September 24, 2025
Project No. 20250119H002

Emergence Institute, LLC
PO Box 1164
Inverness, California 94937

Attention: Zach Whelan

Subject: Updated Nitrate Loading Analysis
Emergence Whidbey
Whidbey Island, Washington

Dear Zach Whelan:

Associated Earth Sciences, Inc. (AESI) is pleased to present this "Updated Nitrate Loading Analysis" report for the parcel owned by Emergence Institute, LLC (Client) (Island County Parcel R32922-205-0620) adjacent to Maxwelton Road to the west, and Campbell Road to the south, on Whidbey Island in Island County, Washington. This report has been prepared for the exclusive use of the Client and their agents. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted hydrogeology practices in effect in this area at the time our report was prepared. No other warranty, express or implied, is made.

BACKGROUND INFORMATION

The Client is planning development of a retreat center at the site that will include the use of on-site sewage systems to manage wastewater. The proposed on-site sewage systems require a nitrate loading analysis, in accordance with the Washington State Department of Health guidance for a large on-site sewage system (LOSS) (DOH; 2024a, 2024b) because it is within a designated critical aquifer recharge area (CARA) in Island County. AESI recently reviewed a PanGEO Inc. (PanGEO) report and met with Island County to discuss the project and is providing an updated nitrate loading analysis based on existing subsurface information at the site along with updated information related to the proposed on-site sewage systems. Specifically, we reviewed the following PanGEO report:

1. "Hydrogeologic Assessment, Emergence Whidbey, Parcels R32922-205-0620, R32922-245-0950, R32922-265-1920, and R32922-297-2250, Island County, Washington," Project No. 23-356.200 REV3," Prepared by PanGEO, Dated April 2025a.

In addition, we reviewed a second PanGEO report to obtain additional subsurface information for the site and met with Island County staff:

2. "Geotechnical, Infiltration, and Critical Areas Report, Emergence Whidbey, Campbell Road and Maxwelton Road, Island County, Washington," Project No. 23-356.300, Prepared by PanGEO, Dated April 2025b.

3. On August 7, 2025 we met with Chris Kelley from Island County and on August 28, 2025 we met with Chris Kelley and Heather Kortuem from Island County who confirmed that code compliance requires the nitrate concentration at the downgradient property line remain below 2 milligrams per liter (mg/l) above the background nitrate concentration and also must not exceed a total of 5 mg/l. These criteria were also noted in an Island County memorandum (2025) for the project.

EXCECUTIVE SUMMARY

AESI reviewed the PanGEO's Hydrogeologic Assessment report (2025a), referenced above, and provided in Attachment A, and used information from the two PanGEO reports (2025a, 2025b) to perform an updated nitrate balance analysis. It is AESI's opinion that:

1. Site-specific information provided in the two PanGEO reports, referenced previously, is relevant and can be used for the nitrate loading analysis for the two proposed on-site sewage systems.
2. AESI's updated nitrate loading analysis indicates the nitrate concentrations at the alternative point of compliance (POC_{ALT}) for the West On-site Sewage System (West OSS) that serves a dining hall, laundry facility, and farmhouse and the East On-site Sewage System (East OSS) that serves the cabins, remain below the threshold of 2 mg/l above background nitrate concentration and also does not exceed a total nitrate concentration of 5 mg/l, as shown in Attachment B.
3. The nitrate loading results discussed in this report, and provided in Attachment B, should replace the nitrate loading results provided in the previous report by PanGEO (2025a).
4. Long-term monitoring of nitrate concentration at the site is not required because the nitrate concentrations at the alternative POCs, for both proposed on-site sewage systems, remain below the thresholds as noted in bullet 2, above.

The following sections provide additional details regarding AESI's updated nitrate loading analysis.

NITRATE LOADING ANALYSIS

General

The Emergence Whidbey site will have two proposed on-site sewage systems (OSS's); one OSS noted in the PanGEO report (2025a) as serving the proposed dining hall, laundry facility, and existing farmhouse (West OSS), and the other OSS noted in the PanGEO report (2025a) as serving the cabin suites (East OSS). Figure 1 shows the locations of the OSS's. The primary drainfield area for the West OSS and East OSS will consist of approximately 3,510 square feet and approximately 3,132 square feet, respectively, which are based only on the area of the drainfield trenches.

The specific contaminant of concern to groundwater quality is nitrate generated from the proposed OSS's.

AESI used the DOH *Level 1 Nitrate Balance Instructions for Large On-site Sewage Systems,* Publication 337-069 (DOH, 2024a) and an associated DOH calculation spreadsheet (Attachment B), Publication 337-070 (DOH, 2024b), to estimate the groundwater nitrate value at both the default POC and the POC_{ALT}.

DOH Publication 337-069 defines what constitutes a POC and a POC_{ALT} for the nitrate concentration in groundwater. According to page 1 of that publication,

> "The default point of compliance (POC) is the downgradient edge of the drainfield. DOH may approve an alternative POC up to but not exceeding the property boundary."

According to page 3 of that publication,

> **"Drainfield Area:** This is the area of the primary drainfield and does not include the reserve area except when part of the reserve area is being used. The area of the drainfield is used to calculate how much dilution is received from infiltrating precipitation (recharge). The down gradient edge of the drainfield is the default point of compliance (POC) for the nitrate concentration in groundwater.
>
> *Instructions:* For a new LOSS, calculate the area of the primary drainfield based on the estimated drainfield size including the area between trenches. As noted previously, only the area of the drainfield trenches was used for our analysis, which is considered conservative, and is similar to the previous analysis performed by PanGEO (2025a). For an existing LOSS, field measure the area of the existing drainfield. Be sure to take credit if you use or plan to use 50% of the reserve area in addition to the primary ("150% of the primary"). Show the drainfield area on the nitrate balance map.

> **Distance from the drainfield to the property boundary:** The LOSS/OSS owner may request an alternative POC and DOH may approve an alternative POC up to but not exceeding the property boundary. An alternative POC can sometimes help dilute the nitrate in the groundwater to an acceptable level. If there is a well, spring, or surface water before the property boundary, then use that point for the distance instead of the property boundary for the alternative POC.
>
> *Instructions*: The nitrate balance must first always be calculated with a zero value for the distance to the property boundary. This allows the spreadsheet to calculate the POC at the downgradient edge of the drainfield. A second nitrate balance can then be completed for an alternative POC (if applicable) using the distance between the down gradient edge of the drainfield and the property boundary or other receptor such as a well, spring or surface water. Measure the distance in the direction of the groundwater flow. Show both the default POC at the edge of the drainfield and the alternate POC on the nitrate balance map (Figure 1).
>
> **Aquifer Width:** The width of the aquifer is the width of the gross area of the drainfield (not the width of the property) perpendicular to the groundwater flow.
>
> *Instructions*: Measure the primary drainfield perpendicular to the direction of groundwater flow. Similar to measuring the drainfield area, be sure to consider the additional width if you use or plan to use 50% of the reserve area."

Based on the excerpts from DOH Publication 337-069, (1) the POC for the proposed OSS's is the hydraulically downgradient edge of the OSS's primary drainfield, and (2) the OSS's owner (Emergence Institute, LLC) is requesting approval of a POC_{ALT} at the closest property boundary hydraulically downgradient for the West OSS and the East OSS (which are approximately 140 feet west (West OSS) and approximately 110 feet northwest (East OSS), respectively, from their primary drainfields). The approximate groundwater flow direction is provided in the PanGEO report (2025a) and is estimated to be to the northwest. Using the property boundary to the west of the West OSS is considered more conservative because it is a shorter distance than the distance to the property boundary in the northwest direction.

The approximate groundwater flow direction underlying the proposed OSS's is to the northwest (PanGEO, 2025a). No wells, no springs, and no surface water exist between the proposed OSS's and their downgradient property boundaries.

The DOH spreadsheet appears to have been adapted from the Hantzsche and Finnemore (1992) methodology to predict the potential long-term average concentrations of nitrate in shallow groundwater immediately downgradient from drainfields.

The nitrate concentration is initially computed as the weighted average nitrate concentration of percolating drainfield effluent and recharge from precipitation using the following mass-balance equation (Equation 1). This initial calculation of nitrate concentration represents the long-term average nitrate concentration at the top of the aquifer prior to mixing or diffusion into the aquifer (N_r). The equivalent equation in DOH (2024a,b) is presented following Equation 1 where $N_r = N_i$. The remaining values and their DOH (2024a,b) equivalents are presented below.

Equation 1 $$N_r = \frac{In_w(1-d)+Rn_b}{I+R}$$ (Hantzsche and Finnemore, 1992)

Equivalent to: $$N_i = \frac{[(V_W\ x\ N_W(1-d))+(V_R\ x\ N_R(1-d))]}{(V_W+V_R)}$$ (DOH, 2024a,b)

Where:

I = V_W = Volume of wastewater discharge, in gallons per day (gpd), averaged over the gross developed area.

Comment: The design flow of the proposed West OSS is 1,111 gpd of treated effluent and the proposed East OSS is 750 gpd.

n_w = N_W = Total nitrogen concentration of wastewater effluent.

Comment: Both OSS's (West and East) are proposed to use an Advantex® system that provides treatment level "N" to treat the wastewater effluent. The Advantex® system provides a 50 percent reduction in the assumed initial nitrate concentration in wastewater of 60 mg/l, resulting in a nitrate concentration at each of the OSS system drainfields of 30 mg/l. Additional information about the Advantex® system is provided in Attachment C.

d = Fraction of nitrate lost to denitrification.

