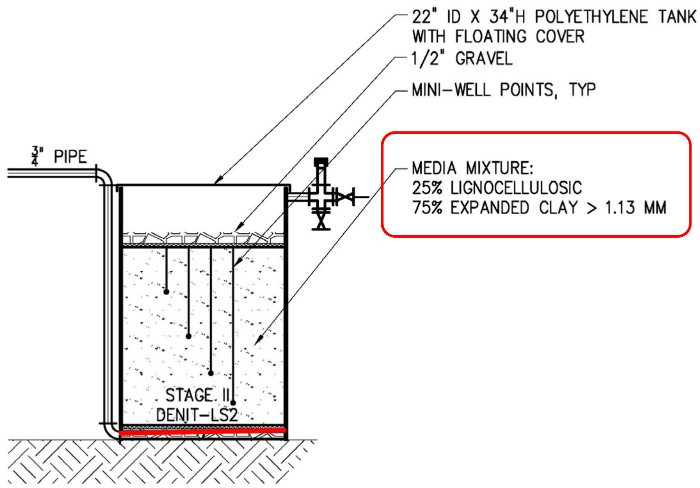

Figure 14: DENIT-LS2 Biofilter Modifications

Replace Alkalinity Supplement (DENIT-SU4, DENIT-SU2)

Sodium sesquicarbonate was supplied as alkalinity supplement in one upflow denitrification biofilter (DENIT-SU4) and one horizontal denitrification biofilter (DENIT-SU2). Sodium sesquicarbonate has exhibited a relatively rapid dissolution rate and possibly reprecipitation in preliminary testing. Sodium sesquicarbonate dissolution rates are too rapid to enable this media to be applied in passive PNRS II systems that are intended for long term deployment. Therefore, limestone will be tested as a replacement for sodium sesquicarbonate in DENIT-SU4 and DENIT-SU2. Additionally, the sulfur content in the biofilters will be reduced to 30%.

The provider will implement the following modifications as depicted in Figures 15 and 16:

a. Replace media within DENIT-SU4 upflow biofilter (see Figure 15)
    i. Media mix: 10% limestone, 30% elemental sulfur, 60% Expanded Clay >1.13 mm
b. Replace media within DENIT-SU2 horizontal biofilter (see Figure 16)
    i. Media mix: 10% limestone, 30% elemental sulfur, 60% Expanded Clay >1.13 mm

The outcome of these modifications will be evaluation of DENIT-SU4 and DENIT-SU-2 denitrification biofilters that are suitable for long term on-site deployment.

