



**TOWN OF SOUTHAMPTON**  
Department of Community Preservation  
24 W Montauk Hwy, Hampton Bays, NY 11946  
Ph: 631-287-5720 Fx: 631-728-1920  
[WQIPP@southamptontownny.gov](mailto:WQIPP@southamptontownny.gov)

Entity: **Verified Water**  
Project Name: **Infrastructure Management**

**2024**

## **Automated Remote Monitoring System for Managing Decentralized Wastewater Treatment Infrastructure**



**Stonybrook Nitrogen Sensor  
3/15/24**

**Application for Southampton Town CPF WQIP Grant**



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**COMMUNITY PRESERVATION FUND (CPF)  
 WATER QUALITY IMPROVEMENT PROGRAM  
 PROPOSAL SUMMARY**

Project Applicant: Verified Water, Inc.  
 Project Title: Automated Decentralized Wastewater Infrastructure Management  
 Project Manager Name: Robert Dunbar  
 Entity Anticipating Grant and Funding: Verified Water, Inc.

Name	Robert Dunbar
Title	President
Organization	Verified Water, Inc.
Address	27 B Foster Lane, Westhampton Beach, NY 11078
Phone	617-448-0440
Email	bud.dunbar@verified-water.com

Property owner (if different from Project manager organization):

Name	8 properties to be selected and preapproved by the CPF WQAC and Town of Southampton
Affiliation	
Organization	
Address	subject to prequalification by the Southampton CPF Water Quality Advisory Committee (WQAC)
Phone	
Email	

Project Address: TBD \*\*\* SCTM #(S) TBD \*\*\*

Type of Project (Check all that apply):

- Reduction     Remediation     Restoration

Project Summary: (Provide a brief narrative description of proposed WQIPP project)

To date, all monitoring of Innovative/Alternative Onsite Wastewater Treatment Systems ( "OWTSs" ) in Southampton has been done by sending a technician out to the site to collect monthly grab samples. Suffolk County intends to install over 200,000 OWTS 's at an estimated cost over \$5 billion. Just monitoring those systems for operations and maintenance will require more technicians and lab testing than we can possibly muster. Manual sampling is not practical for managing this type of decentralized infrastructure in thousands of households. The County must automate . This demonstration could suggest a more practical technology for automating the monitoring and management of decentralized wastewater treatment infrastructure and provide apples to apples comparison of the actual performance of the leading products approved for Article 19 implementation. We know there are deficiencies and failures in some of these OWTS's, but we dont have the right kind of data (real time vs monthly or semi annual) to understand that deficiencies, quantify the environmental damage, or how to manage failures. We dont eevb know the correct assumption for influent concentration.

The Stony Brook Nitrogen Sensor (the " Sensor " ) autonomously measures nitrate and ammonium in OWTS 's and reports the data to a website, 24/7/365. The Sensor has been exclusively licensed to Verified Water, Inc. These Sensors have been verified to be accurate and precise by the USEPA using International Organization for Standardization (ISO) protocol testing. The Sensor reports real time effluent ammonium and nitrate/nitrite concentrations. These measurements provide real time insight into OWTS processes. Changes in levels of ammonium and nitrate reveal the dynamics of nitrification and denitrification, respectively, which are critical indicators of performance and rate limiting process steps. The insight afforded by these Sensors has revealed the true performance of commercial I/A OWTS, often identifying failed OWTSs that monthly sampling miss. We plan to install eight Sensors in various strategically selected sites, transmit the data wirelessly over the cellular network, and report the data from those sites in real time, on-line, through a web browser for one year. The sites will be recommended by Verified Water and consented by the Town ' s CPF WQAC or its assigns to independently evaluate the true performance of the leading OWTS 's, on which the Town intends to spend hundreds of millions of dollars.



\*If additional information is needed to describe the project; a project narrative can accompany the application. Please limit the narrative to approximately 3 pages of project description, provide a summary of water quality benefits/objectives of approximately 2 pages and provide a cost estimate of approximately 2 to 4 pages with supporting estimates. Any additional materials should be focused specifically on the proposed project with references to other studies that are pertinent\*

**1. PROJECT TYPE (check all that apply)**

Must meet at least one of the definitions of "Water Quality Improvement Project" per State Law Chapter 551 cited above. Check all that apply. **Note: Monitoring costs are only potentially eligible for CPF funding within Aquatic habitat restoration projects.**

- Wastewater Treatment Improvement Project
- Non-point source abatement and control
- Aquatic habitat restoration
- Pollution prevention
- Operation of Peconic Bay National Estuary Program (Grant Match)

**2. PRIORITY AREA(S) (check all that apply)**

Priority areas are defined in the [Water Quality Improvement Project Plan \(WQIPP\)](#).

- 303(d) Impaired
- Peconic Estuary Program - [PEP map](#)
- High
- Medium
- Outside High and Medium priority areas\*

\*If Outside High and Medium priority areas, explain how the project is relevant to WQIPP goals.

\*\*\* Project Address - This project will demonstrate equipment that could enable better management and compliance of hundreds of OWTS's contemplated by the Town's decentralized infrastructure plans. The specific sites will be selected with input from the Town CPF staff input, the CPF WQAC, and Verified Water. The eligibility and priority area of those sites has already been established because there are I/A OWTS's operating on them. Verified Water will satisfy all further site location requirements and preferences of the WQIPP (such as priority areas, SCTM #'s, and owners' permission for access to the site).

**3. PROJECT DESCRIPTION**

3a. Existing conditions of applicable groundwater/sub-watershed/waterbody and most recent and relevant data available (provide sources)

The eight sights to be selected will all be previously qualified and near water bodies that have been documented and characterized in the Suffolk County Subwatershed Plan, by Dr Chris Gobler's lab, and elsewhere typically including harmful algae blooms, anoxia, and loss of ecosystem diversity.

3b. How the proposed solution addresses the issue in the context of Reduction, Remediation and/or Restoration as per the CPF Water Quality Project Plan. Note all remediation and restoration projects must assure that reduction measures are also addressed.

The Town of Southampton (the "Town") will be relying on new decentralized I/A OWTS technology to replace conventional septic systems in thousands of households over the next 20 years at a typical cost of \$30,000/house. The Town, and many other jurisdictions in the US will invest hundreds of millions of dollars in these OWTS's. As we build thousands of mini-wastewater treatment plants, managing them as the essential infrastructure they are, becomes a bigger and bigger problem. The current method for measuring their performance involves sending a technician out to the site, taking a grab sample, bringing it to a commercial lab for storage, analysis, and reporting. This project will demonstrate new and more cost-effective technology to help us manage this forthcoming investment in OWTS's.

First, this project will show how this technology will analyze the final effluent from OWTS's, revealing their true performance and, in some cases revealing ways to make them more efficient and better performing. By measuring ammonium, we can tell how well a system is nitrifying. By measuring nitrate, we can tell how well it is



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denitrifying. If a system is nitrifying and denitrifying efficiently, it is highly likely that the system is functioning properly. For example, Figure D below shows how it was used to diagnose a system that was not nitrifying properly.

Second, we simply don't have the technicians, or lab facilities, or budget to support tens of thousands of site visits associated with performance testing, maintenance, and compliance of thousands of mini wastewater treatment plants we plan to install. Unlike conventional centralized wastewater treatment plants, that have dedicated full time operations staff, OWTS's must be monitored frequently. It may not be enough to check on them once or twice a year. OWTS functionality is strongly affected by how they are loaded which for a household varies by day and night, by weekend and weekday water use, and by events such as vacations, parties, and guests. Requisite monthly manual sampling is very expensive. It costs \$3-500/sample. A new vendor must do monthly testing for three years on 20 systems. Following Article 19 requirements with the current method of monitoring an OWTS would cost over \$10,000 per site, just in sampling and lab work to test compliance, for a system at the Provisional, Pilot, or Experimental stage. This discourages some of the best vendors from marketing in Suffolk County. In short, this project will demonstrate new technology to characterize system performance and help manage this huge investment in OWTS's.

Third, the Sensors will also provide apples to apples independent third-party comparisons of the performance of several leading OWTS's. They are not subject to human error in sampling, scheduling, analyzing, and transporting.

Finally, this project will show how effective or ineffective current monitoring protocols are. It will detect high frequency trends and events that do not show up in less frequent data. This will show whether existing performance testing protocols are sufficient for managing the forthcoming huge investment in decentralized treatment.

3c. Describe the proposed technology and its demonstrated efficacy in similar settings. May include published data

Data on the efficacy of the Sensor is described in a Verification Statement published by VerifyGlobal for the USEPA. The Sensor was thoroughly tested and verified (see the ISO 14034 Environmental Test Verification Statement in Attachment B) and performed exceptionally well. The Sensor was extremely **reliable**. It automatically made 449 measurements at prescribed times and dates over six months in six types of wastewater without missing a single sample. 124 time-stamped grab samples were taken to the Barnstable County commercial laboratory for independent standard method "wet lab" analyses. Compared to the commercial lab data, the data from the sensor was **accurate** (average % Recovery was 98.79% for ammonium and 93.46% for Nitrate/Nitrite) and **precise** (average Relative Standard Deviation was 3.27% for ammonium and 2.35% for Nitrate/Nitrite). **Correlation** ( $R^2$ ) with the lab data was .997 for ammonium and .986 for Nitrate/Nitrite. This level of reliability, accuracy, precision, and correlation met all performance claims set by an independent technical panel of industry experts in the ISO 14034 Environmental Test Verification and "exceeded all expectations" (quote by Maggie Theroux, USEPA).