Comment: Denitrification occurs in soils that have high quantities of organic material, high soil moisture content, and a relatively high soil pH. Hantzsche and Finnemore (1992) have reported "d" values as typically ranging between 10 and 25 percent. We have assumed a denitrification "d" value of 10 percent, which is the default value recommended by DOH on page 2 of Publication 337-069 (2024a).

R = V_R = Average recharge rate from rainfall.

Comment: AESI used cumulative annual precipitation data from the Oregon State University's PRISM Group website (2025). The 30-year (1991-2020) annual normal for precipitation at the project site is 31.21 inches. U.S. Geological Survey (USGS) studies have been completed in the Puget Sound Region that estimate the relationship between precipitation and recharge through glacial outwash deposits (Bidlake and Payne, 2001). These studies indicate an average annual recharge rate of 12.8 inches per year (in/yr) for forested outwash soils, based on the annual normal precipitation value of about 31 inches at the Emergence Whidbey site. We used the annual normal precipitation recharge value of 12.8 in/yr in our analysis which is considered conservative because portions of the site are non-forested which would result in a higher recharge value. Calculated recharge over the West OSS and East OSS primary drainfields is 77 and 68 gpd, respectively.

$n_b = N_R$ = Nitrate concentration in infiltrating precipitation.

Comment: The nitrate concentration in infiltrating precipitation was assumed to be 0.24 mg/l, which is the value recommended by Ecology and DOH for evaluating nitrate loading beneath septic systems (Ecology, 2006; DOH, 2024a,b).

Substituting the values estimated for the parameters in Equation 1 yields:

West OSS: $N_r = N_i$ = 25.27 mg/l

East OSS: $N_r = N_i$ = 25.28 mg/l

This N_r concentration of nitrate is predicted for the combination of the infiltrating precipitation and LOSS drainfield effluent at the water table prior to mixing with the aquifer. Note that the methodology used to calculate the nitrate concentration at the top of the water table ignores any dilution effects of lateral groundwater inflow from upgradient areas and therefore provides a conservative (i.e., worst-case) scenario.

Groundwater Throughflow

To calculate dilution effects of mixing drainfield effluent with groundwater in the aquifer, we estimated the amount of groundwater throughflow in the aquifer under the site using the Darcy equation (Equation 2):

Equation 2 $Q = KiA$ (Environmental Protection Agency [EPA], 1980)

Where:

Q = Groundwater flow through a cross-sectional area of the site.

K = Aquifer hydraulic conductivity.

Comment: The sand and gravel of the unconfined aquifer is expected to be stratified and moderately permeable based on (1) observations of grain size from subsurface explorations by others (PanGEO, 2024a), (2) data from pilot infiltration testing (PIT) by others (PanGEO, 2024a), and our experience on project sites with similar geologic/hydrogeologic conditions. The PIT data from the two nearest PITs to each drainfield were used to estimate the hydraulic conductivity (K) in the vicinity of the West OSS and East OSS. The PIT results provide a vertical

K (K_v) while the nitrate loading estimates are based on a horizontal K (K_h). The 2024 *King County Surface Water Design Manual* (King County, 2024) indicates that a K_h of three (3) times the K_v is an acceptable factor to use for layered/stratified soils (King County, 2024) while a K_h of up to 10 times the K_v have been observed in fluvial deposits (Todd, 1980), such as those that underlie the site. We applied a factor of three (3) times the average K_v, which is considered conservative, to determine an average K_h in the vicinity of the West OSS and East OSS. The estimated average K_h within the aquifer in the vicinity of the West OSS and East OSS drainfields is 74 feet per day (ft/d) and 45 ft/d, respectively.

i = Aquifer hydraulic gradient.

Comment: Determination of groundwater gradient requires at least three locations where groundwater elevation can be measured, at approximately the same date and time, within the aquifer. While two wells exist onsite and there are neighboring wells, a third well was unavailable for measurement. We used the default hydraulic gradient of 0.01, which is the default value recommended by DOH in the nitrate loading worksheet (Publication 337-070) when the on-site gradient is unknown (DOH, 2024b).

A = Cross-sectional area of the aquifer.

Comment: The maximum width of the aquifer underlying the proposed West OSS and East OSS primary drainfields, measured perpendicular to the groundwater flow direction, is approximately 140 feet and 210 feet (Figure 1). We used an aquifer thickness value of 20 feet based on measurements, by AESI, in the northern on-site well and the conditions described on exploration logs (PanGEO, 2024a).

Substituting the values estimated for the parameters discussed into Equation 2 results in a groundwater throughflow volume (Q) at the drainfields of 15,500 gpd (West OSS) and 14,138 gpd (East OSS).

Q (West OSS drainfield) = 15,500 gpd

Q (East OSS drainfield) = 14,138 gpd

Predicted Groundwater Nitrate Concentration in Shallow Aquifer

Nitrate Concentration at the POC

The predicted average nitrate concentration in the unconfined aquifer, assuming complete mixing between (1) the vertically infiltrating precipitation/drainfield effluent and (2) groundwater throughflow at the hydraulically downgradient boundary of the proposed West OSS and East OSS primary drainfields (POC (Figure 1)), was estimated using Equation 3 below.

Equation 3 $$N_{GW} = \frac{[(Q \; x \; N_B) + ((V_W + V_R) \; x \; N_i)]}{(Q + V_W + V_R)}$$ (DOH, 2024)

Where:

N_{GW} = Groundwater nitrate concentrations after mixing with groundwater throughflow at the point of compliance.

Q = Estimated groundwater throughflow in the aquifer (15,550 gpd (West OSS drainfield) and 14,138 gpd (East OSS drainfield)).

N_B = Background groundwater nitrate concentration (0.565 mg/l). The highest nitrate concentration measured from the two on-site wells was used as the background nitrate concentration (PanGEO, 2024a).

V_W = Volume of wastewater (1,111 gpd (West OSS) and 750 gpd (East OSS)).

V_R = Average recharge rate from rainfall over the OSS's primary drainfield (77 gpd (West OSS) and 68 gpd (East OSS).

N_i = Nitrate concentration at top of aquifer before mixing (25.27 mg/l (West OSS drainfield) and 24.76 mg/l (East OSS drainfield)).

Substituting the values estimated for the parameters in Equation 3 yields:

N_{GW} (West OSS) = 2.32 mg/l

N_{GW} (East OSS) = 1.89 mg/l

N_{GW} is the predicted average nitrate concentration in the unconfined aquifer at the downgradient edge of the proposed OSS's primary drainfields (POC).

Nitrate Concentration at the Alternative POC

Finally, in order to estimate the groundwater nitrate value at the POC_{ALT} (Figure 1), AESI used Equation 4, below, based on the Nitrogen Balance Equation presented in Appendix A on page 6 of Publication 337-069 (DOH, 2024a) and used in the DOH worksheet Publication 337-070 (DOH, 2024b). The POC_{ALT} for this project is considered the site's hydraulically downgradient western property boundary for the West OSS drainfield (Figure 1), which is approximately 140 feet south of the West OSS primary drainfield and is the downgradient northwestern property boundary (Figure 1) for the East OSS drainfield, which is approximately 110 feet northwest of the East OSS primary drainfield. These POC locations were used because they are the closest property boundary, in the downgradient direction, from each of the drainfields, which is a conservative assumption for the nitrate concentration calculations.

Equation 4 $$N_{GW\ Alt} = \frac{[((Q + V_W + V_R) x N_{GW}) + (V_{RD}\ x\ N_R(1-d))]}{(Q + V_W + V_R + V_{RD})}$$ (DOH, 2024b)

Where:

$N_{GW\ Alt}$ = Groundwater nitrate concentrations after mixing with precipitation recharge over the primary drainfield areas, groundwater throughflow, and precipitation recharge downgradient of the West OSS and East OSS primary drainfield to the POC_{ALT}.

Q = Estimated groundwater throughflow in the aquifer (15,550 gpd (West OSS drainfield) and 14,138 gpd (East OSS drainfield)).

V_W = Volume of wastewater (1,111 gpd (West OSS) and 750 gpd (East OSS)).

V_R = Average recharge rate from rainfall over the OSS's primary drainfield (77 gpd (West OSS) and 68 gpd (East OSS)).

N_{GW} = Groundwater nitrate concentrations after mixing with groundwater throughflow at the POC (2.32 mg/l (West OSS drainfield) and 1.89 mg/l (East OSS drainfield)).

V_{RD} = Average recharge rate from rainfall downgradient of the primary drainfield to the POC_{ALT} (428 gpd (West OSS) and 505 gpd (East OSS).

N_R = Nitrate concentration in infiltrating precipitation (0.24 mg/l, which is the value recommended by DOH on page 2 of Publication 337-069 [2024a]).

d = Fraction of nitrate lost to denitrification (10 percent, which is the value recommended by DOH on page 2 of Publication 337-069 (DOH, 2024a)).

Substituting the values estimated for the parameters in Equation 4 yields:

$N_{GW\ Alt}$ (West OSS) = 2.27 mg/l (1.71 mg/l above background)

$N_{GW\ Alt}$ (East OSS) = 1.83 mg/l (1.27 mg/l above background)

$N_{GW\ Alt}$ is the predicted average nitrate concentration in the aquifer at the requested POC_{ALT} for the West OSS and East OSS, which is the hydraulically downgradient western property boundary for the West OSS and the hydraulically downgradient northwestern property boundary for the East OSS.

CONCLUSIONS

The requested POC_{ALT} for the two proposed OSS's for this project are the hydraulically downgradient western property boundary (West OSS), which is approximately 140 feet west of the West OSS primary drainfield and the northwestern property boundary (East OSS), which is approximately 110 feet northwest of the East OSS primary drainfield. The groundwater flow direction underlying the proposed OSS's is reasonably assumed to be west or northwest. No wells, springs, or surface water bodies are present between the OSS's and the downgradient property boundaries.