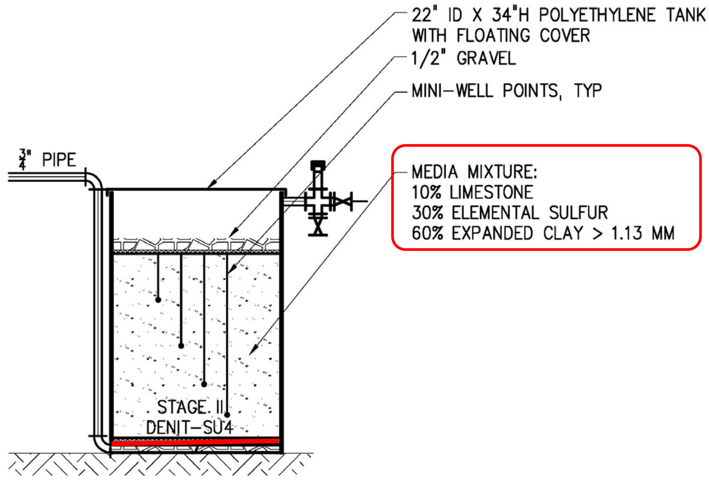

Figure 15: DENIT-SU4 Upflow Biofilter Modifications

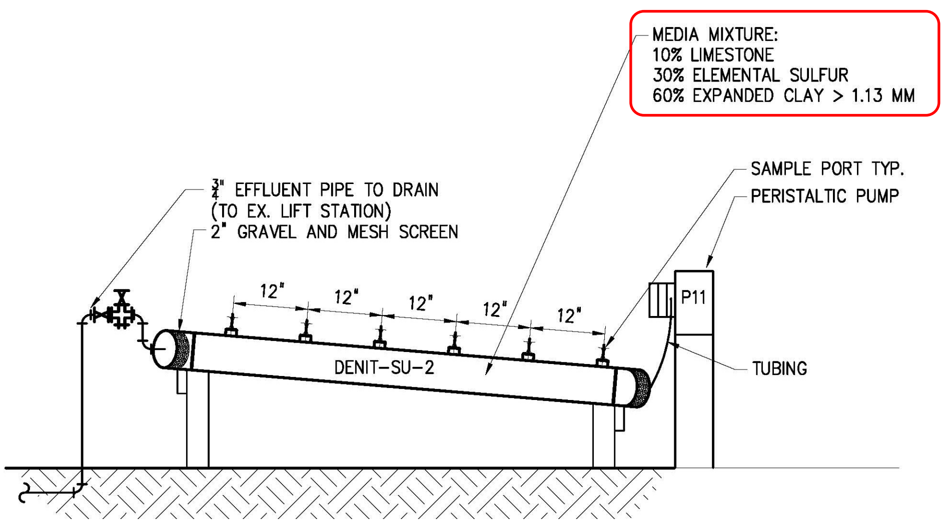

Figure 16: DENIT-SU2 Horizontal Biofilter Modifications

In-Situ Simulator Effluent Sulfate Concentration (UNSAT-IS3, UNSAT-IS4)

The In-Situ Simulators contain vertically stacked media layers intended to affect enhanced simultaneous nitrification and denitrification in a single pass vertical downflow system. The concept of employing a vertically stacked media configuration is to accomplish nitrification and organics oxidation in an upper unsaturated media layer, which then supplies nitrified water to one or more underlying layers containing denitrification media. The enhancement of nitrification/denitrification is due to the inclusion of electron donor (i.e. lignocellulosic material and/or elemental sulfur) in the unsaturated media in the lower layer. The In-Situ Simulators deployed a mixed media of expanded clay, lignocellulosic material and elemental sulfur in an unsaturated condition in the lower layer. It was anticipated that placement of sulfur in an unsaturated location may enable oxygen ingress and greater sulfur oxidation than if sulfur were maintained in a saturated condition. However, the extent to which this would occur was not known.

In Sample Event 1, UNSAT-IS1 and UNSAT-IS2 both produced very low NH_3-N, NO_x-N and organic nitrogen concentrations, but sulfate levels were high. In an attempt to decrease sulfur oxidation in the lower layer, the discharge pipe of both In-Situ Simulators was modified on July 20th to saturate the lower 12" of the media bed. The denitrification media was fully encompassed within the saturated layer. The results of Sample Event 2 showed that effluent sulfate levels decreased. However, the modification resulted in reduced nitrification and an increase of ammonia to 20 mg/L in UNSAT-IS1 that receives STE.

The overall PNRS II objective is to incorporate PNRS II results into the design of full scale testing at homeowner sites in FOSNRS Task B, and the In-situ simulator results are critical for Task B activities. Due to the need to develop functional specifications for vertically stacked single pass biofiltration systems, two additional vertically stacked biofilter systems will be constructed to evaluate alternative media designs. The revised media designs will provide enhanced simultaneous nitrification/denitrification in unsaturated media while minimizing sulfate in the effluent. Two six-inch diameter biofilters will be constructed and will be dosed at the same frequency (once per 4 hours) and average hydraulic loading rate (0.8 gal/ft^2-day) as the currently deployed UNSAT-IS1 and UNSAT-IS2. One of the new biofilters will receive STE and the second will receive nitrified effluent. UNSAT-IS3 will receive STE and UNSAT-IS4 will receive nitrified effluent. The media configuration of UNSAT-IS3 from top to bottom will be: 3 in. coarse sand, 9 in. filter sand, 10 in. mixed lignocellulosic media and expanded clay, 2 in. pea gravel, 3 in. elemental sulfur, and 2 in. gravel as underdrain. The media configuration of UNSAT-IS4 from top to bottom will be: 12 in. filter sand, 12 in. mixed lignocellulosic media and expanded clay, 2 in. pea gravel, 3 in. elemental sulfur, and 2 in. gravel as underdrain. STE will be applied by peristaltic pump to a drip plate at the biofilter center point. Effluent will exit the underdrain from a bottom port located at centerline. STE and nitrified STE supplied to UNSAT-IS3 and UNSAT-IS4 will be the same as that supplied to UNSAT-IS1 and UNSAT-IS2. The effluent line will be directed in an upward direction external to the biofilter column and will be used to control the saturation level within the biofilter media. The saturation levels in UNSAT-IS3 and UNSAT-IS4 will be maintained within and slightly below the gravel layer that underlies the lignocellulosic/expanded clay mixture to maintain sulfur in a completely saturated condition. A shutoff valve will be placed just below the effluent port to enable maintenance of effluent tubing while not draining the biofilter. The effluent line will contain a sampling port for measurement of final effluent. Another sampling location will be in the gravel layer below the lignocellulosic/expanded clay media and above the sulfur media. This port will pass through the column sidewall and extend radially several inches into the media. Monitoring will be conducted of system effluent as well as intermediate nitrogen species within the biofilter below the unsaturated expanded clay and lignocellulosic layer and above the saturated sulfur layer. The effectiveness of the unsaturated system with only lignocellulosic electron donor and the added effect of underlying sulfur will be delineated.