The technology is a nitrogen Sensor that is specifically designed to monitor OWTS's. It is fully automated and sends a very accurate signal using cellular telemetry to a cloud-based server from which it is accessible through a user interface in a standard web browser or smart phone. It gets buried in the ground next to the OWTS, and at prescribed dates and times, automatically pumps sample from the final effluent of the OWTS through a series of steps that separate the ammonium and nitrate/nitrite from the sample and measure each of them.

There are other commercial sensors that measure ammonium and nitrate but in order to measure both, one needs to buy two different sensors plus the control system, the telemetry systems, and the data logging systems. It typically costs well over \$15-\$20,000 for that equipment. But that equipment is designed for municipal wastewater treatment plants where there are full time operators who can clean and recalibrate the sensor every few days. That level of preventative maintenance is not feasible in thousands of residential OWTSs. This new technology is self-calibrating and self-cleaning and has been demonstrated to run for months without human intervention. It costs less than half of what commercial sensors cost. Below are some pictures of the Sensor.



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Figure A

Figure A: The Sensor (left) showing the copper sample tubes that will be connected to a small on-board reservoir that holds the sample which is periodically pumped out of the final effluent basin of the OWTS. The small white tubes will be attached to reservoirs of reagents that are used to separate the ammonium and nitrate. All waste is retained and appropriately disposed of.

Figure B: The Sensor is buried in a watertight septic system riser which maintains a constant temperature above freezing and keeps water from sprinklers and rain out of the system. In the riser are the reservoirs of reagents (clear plastic), the telemetry subsystem (grey), and the stilling well, a small reservoir that holds the sample (white). Although the copper has tarnished, you can see a 1/2" OD tube going into the white stilling well. That tube is connected to the primary sample pump which is a submersible pump that is installed in the final effluent basin of the OWTS. Wastewater is pumped up into the stilling well and then flows through an open channel back into the basin. The other two 1/4" copper tubes coming out of the stilling well bring the sample into and back out of the Sensor. There is a coarse filter upstream of the submersible pump and finer filters upstream of the two smaller copper pipes. This sampling system is automated by the control board in the sensor. After the sample is mixed with reagent, the waste is captured in two of the plastic reagent bags.



Figure B  
Sensor with lid removed



Figure C  
Sensor with lid shut



**Figure D**



Figure D: Shows a screen shot of the user interface in a standard web browser (Chrome). In this case, the ammonium (shown in red) stopped nitrifying from early February to June. The spikes are self-calibrations by the Sensor which takes a sample of known concentration from a small container that is also stored in the riser. Not shown in this picture is the menu of other functions in the user interface, such as the Maintenance record, the Status of the Sensor, User information and authorization, and Settings.

3d. How the project supports Town of Southampton, Suffolk County, NYSDEC, Long Island Nitrogen Action Plan (LINAP) or other adopted goals/policies (provide references with page numbers)

The Town of Southampton intends to use its CPF resources to systematically approach the nitrogen problem and other pollutants of concern in high priority areas by concentrating first on Reduction tactics (upgrading of systems to require treatment before disposal into the ground).

This proposal would demonstrate new technology for measuring the performance of OWTSS. It measures the relevant species of nitrogen which together show how well a treatment system works. With this tool, responsible management entities like the Town of Southampton can:

- tell which technologies are most effective,
- know whether individual systems are working properly, and if not, why not,
- send alarms when a system begins to fail,



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- help vendors design better systems,
- reduce the number of site visits for maintenance, and
- utilize the maintenance and performance testing resources better.

Its real time data shows daily, weekly, seasonal variations in performance that are not available in monthly or semi-annual sampling protocols. These instruments are very precise, meaning any two Sensors will produce the same values when measuring the same wastewater. They also periodically measure a standard sample and then self-calibrate for data quality control. This provides reliable third party, data quality controlled, information by which treatment systems can be compared, evaluated and managed. None of the money from this grant will be used for owners' salaries or compensation, other than that of our field technician. The money from this project will be used in engineering to redesign the product to be more robust, compact, and easy to install and for manufacturability for commercial release.

3e. Review the following statements and indicate whether they are applicable to your project. For all "Yes" responses, please indicate how your project addresses the requirements indicated.

YES	N/A	
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<b>If stormwater system or drainage is proposed:</b> The project must indicate compliance with the New York State Stormwater Design Manual (2015 and as updated).
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<b>If project is related to farmland:</b> Describe any Agricultural Stewardship Plan or other long term strategy for Nitrogen abatement.
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<b>If the project is for habitat restoration:</b> The narrative must address how underlying causes are being ameliorated and expected outcomes for local species populations or other ecological considerations are given.
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<b>If project is a Sewage Treatment Plant (STP) or cluster treatment system:</b> Fund allocation request is based on cost for reduction of pre-existing conditions and not for purpose of accommodating new density (describe pre-existing density and associated flow (gallons per day) and total projected nitrogen reduction in narrative). Include detailed information on how many homes the system would treat as well as potential for formation of Sewer District, if required by Suffolk County Health Department or Town Law.
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<b>If the project is requesting grant match:</b> Include information related to funding program source and purpose of application and any relevant items on this checklist. Note: A Town Board resolution will be required in order to encumber matching funds for grant applications.

**4. WATER QUALITY BENEFIT**

4a. Identify Nitrogen, Pathogen or Pollutant of Concern Existing Condition & Target Reduction.

This Project will verify and more fully document Nitrogen reduction by OWTSs. The systems we are measuring knock Nitrogen (Ammonium and Nitrate/Nitrite) down, from Total Nitrogen of 65 mg-N/L to a target of 10-20 mg-N/L. Ammonium determines how well an OWTS is breaking down urine and nitrifying (converting ammonium to Nitrate). Nitrate plus Nitrite determines how well an OWTS is denitrifying (converting the Nitrate to Nitrogen gas which gets released to the atmosphere). Together, these reactions are usually the rate limiting reactions in the treatment of residential wastewater. If the nitrogen is gone, chances are BOD will be broken down and TSS will be separated.

4b. Describe plans for collecting and reporting water quality improvement over time.

This project is demonstrating a new technology for automating the collecting and reporting of key water quality parameters and their improvement over time. As noted above, this community is planning to install thousands of OWTS's and we must find a way to automate the monitoring and reporting of water quality parameters at these sites.

The Sensor will produce real time data transmitted over the cellular network to a MySQL database on a Cloud-based server from which it can be accessed through a custom user interface from any computer or smart phone,



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any time – 24/7. The data can be downloaded to Excel and manipulated from there. An example of how the user interface presents the data is shown in Figure D.

4c. Indicate the useful life of the proposed technology (must meet or exceed 5 years as required by the law).

The Sensor is designed to operate for approximately 20,000 cycles. We plan to sample these systems twice a day or about 730 cycles per year. So, the design useful life for a Sensor is over 20 years. In practice, Verified Water (see below) will refurbish Sensors, replacing parts rather and recycling as much of the sensors as possible.

The Sensor is measuring nitrogen in wastewater from OWTS's that have a useful life greater than 5 years, and each sensor would operate longer than that. However, it is anticipated that after a year of measurements, the data will be redundant and the units will be removed.

## 5. COST FACTORS

a. Explain how you have confirmed that the proposed budget is reasonable, appropriate, and necessary. If available, please provide all estimates or documentation of how costs were determined.

Verified Water, Inc. will provide the installation, maintenance, and data services. As part of the project NYS CCWT will perform wet lab analysis using ELAP certified methods to verify the results of the Sensors. Our budget includes time for a skilled technician to travel to each of the sites and grab samples and bring them back to the lab for standard method wet chemistry analytics four times in the first year.

b. Describe any additional sources of funding available for the project.

Verified Water, Inc. will provide a total of \$27,200 in Match. \$20,000 of that amount is a discount on the price of equipment. \$7,200 of this is discounts on the services performed by Verified Water for site selection and maintenance.

c. Explain why the project cannot proceed and intended benefits cannot be achieved without external funding. Please describe how the project would proceed if funds awarded are lower than requested or if there are cost overruns.

Verified Water, Inc. is the only company in the world that can supply the Sensors and support services.

## 6. MANAGEMENT, EXPERIENCE, ABILITY

6a. Describe applicant's experience in completing similar projects

Verified Water recently completed a contract with The Nature Conservancy to install and monitor 10 Sensors. An internal Final Report from TNC is attached in Attachment C below. The inventor of the Sensor works with Verified Water on a part-time basis, and we have assigned a PhD (candidate) to provide field services for projects like this. We have also been awarded \$200,000 for a similar project with the Suffolk County DHS and \$112,101 by the East Hampton CPF WQAC for another similar project.

Verified Water will install the systems, monitor them, replace reagents and consumables, empty waste samples as needed and provide all preventative and necessary maintenance at no cost for a year's worth of data. There is a custom user interface maintained by Verified Water that includes a maintenance log for each system. Each Sensor is automatically self-calibrating and to some extent self-cleaning.

NYS CCWT will provide Wet Laboratory Analyses. NYS CCWT has an ELAP certified analytical lab and has done



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many projects like this for the WQAC and others. It has been our experience that not all I/A systems perform as expected..

6b. Describe community support or opposition to project. If there is opposition, explain how this is to be addressed. The Community is not yet aware of this technology.

6c. Describe any permits needed and time frame/status of approvals. If permits are approved, indicate same. No permits are required.

## 7. MAINTENANCE, MONITORING, EVALUATION

Estimate ongoing maintenance costs and explain how these will be supported. Explain stewardship and monitoring activities planned for ensuring sustainability of the project.

Verified Water will provide 100% of the year one installation, maintenance, wet lab verification, data services, and monitoring of the Sensors. The Town will not be required to do anything but use the data. Assuming two samples per day, each Sensor would run 730 samples per year. It is designed to run for six months, or 400 cycles, without maintenance.