Based on the analyses presented in this report and assuming an initial post-treatment nitrate concentration of 30 mg/l, our calculations predict an average nitrate concentration of 2.27 mg/l (West OSS) and 1.83 mg/l (East OSS) (Attachment B) in the aquifer at the nearest hydraulically downgradient property boundary of the project site (i.e., the requested POC_{ALT}). The nitrate concentration at the requested POC_{ALT}, is predicted to be 1.71 mg/l (West OSS) and 1.27 mg/l (East OSS) higher than the background nitrate value of 0.565 mg/l determined from the on-site well samples. DOH (2024a) defines an increase greater than 2 mg/l above the background nitrate concentration as a "moderate impact" which may require additional analysis. *Washington Administrative Code* (WAC) 246-290-310 designates a maximum contaminant level for nitrate of 10 mg/l. In addition, an Island County Public Health memorandum (Island County, 2025) indicates that "The post-mixing nitrate concentration in the aquifer (at the point of compliance) cannot exceed 5 mg/L." The nitrate concentrations at the POC_{ALT} for the West OSS and East OSS are below the DOH (2024a) and WAC (WAC 246-299-310) thresholds, and does not exceed the nitrate concentration indicated by Island County Public Health (2025). Based on the results of our analysis, we conclude that no further analysis or monitoring is required for the proposed West OSS and East OSS.

CLOSURE

This report has been prepared for the exclusive use of Emergence Institute, LLC and its agents for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted hydrogeologic practices in effect in this area at the time our report was prepared. No other warranty, express or implied, is made.

We appreciate the opportunity to be of continued service to the Emergence Whidbey project. If you have any questions or require additional information, please contact us at your earliest convenience.

Sincerely,
ASSOCIATED EARTH SCIENCES, INC.
Mount Vernon, Washington

Christopher W. Allen
Digitally signed by Christopher W. Allen
Date: 2025.09.24 14:54:09 -07'00'

State of Washington
Hydrogeologist
2594
Licensed Geologist
Christopher W. Allen

Jay W. Chennault, L.G., L.Hg., CWRE, P.E.
Principal Hydrogeologist

Christopher W. Allen, L.G., L.Hg.
Associate Hydrogeologist

ATTACHMENTS

Figure 1: Site Plan

Attachment A: Hydrogeologic Assessment Report by PanGEO
Attachment B: DOH Nitrate Loading Worksheets for West OSS and East OSS
Attachment C: Advantex® Information

REFERENCES

Bidlake, W.R. and Payne, K.L., 2001, Estimating recharge to ground water from precipitation at Naval Submarine Base Bangor and vicinity, Kitsap County, Washington: U.S. Geological Survey Water-Resources Investigations Report 01-4110.

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PanGEO Inc., 2025b, Geotechnical, infiltration, and critical areas report, Emergence Whidbey, Campbell Road and Maxwelton Road, Island County, Washington: Project No. 23-356.300, Prepared by PanGEO, Dated April 2025.

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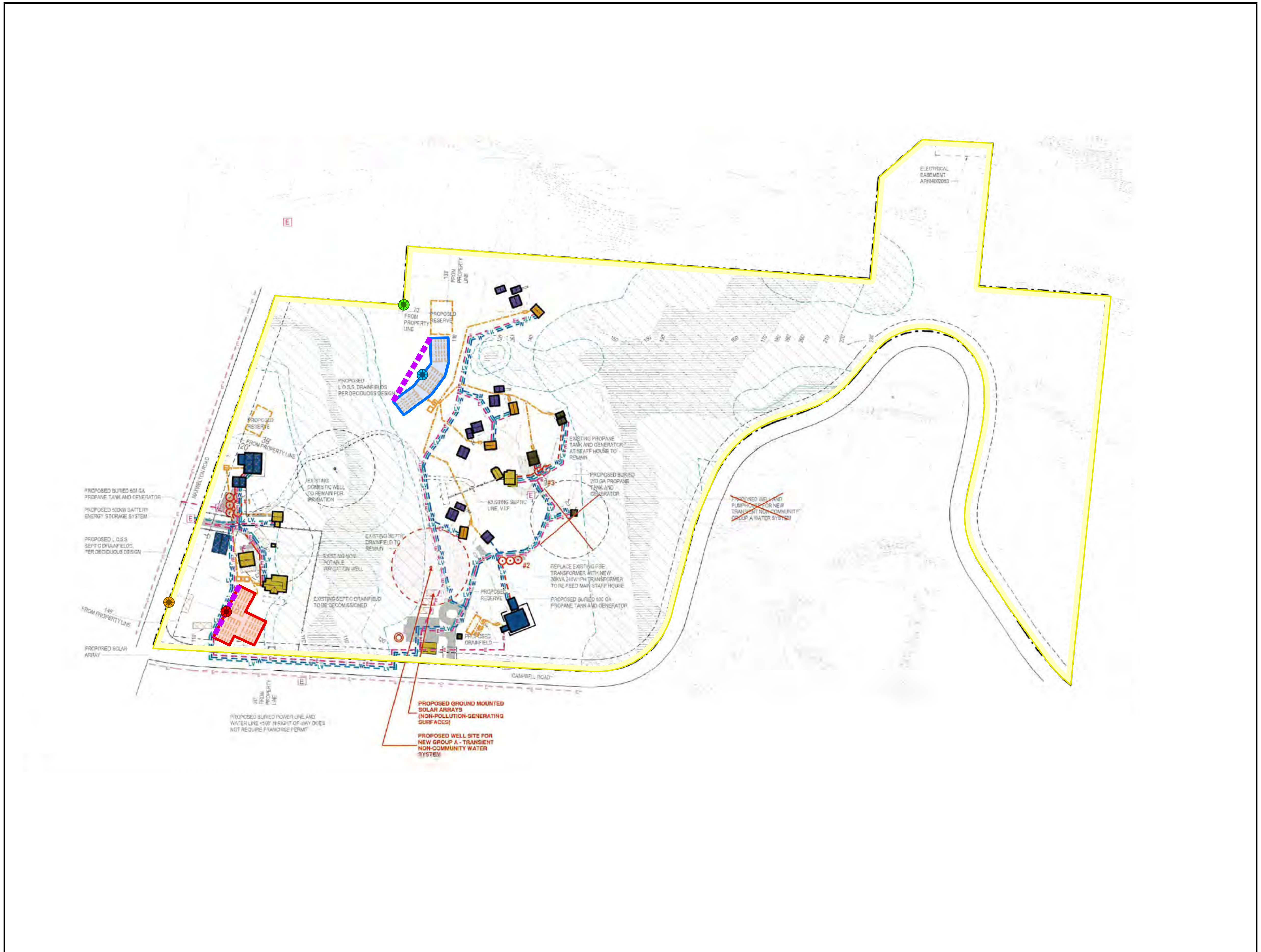
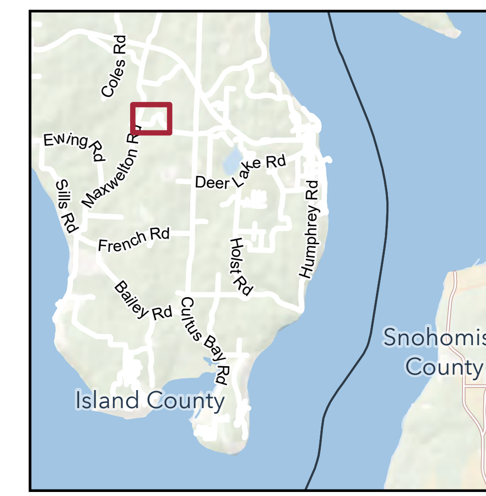
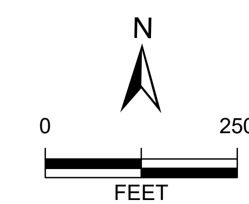


LEGEND

- SITE
- EAST OSS DRAINFIELD
- WEST OSS DRAINFIELD
- POINT OF COMPLIANCE FOR EAST OSS DRAINFIELD
- POINT OF COMPLIANCE FOR WEST OSS DRAINFIELD
- ALTERNATIVE POINT OF COMPLIANCE FOR EAST OSS DRAINFIELD
- ALTERNATIVE POINT OF COMPLIANCE FOR WEST OSS DRAINFIELD
- DRAINFIELD WIDTH





DATA SOURCES/REFERENCES:
MW|WORKS ARCHITECTURE + DESIGN, EMERGENCE INSTITUTE, SITE UTILITIES PLAN, SHEET A1.09, 06/03/2025.

BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION. LOCATION AND DISTANCES SHOWN ARE APPROXIMATE.

associated earth sciences incorporated

SITE PLAN

EMERGENCE WHIDBEY
ISLAND COUNTY, WASHINGTON

PROJECT NO.	DATE	FIGURE
20250119H002	9/25	1

ATTACHMENT A

Hydrogeologic Assessment Report by PanGEO

HYDROGEOLOGIC ASSESSMENT
EMERGENCE WHIDBEY
Parcels R32922-205-0620, R32922-245-0950, R32922-265-1920 and R32922-297-2250
Island County, Washington

PROJECT NO. 23-356.200, REV3

April 2025

Prepared for:

Emergence Institute, LLC
c/o: mw|works architecture+design llc

PanGEO INCORPORATED

Geotechnical & Earthquake
Engineering Consultants

PanGEO
INCORPORATED
Geotechnical & Earthquake
Engineering Consultants

April 22, 2025
Project No. 23-356.200 REV3

Emergence Institute, LLC
c/o: mw|works architecture+design llc
159 Western Avenue West, #484
Seattle, Washington 98119
Attention: Campie Ellis, AIA

Subject: **Hydrogeologic Assessment**
Emergence Whidbey
Whidbey Island, Washington

Dear Campie,

As requested, PanGEO, Inc. completed a hydrogeologic assessment for the proposed large on-site sewage systems (LOSS) for the Emergence Whidbey project in Whidbey Island, Washington. Our scope of services consisted of reviewing subsurface information collected at the site, public well records, water sampling data, and preparation of the attached report.