The provider will implement the following modifications as depicted in Figure 17:

a. Construct 6" Diameter IS3 biofilter
    i. Media used = coarse sand, fine sand, expanded clay, lignocellulosic, elemental sulfur, pea gravel and gravel
b. Construct 6" Diameter IS4 biofilter
    i. Media used = fine sand, expanded clay, lignocellulosic, elemental sulfur, pea gravel and gravel
c. Addition of peristaltic pump

The outcome of these efforts will be specification of the optimal media configuration to be employed in the In-Situ (mini-mound) systems, which will then be constructed at GCREC. In-Situ Simulator results from PNRS II are one critical path in the overall PNRS II project. Modifications to the existing In-situ simulators and deployment of additional vertically stacked systems will provide the functional specifications required in order to proceed with construction of the In-Situ mini-mounds in a timely manner. Effluents from these systems may also be used in Additives Rule testing.

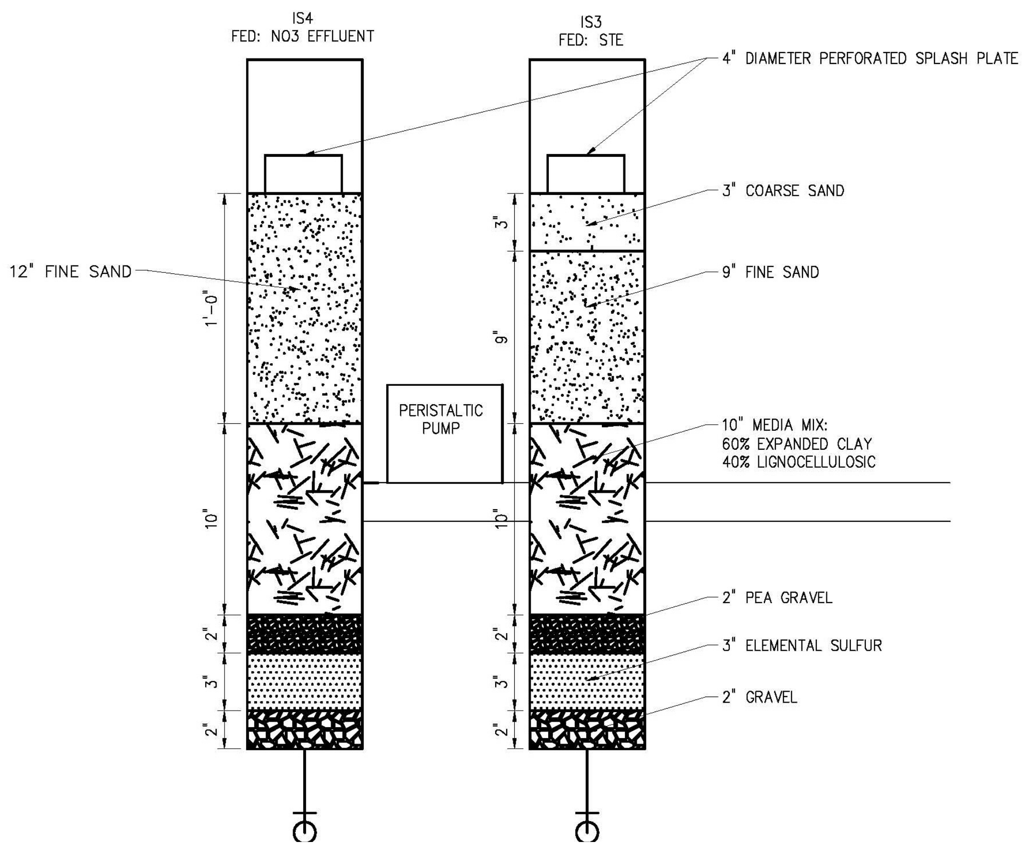

Figure 17: IS3 and IS4 Columns