If there is a preventative or unscheduled maintenance event, Verified Water will send a technician to the site to remove the Sensor and replace it with another Sensor. The removed Sensor will be refurbished and put back into service. We have budgeted \$1,800/sensor which would cover six maintenance visits per sensor.

Additionally, Verified Water will hire NYS Center for Clean Water Technology at standard pricing to do manual sampling at all eight sights twice in the first year. Those grab samples will be taken to NYS CCWT's ELAP certified lab for standard method lab analysis to show that the data from the Sensor is accurate and precise.

Verified Water will provide a final report at the end of 12 months of monitoring.

## 8. DURATION OF THE PROJECT

d. Provide a projected timeline of the project (Committee will only make recommendations for shovel-ready projects; must commence within 6 months of award and complete within 2 years of award.)

Award (Sept '24) > Contract (Nov 24) > Site Selection (Dec 24) > Install Nitrogen Sensors at the eight sites (May '25), Monitor data for 12 months, maintain systems, Final Report (May '26)

e. If this is a multi-year or phased project, please provide a breakdown of the budget and milestones for each year. This project will provide 12 months of data and services. It is important to contrast how OWTS's behave in cold and warm weather cycles and from one day of the week to another but after a year, the data will become redundant. It is not necessary to run longer than one year. Most of the value of this demonstration will be evident from a single year of data.



## 9. ATTESTATION

Allocation of CPF funds will not be for the purpose of accommodating new growth, as this is prohibited by State law. Check all boxes & sign.

I authorize the subject property to be inspected by Town Personnel.

Signature: This signature will be obtained when the Town determines which sites to test Date:

We certify that funds will not be directed for projects for the purpose of accommodating new growth. We understand that progress reports will need to be generated as specified in our Water Quality Improvement Contract AND a final report showing qualitative and/or quantitative data will be generated upon project completion.

Signature: *Robert Dunbar*

Date: 3/15/24

## Attachments:

Attachment A: Budget Proposal and Breakout of Wet Lab Analysis costs

Attachment B: EPA Sponsored ISO 14034 Environmental Verification Test - Verification Statement

Attachment C: Final Report by Nicholas Calderon to The Nature Conservancy on Stony Brook Nitrogen Sensor

Attachment D: Drawings of a Nitrogen Sensor Installation Final Design



**Attachment A: Budget Proposal and Breakout of Wet Lab Analysis costs**

PLANNING, ENGINEERING OR DESIGN	PER SITE	CPF REQUEST	OTHER FUNDS	TOTAL COST
(*For municipal applications provide in-house labor calculations on separate sheet)				
Project Coordination	\$ 971	\$ 3,884	\$ 3,884	\$ 7,768
<b>Subtotal</b>	<b>\$ 971</b>	<b>\$ 3,884</b>	<b>\$ 3,884</b>	<b>\$ 7,768</b>
MATERIALS/SUPPLIES	PER SITE	CPF REQUEST	OTHER FUNDS	TOTAL COST
8 Nitrogen Sensors	\$ 8,000	\$ 56,000	\$ 8,000	\$ 64,000
<b>Subtotal</b>	<b>\$ 8,000</b>	<b>\$ 56,000</b>	<b>\$ 8,000</b>	<b>\$ 64,000</b>
CONTRACTUAL SERVICES for Construction & Site Improvements	PER SITE	CPF REQUEST	OTHER FUNDS	TOTAL COST
Installation of Sensors - Residential	\$ 1,000	\$ 4,000	\$ 4,000	\$ 8,000
12 Months Maintenance of Sensors	\$ 1,800	\$ 14,400		\$ 14,400
Wet Lab Verification - 2 Samples/yr/Site	\$ 612	\$ 4,896		\$ 4,896
12 Months Data Services, Telecom, Reports	\$ 900	\$ 3,600	\$ 3,600	\$ 7,200
<b>Subtotal</b>	<b>\$ 4,312</b>	<b>\$ 26,896</b>	<b>\$ 7,600</b>	<b>\$ 34,496</b>
<b>Grand Total</b>		<b>\$ 86,780</b>	<b>\$ 19,484</b>	<b>\$ 106,264</b>
<b>TOTAL PROJECT COST - 8 SITES</b>	<b>\$ 106,264</b>			
<b>APPLICANT MATCHING FUNDS COMMITTED</b>	<b>\$ 19,484</b>			
<b>TOTAL CPF FUNDS REQUESTED - 8 SITES</b>	<b>\$ 86,780</b>			
Source of matching funds	Amount			
Verified Water ,Inc.	\$ 19,484			



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The following is an estimate of the costs Wet Lab Verification shown in the Budget for Verified Water to send technicians out to the eight site two times over the twelve months of deployment to take samples for each of four analytes and then hire NYS Center for Clean Water Technology to provide independent ELAP standard methods data and compare that with the data from the Sensor. We will do two analyses for each of the four analytes twice a year.

Wet Lab Services by		NYS Center for Clean Water Technology				
	Description	cost /sample	samples /analyte	samples /year	\$ Amount	
<b>Analytical Services:</b>						
NH4+	2 samples/analyte, 2 analyses per year	\$20	2	2	\$ 80	
NO3-/NO2-	2 samples/analyte, 2 analyses per year	\$12	2	2	\$ 48	
NO2-	2 samples/analyte, 2 analyses per year	\$12	2	2	\$ 48	
TkN	2 samples/analyte, 2 analyses per year	\$28	2	2	\$ 112	
Sampling & Analytical Services per site					\$	288
Sites per project						8
<b>Subtotal Analytical Lab Services/1 year</b>					\$	2,304
			mileage /visit	visits/year	sites	
<b>Sampling personnel:</b>		cost/mile				
Vehicle Mileage		\$0.69	54	2	8	\$ 864
		wage/hr	hrs/visit	Site Visits/yr		
Technician's time to visit sites		\$ 54	2	16		\$ 1,728
<b>Subtotal Sample Collection</b>					\$	2,592
<b>Total Project Cost</b>					\$	4,896
Cost per site					\$	612



**Attachment B: EPA Sponsored ISO 14034 Environmental Verification Test**

Stony Brook Nitrogen Sensor  
 Verification Statement



**Verification Statement**



**Stony Brook Nitrogen Sensor**  
**Registration number: (V-2021-09-01)**  
**Date of issue: 2021-September-23**

<b>Technology type</b>	Nitrogen Sensor	
<b>Application</b>	Sensor for real-time nitrate plus nitrite and ammonium measurement in wastewater treatment system effluent	
<b>Company</b>	The Research Foundation for the State University of New York	
<b>Address</b>	Stony Brook University, Intellectual Property Partners N5002 Melville Library, Stony Brook, NY 11794-3369 USA	<b>Phone</b> 1-631-632-4163
<b>Website</b>	<a href="http://www.stonybrook.edu/commcms/ipp/">www.stonybrook.edu/commcms/ipp/</a>	<b>E-mail</b> donna.tumminello@stonybrook.edu

**Verified Performance Claim**

Operating at a temperature not lower than 4°C under low sample turbidity, a single Stony Brook Nitrogen Sensor unit provides simultaneous detection and measurement of nitrate plus nitrite and ammonium concentrations with no interferences from cations, anions, and dissolved organic matter in domestic wastewater matrices, with varying frequency of readings (hourly, daily, weekly, monthly).

Verified performance of the sensor, based on third-party testing over a six-month period, includes the following:

**Measured Parameters:** Nitrate (NO<sub>3</sub><sup>-</sup>) plus nitrite (NO<sub>2</sub><sup>-</sup>) and ammonium (NH<sub>4</sub><sup>+</sup>) in a single sample stream

**Accuracy:** Bias ≤ 20 % using wastewater (as defined in the Test/Quality Assurance Plan<sup>1</sup>) with self-calibration, self-cleaning and self-sensor recovering after power outage

**Precision:** RSD ≤ 20 % using wastewater (as defined in the T/QAP)

**Selectivity:** No interferences from cations, anions, and dissolved organic matter in wastewater

**Response range:** 2 to 70 N-mg/L for NO<sub>3</sub><sup>-</sup>, NO<sub>2</sub><sup>-</sup>, NH<sub>4</sub><sup>+</sup>

**Limit of detection:** 2 N-mg/L

**Measurement frequency:** Variable frequency of readings (hourly, daily, weekly, monthly)

**Data management:** Record and automatically transmit data to designated server on the cloud, including remote capability of programming variable sampling frequencies.

<sup>1</sup> Test Quality Assurance Plan (T/QAP) Phase II of the Advanced Septic System Nitrogen Sensor Challenge, Revision 3.0, June 2019, Battelle and EPA, 2019



**Technology Application**

The Stony Brook Nitrogen Sensor<sup>2</sup> can be directly deployed with advanced septic systems or Innovative/Alternate Onsite Wastewater Treatment Systems (I/A OWTSS) for real-time nitrate plus nitrite and ammonium measurement in the system effluent with a range of 2 to 70 N-mg/L nitrogen, with a frequency of every hour, day, week or anytime scheduled. It could also be used for in-situ nitrogen monitoring in surface water when nitrogen concentration is < 2 N-mg/L if a more sensitive probe is used.

The Stony Brook Nitrogen Sensor could also measure nitrate plus nitrite and ammonium for real-time process control at municipal wastewater treatment plants (WWTPs). Because the sensor is self-cleaning and self-calibrating, it can measure these nitrogen species accurately and reliably in real time for months at a time without taxing instrumentation maintenance staff. Because the sensor is relatively inexpensive, multiple units could be deployed at multiple key points in a WWTP process such as in screened primary effluent, aeration basin influent, aeration basin effluent and final effluent.