PanGEO also prepared a Geotechnical, Infiltration, and Critical Areas Report for the proposed development dated April 8, 2025.

The results of our Level 1 Nitrate Balance indicate the LOSS's will discharge at the point of compliance at greater than 2 mg/L above background levels and will have a moderate impact. We recommend a monitoring plan be established to determine background nitrate levels prior to build-out of the LOSS's and to monitor the performance of the LOSS's.

We appreciate the opportunity to assist you with this project. Please call if you have any questions.

Sincerely,

Scott D. Dinkelman, LEG
Principal Engineering Geologist

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Seattle, WA 98102
Tel (206) 262-0370
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TABLE OF CONTENTS

ATTACHMENTS:

HYDROGEOLOGIC ASSESSMENT
PROPOSED EMERGENCE WHIDBEY
WHIDBEY ISLAND, WASHINGTON

1.0 INTRODUCTION

This report presents the results of our hydrogeologic assessment of the proposed large on-site sewage systems for the Emergence Whidbey retreat center on Whidbey Island, Washington. Our study was performed in accordance with our mutually agreed scope of work as outlined in our agreement dated April 16, 2024. Our service scope included reviewing readily available geologic and geotechnical data in the vicinity of the site, conducting a site reconnaissance, sampling and testing the existing wells, and preparing this report summarizing our findings and recommendations.

2.0 SITE AND PROJECT DESCRIPTION

The subject site is located in the northeast corner of the intersection of Maxwelton Road and Campbell Road near Clinton in unincorporated Island County, Washington. The approximate location of the site is indicated in Figure 1, Vicinity Map.

The site consists of four parcels totaling approximately 40 acres (Island County parcels #R32922-245-0950, #R32922-205-0620, #R32922-265-1920, and #R32922-297-2250). The site is currently occupied by two single family residences and associated outbuildings, however, much of the site is currently undeveloped. The site is vegetated with Douglas fir, cedar, and big leaf maple trees and pasture.

The site is located on the west facing slope of a north south trending ridge and slopes down from the east to the west with about 125 feet of elevation change across the length of the site. In the central portion of the site is a southeast-northwest trending unnamed stream. The approximate layout of the site is shown in Figure 2, Site and Exploration Plan.

The subject site is being developed with a retreat center. The planned improvements will include constructing 20 new cabin suites in the east portion of the site, a dining hall and laundry facility in the west central portion of the site and constructing a gathering building/library in the southeast portion of the site. As part of the development, two large on-site sewer systems (LOSS) are planned to discharge effluent from the cabin clusters and the dining hall and laundry facility.

The LOSS's were designed by Deciduous Design Services. The details of the proposed LOSS designs are provided below.

Cabin Suite Clusters

- A drainfield area of 3,132 square feet
- The estimated peak wastewater flow of 1,000 gpd
- The system will be located 100 feet from the north property boundary in the direction of groundwater flow.

Dining Hall, Laundry and Farmhouse

- A drainfield area of 3,510 square feet
- Estimated peak wastewater flow of 1,481 gpd
- The system will be located about 140 feet from the west property boundary in the direction of groundwater flow

The waste strength that will be discharged to the LOSS's will be residential in nature. Pretreatment will be provided using Advantex AX20 treatment pods which will reduce nitrogen levels to below 30 mg/L.

Waste from the gathering building/library and existing staff residence will be discharged using residential septic systems and are not a consideration in our evaluation of the LOSS's.

3.0 SUBSURFACE EXPLORATIONS

3.1 TEST BORINGS

PanGEO previously completed eight test borings at the site on December 19, 2023 as part of an infiltration assessment. The approximate locations of our previous borings are shown in Figure 2.

The borings were drilled using a limited access drill rig equipped with 5-inch O.D. hollow stem augers. Soil samples were obtained from the borings at 2½- and 5-foot depth intervals. Standard penetration tests were performed in the borings using a 2-inch outside diameter split-spoon sampler.

A geologist from PanGEO was present throughout the field exploration program to observe the drilling, assist in sampling, and to document the soil samples obtained from the borings. The soil samples retrieved from the borings were described using the system outlined on Figure A-1 of Appendix A and the summary boring logs are included as Figures A-2 through A-9.

3.2 TEST PITS

We observed and logged the excavation of 11 test pits at the site on March 11, 2025. The test pits were excavated using a Hyundai track-mounted excavator provided by the client. The field exploration program was overseen by a geologist with our firm who logged and sampled the soils encountered in the test pits. The test pits were excavated to a maximum depth of about eight feet below existing grade. The approximate test pit locations were located in the field relative to the site boundaries and features and are shown in Figure 2, Site and Exploration Plan.

We excavated seven test pits for infiltration testing purposes and four test pits to evaluate bearing soil conditions for the proposed cabins. The infiltration pits are identified as PIT-1 through PIT-7. The cabin test pits are identified as TP-1 through TP-4.

The soils were logged using the system summarized on Figure A-1, Terms and Symbols for Boring and Test Pit Logs. Summary test pit logs are included in Appendix B and provide detailed descriptions of the materials encountered, depths to soil contacts, and depths of seepage or caving, if present. Where soil contacts were gradual or undulating, the average depth of the contact was recorded on the log.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

PanGEO reviewed existing data, reports, and well logs to form an understanding of the subsurface and groundwater conditions near the subject site. Site specific data was collected as part of the infiltration study conducted by PanGEO in 2024 (PanGEO, 2024) and were supplemented using publicly available geologic maps, review of the USDA soil survey, off-site well logs obtained from the Washington Department of Ecology Well Log Database, Island County GIS, and the Island County Hydrogeology Dashboard.

4.1 SITE GEOLOGY

Based on review of the *Preliminary Geologic Map of the Maxwelton Quadrangle, Island County, Washington* (Dethier, *et al.*, 1981), the geologic units in the area of the site include Vashon Till (Geologic Map Unit Qvt) and Vashon Advance Outwash (Geologic Map Unit Qva). The principal characteristics of these geologic units are summarized below:

- Vashon till generally consists of an unsorted deposit (diamict) of clay, silt, sand and gravel that was been deposited glaciers during the Vashon Stade of the Fraser glaciation. In the area of the site, the till forms a discontinuous mantle and is mapped as thin, less than six feet thick, patchy, and has a relatively high percentage of sand and gravel and relatively low percentage of fines (silt and clay sized particles) and has a relatively high hydraulic conductivity.
- Advance outwash stratigraphically underlies till and is described as well-stratified gray pebbly sand with gravel interbeds that was deposited by meltwater streams near the advancing ice sheet. This deposit ranges from 80 to 160 feet thick.
- Early Vashon and pre-Vashon fine grained deposits consisting of silt and fine sand underly the Vashon advance outwash.

4.2 USDA Soil Map Review

We reviewed the USDA Natural Resource Conservation Service (NRSC) Soil Survey (NRCS, 2024) for surficial soil information. The west, gently sloping portion of the site is underlain by Indianola loam sand 0 to 5 percent slopes and 3 to 16 percent slopes while the east, more steeply portion of the site is underlain by Utsalady-Uselessbay complex 2 to 12 percent slopes. Indianola soils formed in sandy glacial outwash while Utsaladay-Uselessbay soils formed in less-sandy glacial outwash.

These soils are known for being highly permeable with saturated hydraulic conductivities in the range of 6 to 100 inches per hour or 12 to 200 feet per day.

4.4 Soil Conditions

For a detailed description of the subsurface conditions encountered at each exploration location, please refer to our boring logs provided in Appendix A and test pit logs provided in Appendix B. The stratigraphic contacts indicated on the boring and test pit logs represent the approximate depth to boundaries between soil units. Actual transitions between soil units may be more gradual or occur at different elevations. The descriptions of groundwater conditions and depths are likewise approximate.

- **Topsoil and Forest Duff:** At most of our test pit and boring locations, we encountered topsoil or forest comprised of loose, silty sand with organics and leaf litter. The topsoil and forest duff layer ranged from 6 to 12 inches thick.

- **Fill:** At the location of Test Pit TP-4, we encountered about two feet of loose silty fine sand containing organics debris that has a disturbed texture. Based on the disturbed texture and the presence of a buried topsoil horizon at the base of the layer, we classified this material as fill.
- **Alluvium:** At the location of Test Pit PIT-1 we encountered medium dense gravelly sand and gravel with silt and sand to about five feet below grade. We classified this material as alluvial deposits consisting of colluvium or slopewash generated from the adjacent slopes and stream channel deposits associated with the unnamed stream that flows through the site.
- **Vashon Till (Qvt):** At the locations of Test Boring PG-2 in the northwest portion of the site, borings PG-5 and PG-8 in the east portion of the site, below the alluvium encountered in Test Pit PIT-1 and in Test Pit TP-1, we encountered medium dense to very silty sand and fine to medium sand gravel and silt that appeared consistent with the mapped Vashon till unit. In general, the grain size distribution of the till was similar to the advance outwash, but contained a relatively higher percentage of silt and clay.
- **Advance Outwash (Qva):** At the locations of Borings PG-1, PG-3, PG-4, PG-6, PG-7 and Test Pits PIT-2 through PIT-7 and TP-2 through TP-4, we encountered medium dense to dense poorly graded sand with varying amounts of gravel and silt. The material appeared to be consistent with the mapped Advance Outwash.