**Technology Description**

The Stony Brook Nitrogen Sensor is designed for in-situ, long-term deployment in domestic wastewater treatment systems, and for low maintenance (i.e., no more than quarterly), self-calibration, self-cleaning, self-sensor recovering after power outage and remote data transmission. The sensor can continuously and simultaneously measure real-time nitrate plus nitrite and ammonium concentrations.

Operation of the Stony Brook Nitrogen Sensor requires 12-volt DC power (or suitable battery/charging system), Internet access over Wi-Fi, and temperature of 4 to 35°C.

A picture of the sensor box (measuring 1 cubic foot), similar to the one used during testing, is shown in Figure 1. Constant data readings are automatically transmitted to designated server/cloud.



*Figure 1. Stony Brook Nitrogen Sensor Housing*

Stony Brook University describes the Stony Brook Nitrogen Sensor as Technology Readiness Level (TRL) 7 based on the sensor system being at, or near, the scale of the operational system, with most functions available for demonstration and use. The Research Foundation for the State University of New York has a patent pending on the Stony Brook Nitrogen Sensor.

<sup>2</sup> Stony Brook Nitrogen Sensor as set forth in the State University of New York (SUNY) Research Foundation New Technology Disclosure 050-9145 and as further developed by Dr. Qingzhi Zhu and colleagues at Stony Brook University



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**Description of Test Procedure**

Field performance testing of the Stony Brook Nitrogen Sensor took place over a six-month period, from November 2020, through May 2021, at the Massachusetts Alternative Septic System Testing Center (MASSTC) located at 4 Kittridge Road, Buzzards Bay, MA. The U.S. Environmental Protection Agency (EPA) designed the test to evaluate the dynamic range, precision, accuracy, and stability of nitrogen sensors under controlled performance conditions following a Test Quality Assurance Plan (T/QAP)<sup>3</sup> prepared by Battelle. The T/QAP specified test procedures and a schedule to test the performance of the Stony Brook Nitrogen Sensor using effluent from advanced septic systems by evaluating the accuracy, precision, and range of nitrate (NO<sub>3</sub>-) and ammonium (NH<sub>4</sub>+) measurements in different wastewater mixtures. Table 1 provides a list of all test fluid solutions used in the six-month field performance test. Standards and spikes were prepared by mixing the indicated salts with deionized water immediately before being added to the test cell.

1. Low Standard Tap Water spiked with:	- Nitrate solution (KNO <sub>3</sub> ): 1-15 mg N/L - Ammonium solution (NH <sub>4</sub> Cl): 10-15 mg/L - Nitrite solution (KNO <sub>2</sub> ): 0.25-1 mg N/L
2. Medium Standard Tap Water spiked with:	- Nitrate solution (KNO <sub>3</sub> ): 10-40 mg N/L - Ammonium solution (NH <sub>4</sub> Cl): 10-40 mg/L - Nitrite solution (KNO <sub>2</sub> ): 1-4 mg N/L
3. High Standard Tap Water spiked with:	- Nitrate solution (KNO <sub>3</sub> ): 30-60 mg N/L - Ammonium solution (NH <sub>4</sub> Cl): 30-60 mg/L - Nitrite solution (KNO <sub>2</sub> ): 4-8 mg N/L
4. Treated Sewage Effluent	Secondary treated effluent that has passed through a traditional septic system and then through additional innovative/advanced nitrogen removal treatment.
5. Matrix Spike – Treated Sewage Effluent spiked with Low Standard:	- Nitrate solution (KNO <sub>3</sub> ): 1-15 mg N/L - Ammonium solution (NH <sub>4</sub> Cl): 10-15 mg/L - Nitrite solution (KNO <sub>2</sub> ): 0.25-1 mg N/L
6. Primary Sewage Effluent	Raw primary treated effluent direct from a traditional septic system without additional treatment for nitrogen removal.

**Table 1 - Test Fluid Solutions for 6-month Field Performance Test**

Testing was conducted inside a temperature-controlled trailer on the MASSTC property to facilitate sensor testing using effluent from different advanced septic treatment technologies installed and in use at the Center. The trailer provided heat and air conditioning to protect the contents of the sensor test cell from freezing and overheating. The sensor was immersed in fluids with a temperature range between 5.9 and 20.8°C, measured by MASSTC's Yellow Springs Instrument (YSI) probe. The sensor recorded air temperatures in the range of 3 to 25°C.

The intake tubing for the Stony Brook Nitrogen Sensor was placed or immersed in a sensor test cell, a circular enclosed tub made of plastic, approximately 2 feet in diameter and 1 foot in depth. The thickness of the outside wall of the test cell was approximately ¼ inch. The septic system treatment unit discharge effluent entered the sensor test cell via flow-through plumbing, which was situated at the top of the test cell and exited at the center bottom of the test cell, with the sensor being tested just outside of the tub. A positive displacement mixing pump was used inside the tub to ensure uniform sensor exposure to the challenge and field performance test solutions. Figure 2 shows the nitrogen sensor test cell.



**Figure 2. The Nitrogen Sensor Test Cell at MASSTC**

<sup>3</sup> Test Quality Assurance Plan (T/QAP) Phase II of the Advanced Septic System Nitrogen Sensor Challenge, Revision 3.0, June 2019, Battelle and EPA, 2019



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120-volt alternating current (AC) power was available inside the trailer for use by the sensor system. The sensor's power adapter converts the 120-volt AC to the sensor's required 12-volt DC. The sensor had to maintain electrical isolation between the fluid, 120-volt AC power, and earth ground to prevent galvanic issues or ground looping. The sensor system (sensor and associated connections and tubing) could not discharge or release any substance into the test cell that would alter the test fluid. The sensor itself was located outside the test cell but was connected to two intake tubes inside the test vessel, which fed sample fluid to the sensor at predetermined sampling times to take measurements during the performance test.

Stony Brook set up and calibrated the sensor prior to initiating the six-month field performance test. The Barnstable County Department of Health and Environment (BCDHE) laboratory located in Barnstable, Massachusetts, independently analyzed discrete septic test fluid and wastewater samples using standard EPA test methods.

The field performance test had two components: off-line testing and on-line effluent testing. During the off-line testing (intake valves of the test cell closed), sampling for laboratory testing and sensor readings were conducted simultaneously. The sensor test cell was sequentially filled with tap water, low standard test fluid, medium standard test fluid, and high standard test fluid. Nitrogen salts to prepare the standards were supplied by U.S. EPA Region 1 personnel. The sensor test cell was mixed for one hour, and a time stamped laboratory sample was collected no less than 50 minutes after the introduction of each test fluid. During the off-line part of the test, the flow-through septic fluid plumbing was turned off so the test fluid was "off-line" or static.

During the on-line effluent monitoring phase, the flow-through valves were opened and used to deliver the live advanced septic system effluent to the sensor. Testing was done using the advanced OWTS treated effluent and raw untreated wastewater effluent (to simulate OWTS failure).

During off-line testing (valves of the test cell closed), the sensor was supplied with tap water alone, or with tap water spiked with a test fluid solution. Measured standard spikes were added manually with test cell water rinse. Other test fluids were supplied to the sensor through a gravity-fed calibration inlet with test cell valves open (on-line). Sensor probes or inlet tubing immersed in each test fluid solution were supplied for no less than 50 minutes prior to sampling.

During on-line testing, twenty-four hours prior to sampling, MASSTC staff introduced live advanced septic system on-line effluents to ensure that the test vessel was flushed and uniform before taking a test sample. MASSTC staff collected samples throughout the performance test period following procedures described in the T/QAP. MASSTC used a polyethylene bottle to collect grab samples of the test vessel fluid, which were then aliquoted to the appropriate sample containers, preserved if necessary, and submitted to the BCDHE laboratory for analysis. The sensor provided results for nitrate plus nitrite and ammonium as nitrogen. BCDHE analyzed samples for nitrate, nitrite, and ammonium as nitrogen. Each grab sample was documented, and date and time stamped. Samples were transported to the BCDHE laboratory for analysis using appropriate chain-of-custody procedures to ensure analysis holding times were met.

Test vessel measurements of pH, dissolved oxygen (DO), conductivity, and temperature were performed after each test fluid was stabilized and during each sampling period. The measurement of these test vessel solution parameters was performed with a YSI ProDSS Multi Probe Sensor (MPS) by MASSTC personnel. All calibrations, field observations, and data were recorded in the sampling logbook. An electronic download of these data was provided to Battelle for review.

The Stony Brook Nitrogen Sensor recorded sensor readings remotely and then transferred the data to an Excel spreadsheet, which was provided to Battelle for review.

### **Performance Test Results**

The Stony Brook Nitrogen Sensor was tested for accuracy, precision, range, and completeness of data return as the sensor was exposed to a range of test fluids over the duration of the six-month field performance test. Data from the sensor were compared to laboratory analytical data from samples taken at specific time intervals.



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**Accuracy** was estimated by comparisons between reference and measured values. A percent recovery was determined for each sensor reading against each laboratory value. Mean recoveries were determined for each similar test material by parameter tested. Data accuracy results are summarized in Table 2 for each test fluid (i.e., all test fluids, standard solutions only, and wastewater).

Stony Brook Nitrogen Sensor recoveries for nitrate plus nitrite range from 46.8% to 115.36%. Of the 123 calculable recoveries, 119 or 96.75% are within the performance criteria of 80 to 120%. Stony Brook Nitrogen Sensor recoveries for ammonium ranged from 81.96% to 136.39%. Of the 79 calculable recoveries, 77 or 97.47% are within the performance criteria of 80 to 120%.

	% Recovery 80-120%					
	All Test Fluids		Standard Solutions		Wastewater	
	Nitrate + Nitrite-N	Ammonium-N	Nitrate + Nitrite-N	Ammonium-N	Nitrate + Nitrite-N	Ammonium-N
Minimum	46.80%	81.96%	46.80%	82.12%	79.16%	81.96%
Maximum	115.36%	136.39%	115.36%	113.14%	108.27%	136.39%
Average	93.46%	98.79%	94.36%	97.93%	93.12%	99.40%
Available Points	123	79	34	33	89	46
# In Control	119	77	31	33	88	44
% In Control	96.75%	97.47%	91.18%	100%	98.88%	95.65%

*Table 2. Stony Brook Nitrogen Sensor 6-Month Performance Test – Accuracy Summary in Different Test Fluids*

**Precision** is closeness of agreement between independent test results obtained under stipulated controlled conditions. Relative standard deviation (RSD) was used to provide precision measurements where repeated measurements (n=3) during testing were done with sensors placed in, or exposed to, known stable test fluid conditions. Data precision results are summarized in Table 3 for each test fluid (i.e., all test fluids, standard solutions only, and wastewater).

RSD results were calculated for all sensor results where replicate measurements were collected. All RSD results (37 for nitrate plus nitrite and 25 for ammonium) met the performance criteria of ≤20% RSD for both nitrate plus nitrite and ammonium in all test fluids.

	% RSD ≤20%					
	All Test Fluids		Standard Solutions		Wastewater	
	Nitrate + Nitrite-N	Ammonium-N	Nitrate + Nitrite-N	Ammonium-N	Nitrate + Nitrite-N	Ammonium-N
Minimum	0.30%	0.73%	1.22%	0.76%	0.30%	0.73%
Maximum	14.55%	6.61%	14.55%	6.61%	5.20%	6.59%
Average	2.35%	3.27%	4.06%	2.64%	1.72%	3.69%
Available Points	37	25	10	10	27	15
# In Control	37	25	10	10	27	15
% In Control	100%	100%	100%	100%	100%	100%

*Table 3. Stony Brook Nitrogen Sensor 6-Month Performance Test – Precision in Different Test Fluids*

**Range** is the upper and lower-level limits of detection and quantification, determined by an analysis of the variance within repeated sensor readings on a known test solution of the measurement parameter. Table 4 provides a summary of the concentration ranges and the counts of samples collected for each parameter for the BCDHE laboratory and the Stony Brook Nitrogen Sensor.

The exposed (lab) and measured (sensor) ranges of the nitrate plus nitrite data were 2.24 mg/L to 79.6 mg/L and 2.34 mg/L to 70.83 mg/L, respectively. The exposed and measured ranges of the ammonium data were 0.32 mg/L to 48 mg/L and 2.14 mg/L to 47.67 mg/L, respectively.



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The performance claim range is <2 to 70 mg/L. For nitrate plus nitrite that range was achieved. For ammonium, spiked levels to 70 mg/L were not provided during the six-month field performance test, even though the ammonium spike concentrations used in the six-month field performance test were within the planned concentrations of the T/QAP design. However, linearity for ammonium as nitrogen was shown to be  $r^2=0.997$ , indicating linearity from 2 to 70 mg/L is likely.

	BCDHE Laboratory		Stony Brook Nitrogen Sensor	
	Nitrate + Nitrite-N	Ammonia-N	Nitrate + Nitrite-N	Ammonium-N
Minimum	2.24	0.32	2.34	2.14
Maximum	79.6	48	70.83	47.67
Average	26.09	11.12	25.02	11.81
Non-detect or <2	8	48	9	50
Total Detected	129	89	124	83
Missed Samples <sup>1</sup>	1	1	5	5
Total Samples	138	138	138	138

Note - Minimum, maximum, and average concentrations are in mg/L.  
 1 - Sensor missed samples are from power outage. Laboratory missed sample from MASSTC failed collection.

**Table 4. Stony Brook Nitrogen Sensor 6-Month Field Performance Test – Concentration Ranges and Counts of Samples Collected**

**Completeness** is the amount of time the sensor operates in a submerged deployment setting without needing maintenance or recalibration. Sensor data were recorded hourly when samples were being collected for the laboratory and daily when no samples were being collected. Comparisons were also made of the percent data recovered as a proportion of the planned data collected during its deployment period.

Table 5 shows the number of hourly and daily (depending on the sampling activity) sensor readings planned and completed each month and a completeness summary. The T/QAP called for a total of 465 sensor readings to be taken for nitrate plus nitrite and ammonium over the full six-month period. One reading was a planned failure, so 464 readings were planned. 15 readings were missed due to power outages or Wi-Fi loss. Considering power and Wi-Fi loss are outside the sensor control, function of the sensor showed completeness as 100%.

Month	# Hourly Readings	# Daily Readings	Total Planned Readings	Adjusted Total	Total Completed Readings	% Complete (based on Total Planned)	% Complete (based on Adjusted Total)	Missed Readings	Reason
1	121	20	141	140	140	99%	100%	1	Planned power off
2	33	28	61	56	56	92%	100%	5	Power outage
3	44	27	71	63	63	89%	100%	8	No Wi-Fi
4	33	28	61	59	59	97%	100%	2	No Wi-Fi
5	33	28	61	61	61	100%	100%	0	
6	44	26	70	70	70	100%	100%	0	
<b>Total</b>	<b>308</b>	<b>157</b>	<b>465</b>	<b>449</b>	<b>449</b>	<b>97%</b>	<b>100%</b>	<b>16</b>	

Note - Adjusted Total = Total Planned Readings minus readings omitted due to conditions outside the control of the sensor (i.e., power outage and loss of Wi-Fi).

**Table 5. Stony Brook Nitrogen Sensor 6-Month Field Performance Test – Completeness Summary**

Two maintenance visits were performed during the six-month period, which included adding additional reagents, dumping the sensor waste containers, recalibrating the sensors, changing pump tubing, checking for leaking, and other preventive maintenance.



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At the conclusion of the test, on May 10, 2021, the Stony Brook Nitrogen Sensor team, the U.S. EPA Coordinator, and the Battelle Quality Assurance Officer inspected the condition of the sensor. The sensor was in a condition good enough that with some minor preventive maintenance the sensor team left the sensor at MASSTC for another six-month testing period to continue to evaluate the performance of the sensor.

**Verified Performance**

Verification of the Stony Brook Nitrogen Sensor was conducted by Battelle Memorial Institute (505 King Avenue, Columbus, OH 43201 USA) in accordance with the International Organization for Standardization (ISO) standard for environmental technology verification (ETV), ISO 14034:2016, and the VerifiGlobal Performance Verification Protocol. A Verification Plan was prepared by VerifiGlobal to guide the verification process<sup>4</sup>.

The performance claim verification is based on data and information provided by Stony Brook University and test results obtained through third-party testing at the Massachusetts Alternative Septic System Testing Center (MASSTC) and the Barnstable County Department of Health and Environment (BCDHE) laboratory.

BCDHE provided 49 data reports for the full six-month field performance test to the Battelle for compliance review to laboratory SOP requirements and the T/QAP. Battelle verified 100 percent of the reported results with the laboratory data reports and recalculated 10 percent of the sample results from the raw data. All laboratory method blanks, laboratory fortified blanks (LFBs), laboratory duplicates, and laboratory fortified matrix samples (LFMs) were within method control limits. All calibration criteria were met.

Figures 3 and 4 provide the plots of the sensor data and laboratory data for nitrate plus nitrite and ammonium, respectively, for the six-month field performance test. As shown in the figures, the sensor and laboratory data overlap, indicating significant agreement. The blue sensor data lines tracked throughout the time period, whereas the orange laboratory data lines only tracked periodically when samples were collected. When both laboratory and sensor data are displayed, the overlap is such that only one line is visible, showing complete agreement.

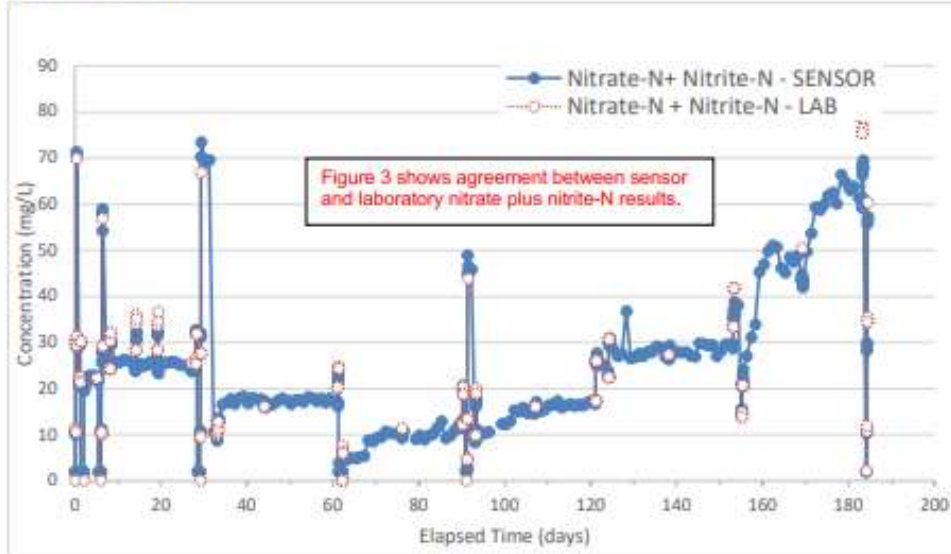
To illustrate the accuracy of the Stony Brook Nitrogen Sensor, the sensor data were plotted against the laboratory data, showing correlation coefficients of 0.986 for nitrate plus nitrite and 0.997 for ammonium, where non-detects were reported as zero. The linear regression of laboratory results versus sensor results is shown in Figure 5.