Our subsurface descriptions are based on the conditions encountered at the time of our exploration. Soil conditions between our exploration locations may vary from those encountered. The nature and extent of variations between our exploratory locations may not become evident until construction. If variations do appear, PanGEO should be requested to reevaluate the recommendations in this report and to modify or verify them in writing prior to proceeding with earthwork and construction.

4.5 Well Log Review

The site is located in a rural area and groundwater is the primary source of water for nearby properties. We identified nine wells located within one quarter mile of the site, including two wells at the site, a water supply well (Domestic Well) and a well that is used for irrigation

(Irrigation Well). Well records for the onsite wells and wells on the adjacent property to the north (6205 and 6165 Maxwelton Road) could not be located.

The locations of the reviewed wells are approximately shown in Figure 3. Well logs for the reviewed logs are provided in Appendix C.

4.6 Surface Water in the Project Vicinity

A north south trending unnamed stream extends through the west-central portion of the site. The stream enters the site at the south through a culvert below Campbell Road and exists the site at the northwest through a culvert below Maxwelton Road. The unnamed stream eventually discharges to Miller Lake about 1,200 feet northwest of the site.

5.0 HYDROGEOLOGY

We identified nine water supply well logs within a one quarter mile radius of the site. The approximate locations of these well logs are shown in Figure 3. Copies of the well logs are included in Appendix C.

5.1 Groundwater Occurrence and Aquifer Properties

Hydrogeologic units that conduct significant groundwater flow are known as aquifers. Hydrogeologic units that significantly retard or block groundwater flow are known as aquitards or confining layers. Based on review of the nearby well logs hydrogeologic units present at the site from shallowest to deepest are:

Vashon Till – Till is typically an aquitard or confining layer, however in the vicinity of the site, the till is patchy, thin and contains relatively lower fines than a typical till. However, due to its soil structure, the Vashon till on site has low permeability

Vashon Advance Outwash Aquifer – Vashon advance outwash is the shallow aquifer that underlies the site. This unit consists of sand with pebbly gravel and small amounts of silt and clay. Static water elevations range from 78½ to 65 feet and descend from the southeast to the northwest. We interpret flow in the shallow aquifer is to the northwest.

Early Vashon and Pre-Vashon Deposits – This hydrogeologic unit consists of fine-grained deposits and represents a lower aquitard making up the base of the Vashon advance outwash aquifer. The water wells reviewed as part of this study generally did not encounter early Vashon or Pre-Vashon deposits except for well 78K which encountered a clay layer at 106 feet below grade.

This unit may have been encountered in the Kyllonen Hill Water Associations well (78K) at about 106 feet below grade.

5.2 Interpretation of Well Logs

Based on our interpretation of the well logs, the five logs reviewed as part of this study are screened in the advance outwash shallow aquifer.

5.3 Depth to Groundwater and Flow Direction

The water table in the shallow aquifer is at about elevation 60 to 80 feet in the area of the site. Groundwater elevation contours are presented in Figure 3 and show the direction of groundwater flow is from the southeast to the northwest. Figure 4 is a Hydrogeologic Profile that shows the relationship between the subsurface units and groundwater levels.

5.4 Background Nitrate Levels

Background nitrate levels were determined by sampling the Domestic Well and Irrigation Well at the site and reviewing records of previous water quality sampling of the Domestic Well provided by the client. A summary of the results of our sampling and testing are provided in Table 1, below. The analytical testing results are included in Appendix D.

TABLE 1: Well Nitrate Levels

Date	Nitrate Levels [mg/L]			
	Domestic Well	Irrigation Well	Creek [upstream]	Creek [downstream]
March 11, 2025	0.499	Not Detected	0.968	0.895
August 19, 2024	0.565	0.408	0.436	Not Sampled
May 7, 2024	0.514	Not Sampled	Not Sampled	Not Sampled
February 16, 2021	0.44	Not Sampled	Not Sampled	Not Sampled

5.5 GROUNDWATER

Test borings PG-4 and PG-6 encountered perched groundwater during drilling on December 19, 2023. Both borings are located near the northwest corner of the site. The groundwater was encountered within perched within advance outwash. In boring PG-4, the wet soil layer was about 3½-feet thick, located between 4½ to 8 feet below existing grade. In boring PG-6, the perched groundwater layer was about one-foot thick, located between 5 and 6 feet below existing ground surface.

We did not observe indications of groundwater in the other six test borings during drilling.

Groundwater elevations in the shallow advance outwash aquifer range from elevation 60 to 80 feet. We used water elevation data from review of the nearby well logs to estimate site direction of groundwater flow in the shallow advance aquifer. Based on our review, groundwater flow is from the southeast to the northwest, generally following the regional topography.

It should also be noted that groundwater elevations may vary depending on the season, local subsurface conditions, and other factors. Groundwater levels are normally highest during the winter and early spring.

6.0 DISCUSSION

6.1 FATE OF NITRATE IN THE SUBSURFACE

The potential for nitrate contamination below septic drainfield has become a primary concern regarding groundwater quality and drinking water supplies. The Washington State Department of Health has established a primary maximum contaminate level (MCL) for nitrate contamination in groundwater of 10 mg/L under Chapter 173-200 of the Washington Administrative Code (WAC), Water Quality Standards for Groundwaters of the State of Washington.

6.2 NITRATE BALANCE EQUATION

The DOH uses a Nitrate Balance Equation as a screening tool to identify LOSS's which may have potential impacts to the underlying aquifers. The analysis takes into account the denitrification that occurs in the unsaturated zone above the water table and dilution due to groundwater recharge due to precipitation. This results in a net concentration and an overall average flowrate for mixed water and filtrate that infiltrates down to the groundwater table, where it recharges the groundwater. The equation used to evaluate LOSS's is provided below along with a summary of the values used in our analysis is shown below.

$$N_{GW} := \frac{\left(\left(Q \cdot N_B\right) + \left(V_W \cdot N_W \cdot (1-d)\right) + \left(V_R \cdot N_r\right)\right)}{\left(Q + V_W + V_r\right)}$$

Where:

$$Q := K \cdot i \cdot b \cdot W_A$$

Where:

$$V_R := A_D \cdot R \cdot 0.0017$$

- N_{GW} - Nitrate concentration in groundwater at the selected point of compliance. The Level I Nitrate Balance requires considering two points of compliance, the edge of the drainfield and the property boundary. These locations are shown in Figure 2.
- N_B - Nitrate concentration in precipitation. The default value of 0.24 mg/L was used to account for nitrates in precipitation from natural and man-made sources.
- Nw – Nitrogen concentration in wastewater. The septic designer provided a value of 30 mg/L based on the use of the Advantex AX20 pretreatment pods.
- d – Soil denitrification. The default value of 10 percent was used.
- b – Aquifer thickness. Based on review of the Kyllonen Hill water system well (78K), the aquifer in the vicinity of the site is about 50 feet thick. The Level I Nitrate Balance specifies a default value of 20 feet or the actual aquifer thickness, whichever is less. We used 20 feet.
- D_{pb} – Distance from drainfield to property boundary. We used a value of 8 feet for the Dining Hall/Laundry drainfield and 110 feet for the Cabin Suites drainfield based on design information provided by Deciduous Design Services.
- W_A – Aquifer width perpendicular to the direction of groundwater flow. We used a value of 140 feet for the Dining Hall/Laundry drainfield and 210 feet for the Cabin Suites drainfield.
- K – Hydraulic conductivity. We used a value of 15 feet per day for advance outwash deposits which is the predominate unit in the shallow aquifer. This value was based on review of the Geology of Seattle, Washington (Galster and Laprade, 1999) which provide a range of hydraulic conductivities for advance outwash of 0.33 feet per day to 330 feet per day. The value is also consistent with the saturated hydraulic conductivity results from

the five infiltration tests conducted at the site which yielded saturated hydraulic conductivities of 24 to 28.8 feet per day feet per day and an average of 26.2 feet per day.

- i – Hydraulic gradient of the aquifer. Synoptic groundwater level readings, i.e., obtained within a short period of time, are not available for water supply wells in the study area. Therefore, we used the default value of 0.01 feet per foot.
- A_D – This value corresponds to the area of the drainfield which was provided by Deciduous Design. A value 3,348 square feet was used for the Dining Hall/Laundry drainfield and a value of 3,132 square feet was used for the Cabin Suites.
- R – Rate of recharge due to precipitation as a percent of the annual precipitation. We used 35 percent of the annual precipitation for Island County of 24 inches or 8.4 inches.
- N_B – Nitrate concentration of upgradient groundwater. The Domestic Well was sampled in May 2024 and August 2024. We used a value of 0.565 based on the August 2024 sample.

6.3 Summary

Based on the assumptions described above, we calculated a nitrate concentration in the shallow aquifer at the edge of the drainfields of 8.94 mg/L and 5.15 mg/L for the Dining Hall/Laundry LOSS and Cabin Suites LOSS, respectively. The nitrate concentration at the property boundary will range from to 8.44 mg/L to 4.88 mg/L for the Dining Hall/Laundry LOSS and Cabin Suites drainfield, respectively. The results of the nitrogen balance calculations are provided in Figures 5 and 6. The concentration of nitrate is less than the Washington State Drinking Water Standard of 10.0 mg/L but exceeds 2 mg/L above the background nitrate level and as such would represent a moderate impact to groundwater. Therefore, we recommend a monitoring program be established to record background nitrate levels prior to building out of the LOSS's and to monitor the performance of the LOSS's.