The performance claim for the Stony Brook Nitrogen Sensor specified that the accuracy is based on "using wastewater". The six-month field performance test utilized both standard solutions and wastewater test fluids. Table 2 shows a summary of all test fluid accuracy results, just standard solutions, and the wastewater accuracy results. Based on the wastewater results only, one nitrate plus nitrite result exceeded the performance claim goal of  $\leq 20\%$  bias out of 89 possible readings (99% of the data were in control), with an average of 93.12% recovery. Ammonium had two exceeded wastewater results out of 46 possible readings (96% of data were in control), with an average of 99.4% recovery.

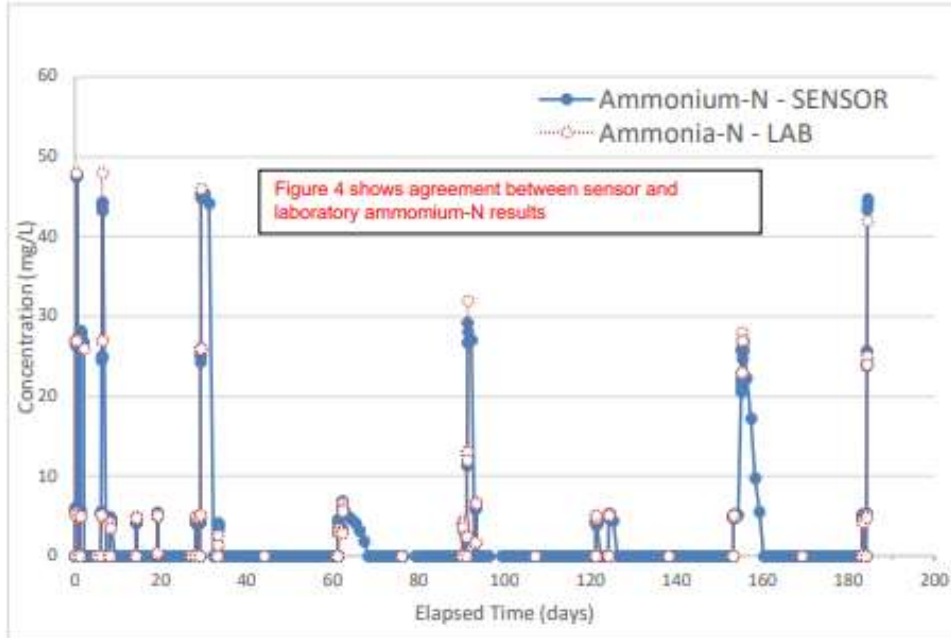
<sup>4</sup> VerifiGlobal. 2021. Verification Plan for The Research Foundation for the State University of New York Stony Brook University New York State Center for Clean Water Technology, Stony Brook Nitrogen Sensor. June 2021



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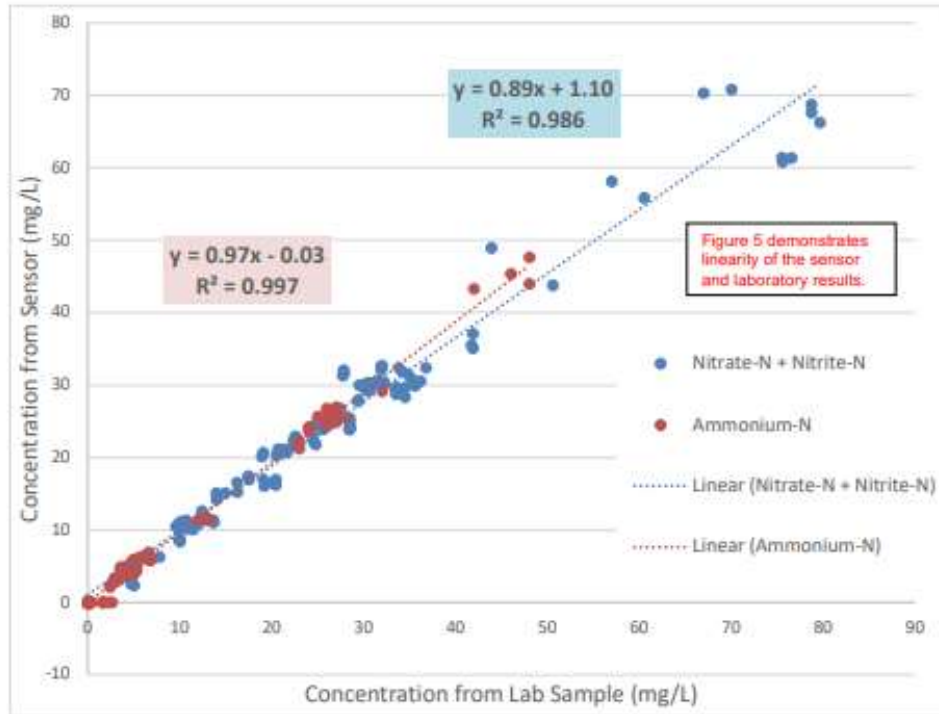
**Figure 3. Stony Brook Nitrogen Sensor –  
Comparison of Nitrate and Nitrite Nitrogen as Measured by the Sensor and in Lab Samples**



**Figure 4. Stony Brook Nitrogen Sensor –  
Comparison of Ammonium Nitrogen as Measured by the Sensor and in Lab Samples**



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**Figure 5. Stony Brook Nitrogen Sensor – Linear Regression of Laboratory Results versus Sensor Results**

Table 6 below provides a summary of the verified Stony Brook Nitrogen Sensor performance claim in relation to the sensor test results.

Attribute	Performance Claim Met	Stony Brook Nitrogen Sensor Performance Summary Comments
Parameter	Yes. Measures Nitrate and Nitrite (NO <sub>3</sub> /NO <sub>2</sub> ) and Ammonium (NH <sub>4</sub> <sup>+</sup> )	Measures NO <sub>3</sub> plus NO <sub>2</sub> , not NO <sub>3</sub> only. However, NO <sub>3</sub> plus NO <sub>2</sub> provides additional data towards TN. Also measures NH <sub>4</sub> <sup>+</sup>
Data Management	Yes. Records and automatically transmits data to designated server on the cloud.	Internal computer tracks data. Data accessible to sensor developer over the internet. Sensor reading frequencies are programmable remotely. Daily and hourly reading options demonstrated during the six-month field performance test. Also, had a situation which required change in sampling schedule during the field performance test due to a holiday necessitating the sensor developer to revise the sampling schedule of the sensor remotely after deployment, which was done without an issue.
Applicability & Accessibility	Yes. Can be directly deployed with advanced septic systems or I/A DWTS for real-time NO <sub>3</sub> /NO <sub>2</sub> and NH <sub>4</sub> <sup>+</sup> measurement and in WWTPs.	During the six-month period, the sensor was subject to six different treated sewage effluent fluids and ranges in concentrations from 2 to 70 mg N/L for nitrate plus nitrite and 2 to 50 mg N/L for ammonium, showing diversity in conditions and concentrations.
Frequency of Sensor System Maintenance	Yes. Sensor designed for in-situ, long-term deployment in wastewater systems with low maintenance (i.e., no more than quarterly), self-calibration, self-cleaning.	Two maintenance visits were included in the Verification Plan and were completed on December 4, 2020 and March 4, 2021. The maintenance that was done was only preventative and not for repairs. The chemical reagents, waste solution, nitrogen reactors, pump tubing and flow cell were checked. Reagents were topped off and waste emptied. No repairs were necessary.
Accuracy: Bias ≤ 20 % using wastewater	Yes. 97% of data met criteria	119 of 123 recoveries (97% of data) for nitrate plus nitrite are within ±20% recovery range with total average recovery of 93.46% in all test fluids. The low recoveries for nitrate plus nitrite may be due to the test vessel recirculation being left on Feb. 3, 2021 (a deviation from the test design). 77 of 79 recoveries (97% of data) for ammonium are within ± 20% recovery range with total average recovery of 98.79% in all test fluids. The performance claim specifies accuracy in "wastewater". Evaluating only the wastewater samples (not the standard solutions), 88 of 89 recoveries (99% of data) for



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		nitrate plus nitrite are within ±20% recovery range and 44 of 46 (96% of data) for ammonium are within ±20% recovery range.
Precision: RSD ≤ 20 % using wastewater	Yes. All data met criteria	All %RSD results met the ideal criteria of ≤20% RSD for both parameters (nitrate plus nitrite and ammonium). The highest %RSD for nitrate plus nitrite was 14.55% and the highest for ammonium was 6.61% in all test fluids. The performance claim specifies precision in "wastewater". Evaluating only the wastewater samples (not the standard solutions), all %RSD results met the ≤20% RSD for both parameters.
Range	Yes. Response range is 2 - 70 N-mg/L for NO3 <sup>-</sup> , NO2 <sup>-</sup> , NH4 <sup>+</sup>	Range measured for nitrate plus nitrite-N was <2 to 70.83 mg/L. Note: lowest reported value was 2.34 mg/L. Range measured for ammonium-N was <2 to 47.67 mg/L. Note: lowest reported value was 2.24 mg/L. For ammonium, spiked levels to 60 mg/L were not provided during the six-month field performance test, however, linearity was shown to be r <sup>2</sup> = 0.997.
Frequency of Sensor Readings <sup>1</sup>	Yes. frequency: Variable frequency of measurement readings (hourly, daily, weekly, monthly)	The sensor provided daily and hourly readings throughout the six-month field performance test, varying depending on when laboratory sampling was performed. The schedule adjustment was also available remotely. 449 readings recorded out of 449 obtainable readings (with power and Wi-Fi) for nitrate plus nitrite and ammonium. 100% completion.
Sensor Operating Temperature Range	Yes. Operates at a temperature not lower than 4°C	The water temperature of the test cell was recorded during the performance test, but the air temperature was not independently recorded. The test cell water temperature range was 5.9°C to 20.8°C. The sensor recorded air temperature range from 3°C to 25°C; therefore, this attribute was achieved.
Deployment	Yes. Sensor designed for in-situ, long-term deployment in wastewater systems	The sensor operated the entire six-month period as documented from the hourly or daily readings received. The only times the system was not working was when there was a power outage. The sensor automatically recovered after power outage.
Selectivity	Yes. There are no interferences from cations, anions, and dissolved organic matter in wastewater	Accuracy recoveries of nitrate plus nitrite and ammonium within 80 to 120% demonstrate selectivity of sensor within complex matrices, which likely contain multiple cations, anions, and dissolved organic matter.
Limit of Detection	Yes. Limit of detection is 2 N-mg/L	The lowest value reported when not detected was 2 N-mg/L.