7.0 RECOMMENDATIONS

7.1 General

The results of our Level 1 Nitrate Balance indicate the LOSS's will discharge at the point of compliance at greater than 2 mg/L above background levels. Several assumptions were made for this hydrogeologic assessment. Values for denitrification by soils, amount of effluent per dwelling unit, effectiveness of the treatment system, and shallow aquifer characteristics are a few of the factors that could influence the analysis results. In general, conservative or default values were used to provide a conservative assessment for a permit-level review of the planned improvements.

Because of the uncertainties involved with the analysis, we recommend the Emergence Whidbey project incorporate design features that can reduce the amount of effluent reaching the LOSS's and measures that can enhance denitrification. We also recommend the implementation of a nitrate monitoring program as outlined below.

7.2 MONITORING PLAN

The following monitoring program is intended to provide additional information on the denitrification performance of the proposed LOSS's. The monitoring program should include monitoring the existing stream, the existing wells upgradient of the LOSS's, the domestic wells downgradient of the LOSS's, the monitoring of new monitoring wells installed in the shallow aquifer downgradient of the LOSS's, and the effluent from the Advantex AX20 treatment system The following is a description of the monitoring locations:

- The two new monitoring wells should be located downgradient of the LOSS drainfields along the west and north property boundaries. The monitoring wells should be completed as 2-inch PVC standpipe piezometers screened in the shallow aquifer, with an anticipated depth of 40 to 60 feet below the grade.
- The Domestic Well and Irrigation Well on-site should be monitored to establish a baseline of the upgradient groundwater quality.
- Surface water samples should be collected from the stream where it enters the south end of the site at the crossing with Campbell Road and where the stream exits the site at the intersection with Maxwelton Road.
- The effluent from the Advantex AX20 treatment pods should be sampled to monitor the effectiveness of the denitrification process and to monitor the effluent quality entering the LOSS drainfields.
- If feasible, the wells at 6205 Maxwelton Road and 6165 Maxwelton Road, down gradient of the site should be included in the baseline monitoring and post-built out monitoring.

We recommend that the monitoring plan start as soon as practical to establish background levels of nitrogen compounds. The monitoring program should follow the following schedule:

- Prior to the build-out of the LOSS's, sampling of the Domestic Well, Irrigation Well and stream should be performed twice a year to establish baseline conditions.

- After the build-out of the LOSS's, sampling of the monitoring wells, Domestic Well, Irrigation Well, stream and the neighboring wells at 6205 Maxwelton Road and 6165 Maxwelton Road should be performed quarterly for two years to monitor the system performance and operating conditions.
- Two years after build-out of the LOSS's, the monitoring frequency can be reduced to twice a year or annually if the monitoring results indicate that significant water quality changes have not occurred.

The analytical results should be reviewed and compiled in annual reports and submitted to Island County. The annual report should include a map of the sampling locations, laboratory analyses, trench analysis, and recommendations for future monitoring.

8.0 LIMITATIONS

We have prepared this report for use by Emergence Institute, LLC and their designers and consultants. Conclusions and recommendations contained in this report are based on a site reconnaissance, a subsurface exploration program, review of pertinent subsurface information, and our understanding of the project. The study was performed using a mutually agreed-upon scope of work.

Variations in soil conditions may exist between the locations of the explorations and the actual conditions underlying the site. The nature and extent of soil variations may not be evident until construction occurs. If any soil conditions are encountered at the site that are different from those described in this report, we should be notified immediately to review the applicability of our recommendations. Additionally, we should also be notified to review the applicability of our recommendations if there are any changes in the project scope.

The scope of our work does not include services related to construction safety precautions. Our recommendations are not intended to direct the contractors' methods, techniques, sequences or procedures, except as specifically described in our report for consideration in design. Additionally, the scope of our work specifically excludes the assessment of environmental characteristics, particularly those involving hazardous substances.

This report has been prepared for planning and design purposes for specific application to the proposed project in accordance with the generally accepted standards of local practice at the time this report was written. No warranty, express or implied, is made.

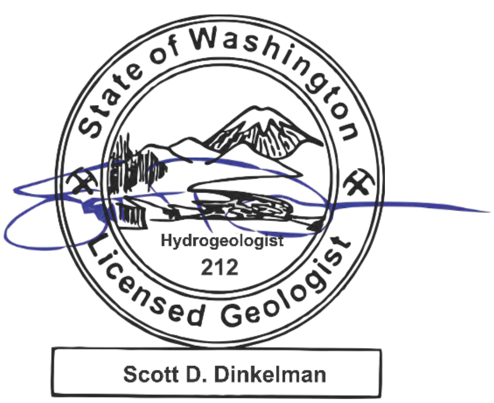
This report may be used only by the client and for the purposes stated, within a reasonable time from its issuance. Land use, site conditions (both off and on-site), or other factors including advances in our understanding of applied science, may change over time and could materially affect our findings. Therefore, this report should not be relied upon after 24 months from its issuance. PanGEO should be notified if the project is delayed by more than 24 months from the date of this report so that we may review the applicability of our conclusions considering the time lapse.

It is the client's responsibility to see that all parties to this project, including the designer, contractor, subcontractors, etc., are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the contractor's option and risk. Any party other than the client who wishes to use this report shall notify PanGEO of such intended use and for permission to copy this report. Based on the intended use of the report, PanGEO may require that additional work be performed and that an updated report be reissued. Noncompliance with any of these requirements will release PanGEO from any liability resulting from the use this report.

We appreciate the opportunity to be of service.

Respectfully submitted,

PanGEO, Inc.



Scott D. Dinkelman, LEG, LHG
Principal Hydrogeologist

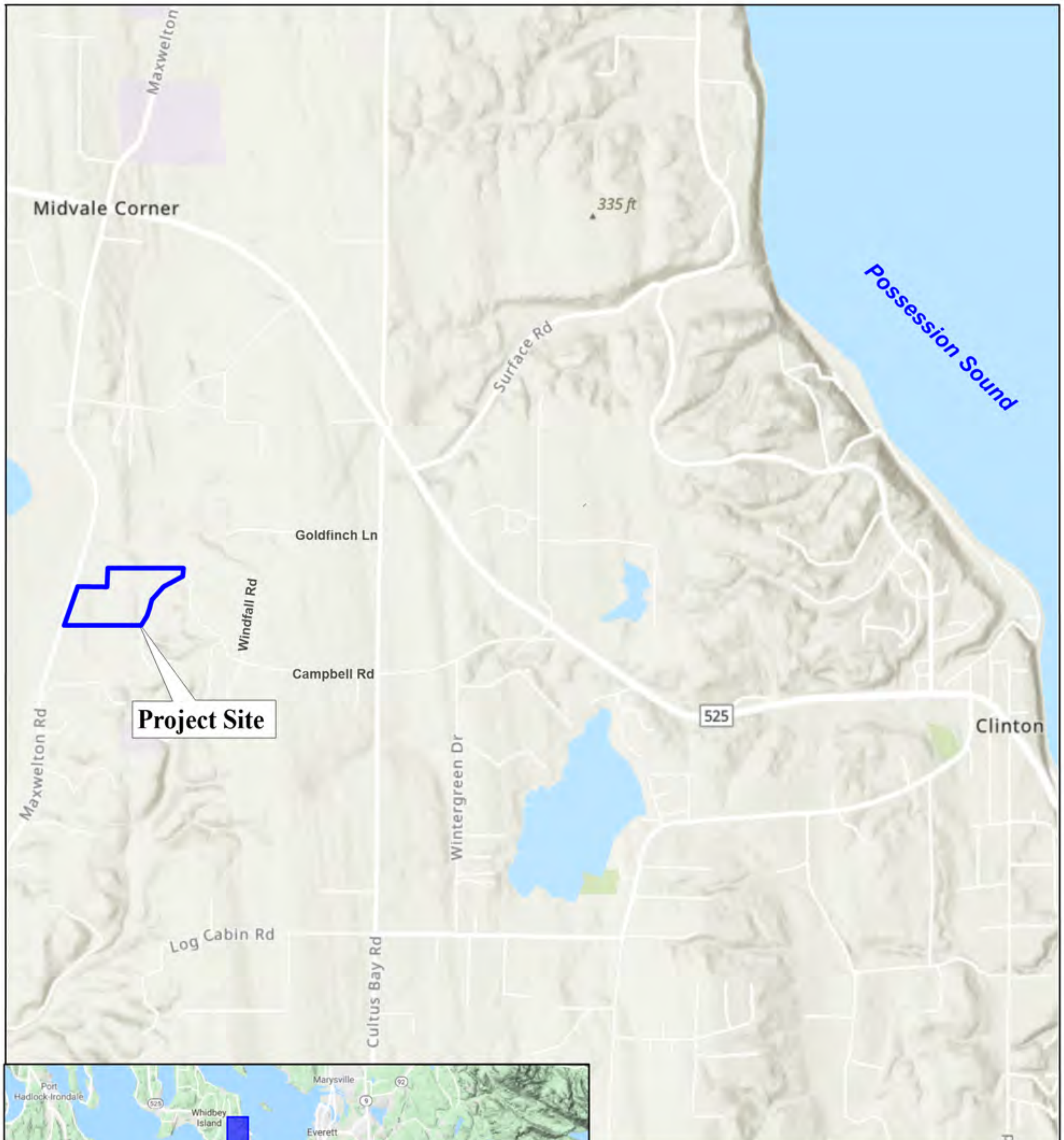
9.0 REFERENCES

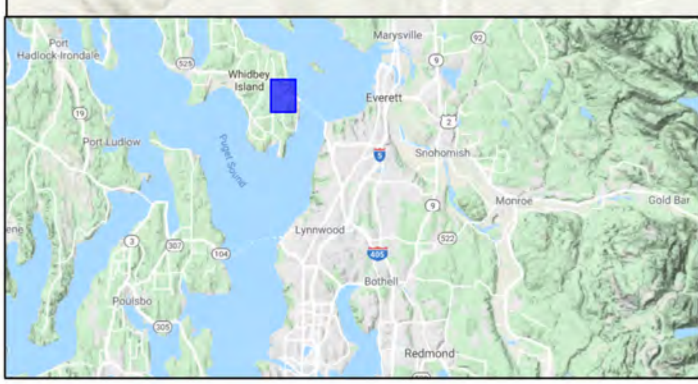
Deciduous Design Services, 2024, Wastewater Flow Estimates for Proposed Retreat Center, Parcels R32922-205-0620, R32922-245-0950, and R32922-265-1920, two pages and one sheet.