**Table 6. – Summary of verified Stony Brook Nitrogen Sensor performance claim in relation to sensor test results.**

**Variance**

- Only three deviations from the test schedule in the T/QAP were noted. These were:
- One laboratory sample (1110-APD-MS-1) was not collected for analysis on November 10, 2020, which resulted in loss of data to determine accuracy of the sensor based on that sample.
  - A power outage on December 7, 2020 resulted in the loss of 5 sensor data readings.
  - Test vessel recirculation was left on when it was supposed to be turned off during off-line testing on February 3, 2021.

The verifier determined that these deviations did not alter the performance of the technology (i.e., the sensor continued to operate and/or restart after power was restored). There may have been some low recoveries due to the test vessel recirculation being left on but the overall performance of the sensor was not affected.

**Quality assurance**

Performance testing and verification of the Stony Brook Nitrogen Sensor were conducted in accordance with the requirements of ISO 14034:2016 and the VerifiGlobal Performance Verification Protocol. The verifier, Battelle, has confirmed that quality assurance requirements were addressed throughout the performance testing process and in the generation of performance test results. This includes reviewing all data sheets and data downloads, as well as overall management of the test system, quality control and data integrity.

In November 2020, the Battelle Quality Assurance Officer visited the MASSTC site to observe the project setup, sampling procedures, and chain-of-custody process in the field. Project conditions, sampling procedures, and chain-of-custody process were compliant with the T/QAP. Field documentation and calibration documentation were complete. The Battelle QAO also visited the BCDHE Laboratory to review the project sampling scope and T/QAP requirements with the Laboratory Director and analysts to ensure readiness for the upcoming performance sample analysis. No issues were found. In December 2020, Battelle completed and submitted an ISO 17025 audit checklist review of BCDHE as a more in-depth review of the laboratory's QA processes.



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### **Verification Summary**

In summary, the Stony Brook Nitrogen Sensor<sup>5</sup> can be directly deployed with advanced septic systems or Innovative/Alternate Onsite Wastewater Treatment Systems (I/A OWTSs) for real-time nitrate plus nitrite and ammonium measurement in the system effluent with a range of 2 to 70 N-mg/L nitrogen, with a frequency of every hour, day, week or anytime scheduled. It could also be used for in-situ nitrogen monitoring in surface water when nitrogen concentration is < 2 N-mg/L if a more sensitive probe is used.

The verified performance claim is as follows:

*Operating at a temperature not lower than 4°C under low sample turbidity, a single Stony Brook Nitrogen Sensor unit provides simultaneous detection and measurement of nitrate plus nitrite and ammonium concentrations with no interferences from cations, anions, and dissolved organic matter in domestic wastewater matrices, with varying frequency of readings (hourly, daily, weekly, monthly).*

*Based on the results of a six-month field performance test conducted at MASSTC during the period of November 2020 to May 2021, this verification of the Stony Brook Nitrogen Sensor confirms the following:*

**Measured Parameters:** nitrate ( $\text{NO}_3^-$ ) plus nitrite ( $\text{NO}_2^-$ ) and ammonium ( $\text{NH}_4^+$ ) in a single sample stream

**Accuracy:** bias  $\leq 20\%$  using wastewater (as defined in the Test/Quality Assurance Plan<sup>6</sup>) with self-calibration, self-cleaning and self-sensor recovering after power outage

**Precision:** RSD  $\leq 20\%$  using wastewater (as defined in the T/QAP)

**Selectivity:** no interferences from cations, anions, and dissolved organic matter in wastewater

**Response range:** 2 to 70 N-mg/L for  $\text{NO}_3^-$ ,  $\text{NO}_2^-$ ,  $\text{NH}_4^+$

**Limit of detection:** 2 N-mg/L

**Measurement frequency:** variable frequency of readings (hourly, daily, weekly, monthly)

**Data management:** record and automatically transmit data to designated server on the cloud, including remote capability of programming variable sampling frequencies.

The verified performance test results also confirm that:

- The Stony Brook Nitrogen Sensor operated continuously during the 6-month period with 449 readings out of 449 achievable readings (100% completion).
- The concentration ranges of the sensor were: <2 to 70.83 milligrams per liter (mg/L) for nitrate plus nitrite as nitrogen and <2 to 47.67 mg/L for ammonium
- 119 of 123 recoveries in all test fluids for nitrate plus nitrite were within the  $\pm 20\%$  recovery range with average recovery of 93.46%
- 77 of 79 recoveries in all test fluids for ammonium were within the  $\pm 20\%$  recovery range with average recovery of 98.79%.
- The sensor operated within an air temperature range of 3°C to 25°C and a water temperature range of 5.9°C to 20.8°C.
- Two maintenance visits were conducted during the six-month field performance test as preventive maintenance, not repair visits.
- All sensor components were contained in a 1 cubic foot box.

<sup>5</sup> Stony Brook Nitrogen Sensor as set forth in the State University of New York (SUNY) Research Foundation New Technology Disclosure 050-9145 and as further developed by Dr. Qingzhi Zhu and colleagues at Stony Brook University

<sup>6</sup> Test Quality Assurance Plan (T/QAP) Phase II of the Advanced Septic System Nitrogen Sensor Challenge, Revision 3.0, June 2019, Battelle and EPA, 2019. Note: Some of the qualitative attributes included in the original EPA challenge performance goals, such as installation price and system lifetime, were not verified.






**Stony Brook Nitrogen Sensor  
 Verification Statement**

**What is ISO 14034?**

The purpose of environmental technology verification is to provide a credible and impartial account of the performance of environmental technologies. Environmental technology verification is based on a number of principles to ensure that verifications are performed and reported accurately, clearly, unambiguously and objectively. The International Organization for Standardization (ISO) standard for environmental technology verification (ETV) is ISO 14034, which was published in November 2016.

**Benefits of ETV**

ETV contributes to protection and conservation of the environment by promoting and facilitating market uptake of innovative environmental technologies, especially those that perform better than relevant alternatives. ETV is particularly applicable to those environmental technologies whose innovative features or performance cannot be fully assessed using existing standards. Through the provision of objective evidence, ETV provides an independent and impartial confirmation of the performance of an environmental technology based on reliable test data. ETV aims to strengthen the credibility of new, innovative technologies by supporting informed decision-making among interested parties.

For more information on the Stony Brook Nitrogen Sensor, contact:	For more information on VerifiGlobal, contact:
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Signed for The Research Foundation for the State University of New York, Stony Brook University:    Dr. Qingzhi Zhu, Associate Professor, School of Marine and Atmospheric Sciences, Stony Brook University	Signed for VerifiGlobal:    Thomas Bruun Managing Director    John Neate Managing Director

**NOTICE:** Verifications are based on an evaluation of technology performance under specific, predetermined operational conditions and parameters and the appropriate quality assurance procedures. VerifiGlobal and the Verification Expert, Battelle, make no expressed or implied warranties as to the performance of the technology and do not certify that a technology will always operate as verified. The end user is solely responsible for complying with any and all applicable regulatory requirements. Mention of commercial product names does not imply endorsement.

VerifiGlobal and the Verification Expert, Battelle, provide the verification services solely on the basis of the information supplied by the applicant or vendor and assume no liability thereafter. The responsibility for the information supplied remains solely with the applicant or vendor and the liability for the purchase, installation, and operation (whether consequential or otherwise) is not transferred to any other party as a result of the verification.



**Attachment C: “Letter of Support” Final Report by Nicholas Calderon to The Nature Conservancy on Stony Brook Nitrogen Sensor**

**Nitrogen Sensor Update FW: Final Report**

Nicholas Calderon <n.b.calderon@>  
 To  Kevin G. McDonald;  Sheila Webb-Halpern;  Jessica L. Ottney;  Ellen Weiss;  chris.clapp@oceansewagealliance.org  
 Cc  Stuart Lowrie;  bud.dunbar@verified-water.com;  'Qingzhi Zhu'  
 5/31/2023  
 TNC Summary Report Final 2.docx  
 6 MB

Hey team,

I've got some good news about the EPA-TNC Nitrogen Sensor Challenge! Can you believe it's been almost seven years since TNC and the EPA joined forces for this project? Well, I'm thrilled to announce that we've made incredible progress, and I wanted to give you a quick update.

Our goal was to create a nitrogen sensor that would revolutionize the industry by slashing costs from a whopping \$20,000 per unit to a mere \$1,500, all while eliminating the need for those pesky grab samples to test nitrogen levels in septic systems. After an intense competition, researchers from Stonybrook University blew everyone away with their innovative nitrogen sensor design.

As an academic institution, SBU needed a lot of support transforming their benchtop prototype to a product. They joined forces with Bud Dunbar and started working with TNC, and together, we formed an unconventional partnership with Verified Water, a company that spun off from the university.

Over the past year, with TNC's support, Verified Water been working on developing this an alpha prototype into a field prototype. It has been transformed from a clunky metal box into a sleek waterproof pelican case. Now, it wirelessly connects to a cloud server, boasts a user-friendly web interface for real-time data access, and even has a fancy new control that lets you adjust the sampling rate. We've also made several tweaks to ensure it works like a charm in any weather condition, including freezing cold.