Dethier, D. P., Safioles, S.A., and Minard, J.P., 1981, Preliminary Geologic Map of the *Maxwelton Quadrangle, Island County, Washington* – U. S. Geological Survey Open File Report 82-192, scale 1:24,000.

Galster, R.W., and Laprade, W.T., 1991, Geology of Seattle, Washington, Bulletin of the Association of Engineering Geologists, v. 28, no. 3, p. 235-302

Washington Department of Health (DOH), 2013. Publication #337-069 (Revised October 2013) Level 1 Nitrate Balance Instructions for Large On-site Sewage Systems.



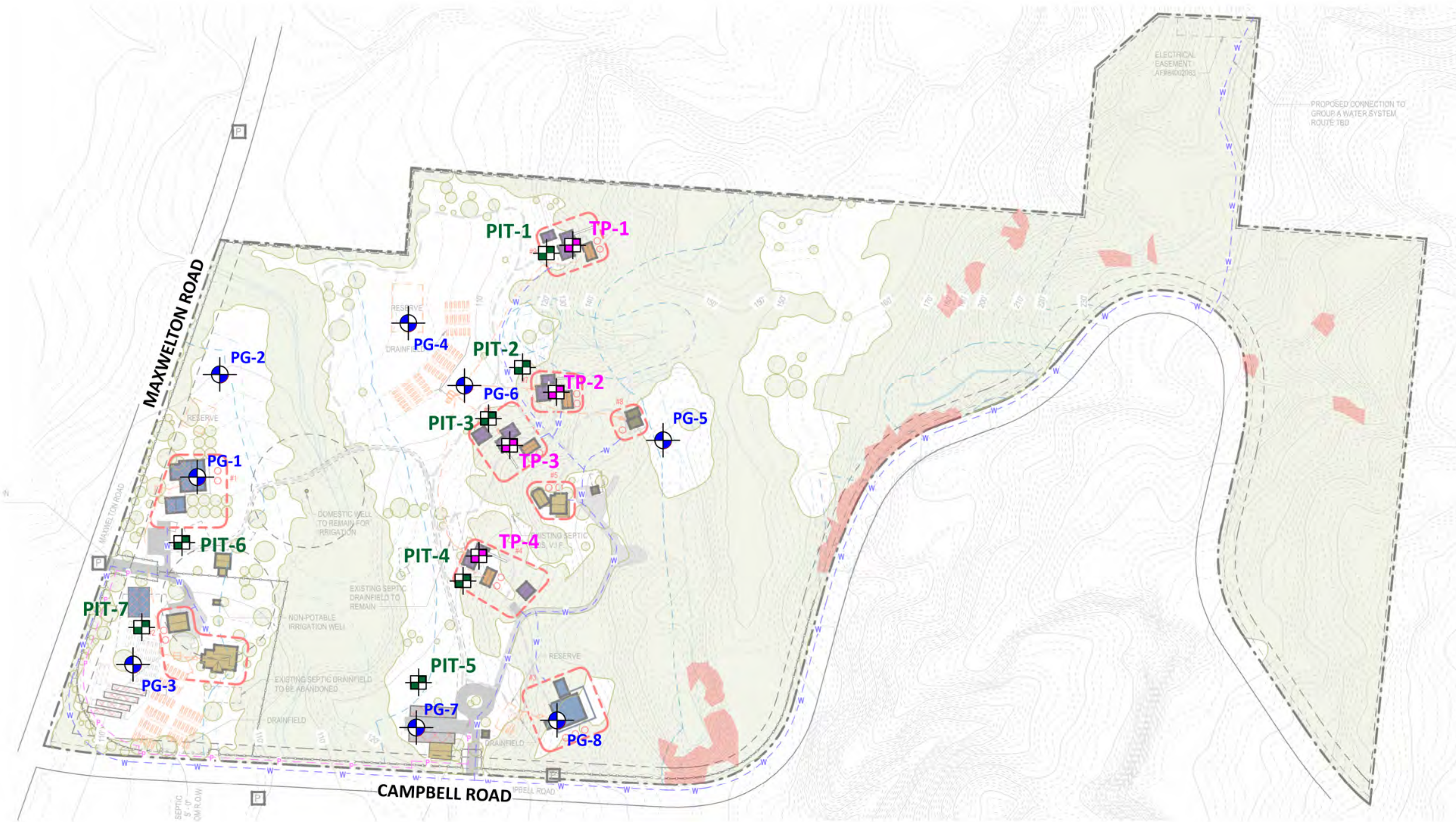


Base Map: ESRI Topographic

NORTH

Not to Scale

PanGEO INCORPORATED	Emergence Whidbey Campbell Road and Maxwelton Road Island County, WA	VICINITY MAP	
		Project No. 23-356.300	Figure No. 1



LEGEND:

Subject Site

Approximate Extent of 40 Percent Slopes Greater than 10 Feet in Height

Approximate Boring Location, PanGEO, Inc.

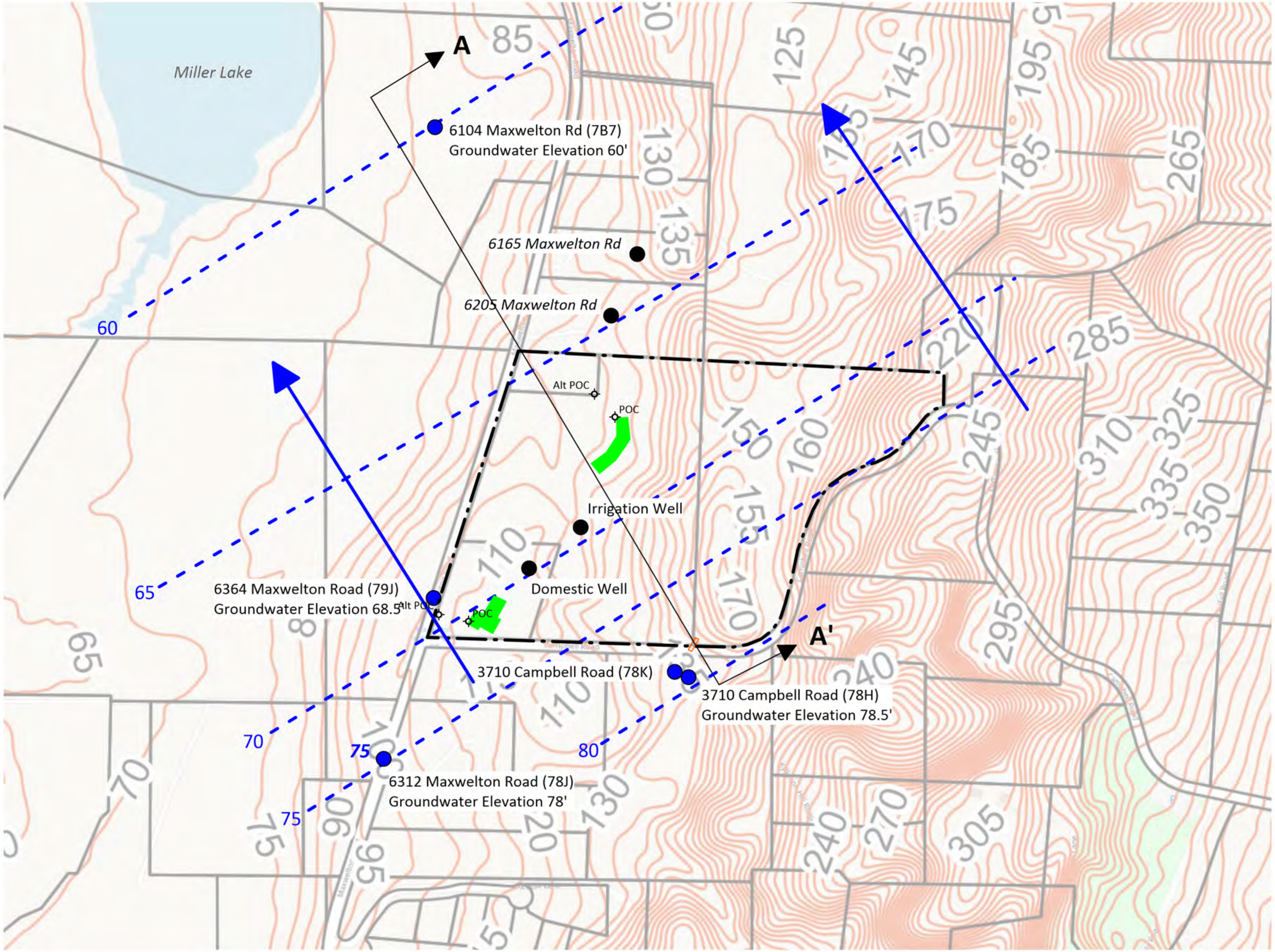
Approximate Infiltration Test Location, PanGEO, Inc.

Approximate Test Pit Location, PanGEO, Inc.

Note: Site plan modified from Site Plan Utilities by mw|works, dated January 14, 2025.