I've attached a detailed report with some photos for you to check out. But to give you a quick rundown, here are the key highlights:

1. **Project Background:** We kicked off the TNC contract on 4/5/22 when SBU launched Verified Water, Inc.
2. **Product Development:** Verified Water put in a ton of effort to develop the Beta version 2 of the nitrogen sensor. Making all sorts of cool improvements, like revamping the control board, enabling wireless data transmission, setting up an internet-accessible SQL database, and creating user-friendly software.
3. **Cellular Service and Telemetry:** At first, Verified Water ran into some hiccups with the network when we tried T-Mobile, but things got way better when they switched to Verizon. The sensor still had a few connection issues, mostly related to WiFi, so they had to redesign the control board to have a hardwired connection.
4. **Installation:** Verified Water nailed down the installation process, using plastic risers and a separate sampling system to analyze water from different levels. Oh, and they added a nifty waterproof heating mat to keep things from freezing in winter.
5. **Pilot Test:** Verified Water has been busy testing the sensors at five different sites with four different brands of I/A systems. The real-time data they've been providing is gold, giving valuable insights into how clean water septic systems perform.
6. **Assembly and Manufacturing:** Verified Water manually assembled ten nitrogen sensor prototypes (Beta versions 1 and 2). But moving forward, they are outsourcing the assembly process and have even brought on a mechanical engineer to streamline everything. Now Verified water is testing a laser cutting machine to make custom parts.



## TOWN OF SOUTHAMPTON

Department of Community Preservation  
24 W Montauk Hwy, Hampton Bays, NY 11946  
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[WQIPP@southamptontownny.gov](mailto:WQIPP@southamptontownny.gov)

Entity: **Verified Water**  
Project Name: **Infrastructure Management**

# 2024

7. **Field Support:** field support was set up in Cape Cod, and the company is currently exploring options for Suffolk County. Its focus is on making installation and maintenance easy for plumbers, and they are working on adding remote diagnostics and recovery features.
8. **Web Development and Data Management:** Verified Water's website is ready to rock. However, they have been waiting for more manufacturing capacity and systems in the field before it is made accessible to the public. It's got a user-friendly interface that lets you easily download data to Excel for efficient management and analysis.

I couldn't be prouder of what we've accomplished together. I want to give a huge shout-out to Dr. Zhu for his groundbreaking invention of the innovative sensing system and to Bud for transforming it into a remarkable product. And of course, a special mention to the original team members, Chris Clapp, Kevin McDonald, and Stuart Lowrie, for their invaluable partnership with the EPA in launching this incredible challenge.

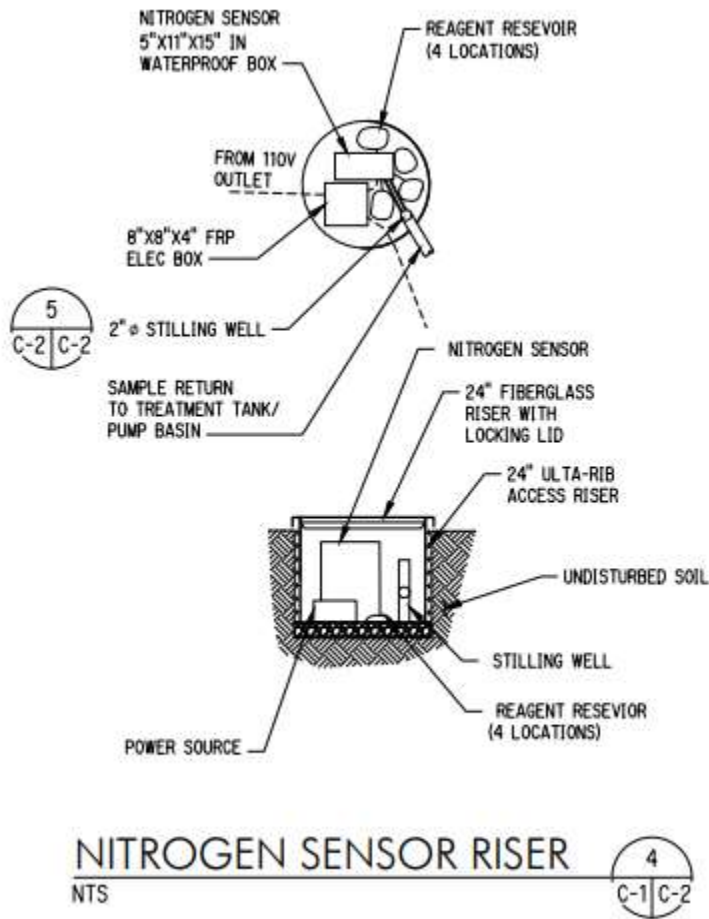
It's been a pleasure working with all of you on this project!

Nico Calderon  
The Nature Conservancy



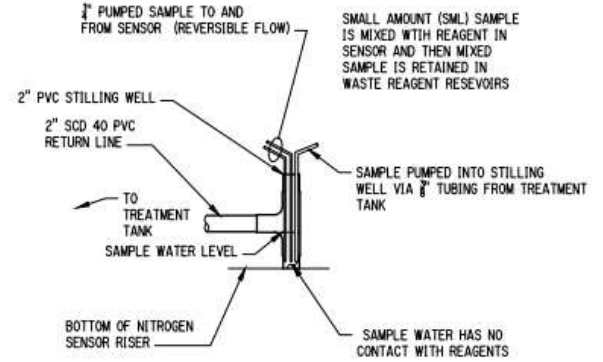
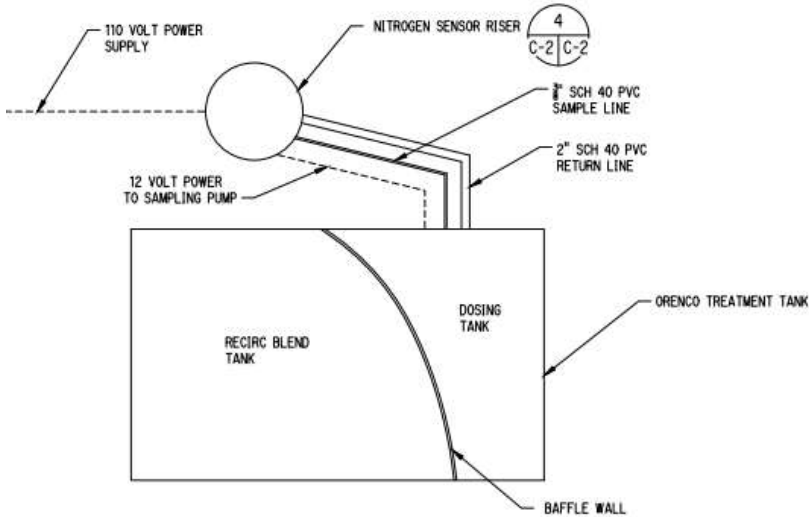
### Attachment D: Drawing Details for a Nitrogen Sensor on a residential Orenco I/A OWTS Installation

The following drawings were done by TF Engineering, PLLC of Sag Harbor for project to test Woodchip Biofilter Denitrifying Unit's downstream from the OWTS and upstream of the leaching field.

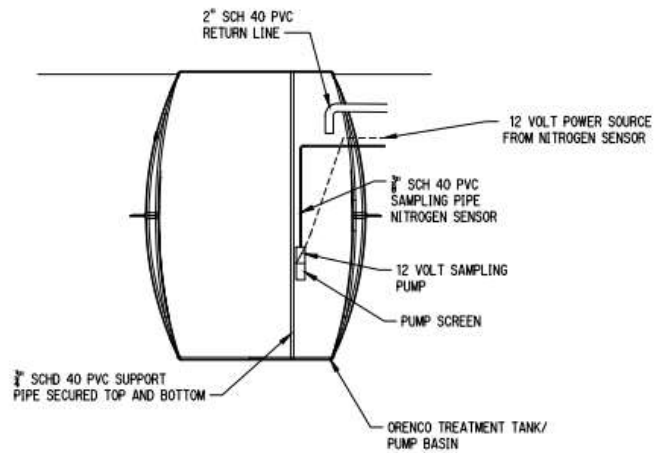
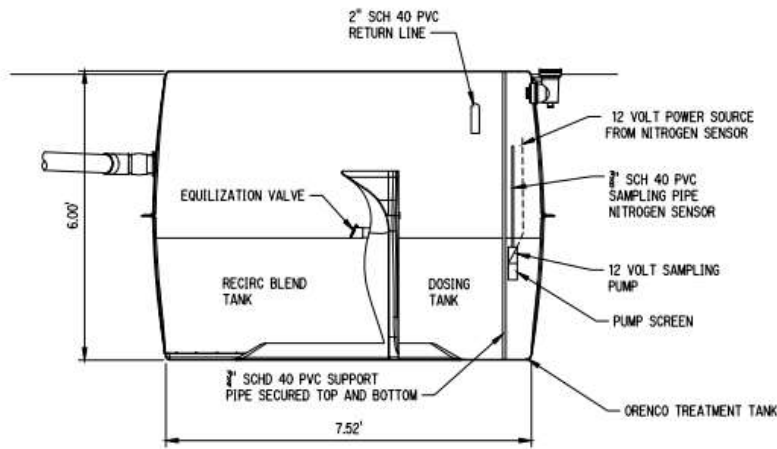




**CHIP TANK** 2  
 NTS C-1 | C-2



**STILLING WELL** 5  
 NTS C-1 | C-2



**NITROGEN SENSOR CONFIGURATION** 6  
 NTS C-2