PanGEO INCORPORATED	Emergence Whidbey Campbell Road and Maxwelton Road Island County, WA	SITE AND EXPLORATION PLAN	
		Project No. 23-356.300	Figure No. 2

13-011_Fig 2 Site & Exploration Plan.grf 4/7/25 JCR



LEGEND:

- Subject Site
- Approximate Location of Proposed LOSS
- Approximate Location of Water Well, Log Not Available
- Approximate Location of Water Well, Log Available, See Appendix B
- Groundwater Contours
- Hydrogeologic Cross-Section, See Figure 4

NORTH

Approx. Scale (feet)

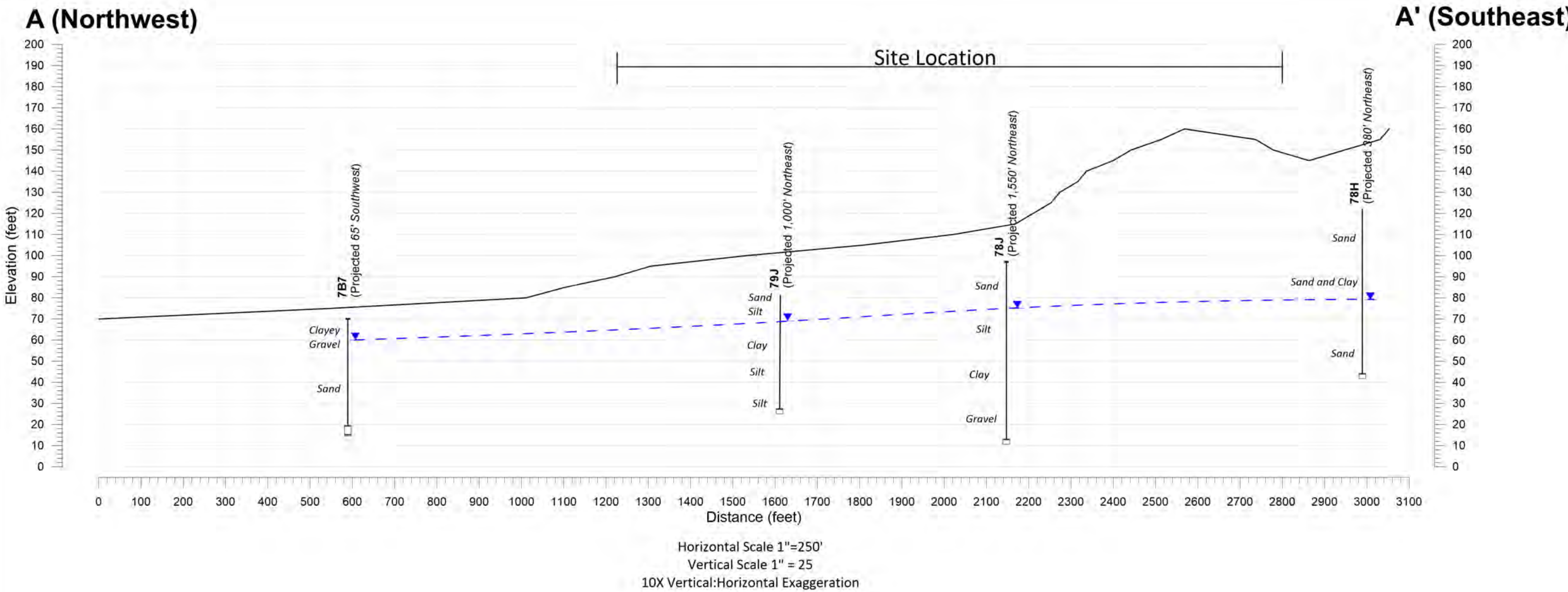
0 200 400

PanGEO INCORPORATED

Emergence Whidbey Campbell Road and Maxwelton Road Island County, WA

GROUNDWATER ELEVATION AND FLOW DIRECTION

Project No.	23-356.300	Figure No.	3



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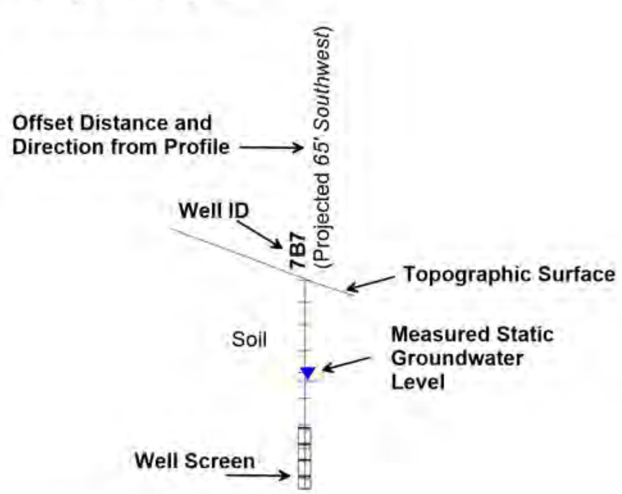

PanGEO INCORPORATED

Emergence Whidbey Campbell Road and Maxwelton Road Island County, WA

HYDROGEOLOGIC PROFILE A-A'

Project No. 23-356.300 | Figure No. 4

Large On-Site Sewage System (LOSS)

LEVEL 1 NITRATE BALANCE

Project name:	**Whidbey Compound - Emergence - Dining Hall, Laundry and Farmhouse**
Address, city and county:	**Island County parcels #R32922-245-0950, #R32922-205-0620, #R32922-265-1920, and #R32922-297-2250)**
Completed by (name and title):	**Scott Dinkelman, Principal Hydrogeologist**
Date:	**1/14/2025**

Input Values		**Factor**	**Units**	**Values**	Instructions	**Information Source**
Nitrate concentration in precipitation		N_R	mg/l as N	0.24	Default	Default Value
Total nitrogen concentration in wastewater		N_W	mg/l	30		
Soil denitrification		d	unitless	0.1	Default	Default Value
Aquifer thickness		b	ft	20	Default or aquifer thickness if known	Default Value
Drainfield area		A_D	ft^2	3,510	Primary drainfield area	Deciduous Design Services
Distance from drainfield to property boundary		D_{pb}	ft	140	Measure in direction of GW flow	Deciduous Design Services
Aquifer width		W_A	ft	140	Perpendicular to GW flow	Deciduous Design Services
Aquifer hydraulic conductivity		K	ft/day	15	Measured or literature value	Galster, R.W., and Laprade, W.T., 1991, Geology of Seattle, Washington
Hydraulic gradient		i	ft/ft	0.010	If unknown, use 0.01	Default Value Used
Recharge		R	in/yr	8.40	Recharge will be a % of ppt	35% of Island County Annual Precip of 24"
Nitrate concentration of upgradient ground water		N_B	mg/l	0.565	Prefer sampling data	Domestic Well sampling
Wastewater volume		V_W	gpd	1,481	Design flows or measured volume	Deciduous Design Services
Output Values						
Groundwater nitrate value		N_{GW}	mg/l as N	8.94	Point of Compliance (POC)	
Groundwater nitrate value		$N_{GW\ ALT}$	mg/l as N	8.44	Alternative POC	

Figure 5

Washington State Department of HEALTH

Large On-Site Sewage System (LOSS)
LEVEL 1 NITRATE BALANCE

Project name:	**Whidbey Compound - Emergence - Cabin Suites**
Address, city and county:	**Island County parcels #R32922-245-0950, #R32922-205-0620, #R32922-265-1920, and #R32922-297-2250)**
Completed by (name and title):	**Scott Dinkelman, Principal Hydrogeologist**
Date:	**1/14/2025**

Input Values	Factor	Units	Values	Instructions	Information Source
Nitrate concentration in precipitation	N_R	mg/l as N	0.24	Default	Default Value
Total nitrogen concentration in wastewater	N_W	mg/l	30		
Soil denitrification	d	unitless	0.1	Default	Default Value
Aquifer thickness	b	ft	20	Default or aquifer thickness if known	Default Value
Drainfield area	A_D	ft^2	3,132	Primary drainfield area	Deciduous Design Services
Distance from drainfield to property boundary	D_{pb}	ft	110	Measure in direction of GW flow	Deciduous Design Services
Aquifer width	W_A	ft	210	Perpendicular to GW flow	Deciduous Design Services
Aquifer hydraulic conductivity	K	ft/day	15	Measured or literature value	Galster, R.W., and Laprade, W.T., 1991, Geology of Seattle, Washington
Hydraulic gradient	i	ft/ft	0.010	If unknown, use 0.01	Default Value Used
Recharge	R	in/yr	8.40	Recharge will be a % of ppt	35% of Island County Annual Precip of 24"
Nitrate concentration of upgradient ground water	N_B	mg/l	0.565	Prefer sampling data	Domestic Well sampling
Wastewater volume	V_W	gpd	1,000	Design flows or measured volume	Deciduous Design Services
Output Values					
Groundwater nitrate value	N_{GW}	mg/l as N	5.15	Point of Compliance (POC)	
Groundwater nitrate value	$N_{GW\ ALT}$	mg/l as N	4.88	Alternative POC	

Figure 6

APPENDIX A
SUMMARY BORING LOGS

RELATIVE DENSITY / CONSISTENCY

SAND / GRAVEL			SILT / CLAY		
Density	SPT N-values	Approx. Relative Density (%)	Consistency	SPT N-values	Approx. Undrained Shear Strength (psf)
Very Loose	<4	<15	Very Soft	<2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250 - 500
Med. Dense	10 to 30	35 - 65	Med. Stiff	4 to 8	500 - 1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000 - 2000
Very Dense	>50	85 - 100	Very Stiff	15 to 30	2000 - 4000
			Hard	>30	>4000

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS		GROUP DESCRIPTIONS	
Gravel 50% or more of the coarse fraction retained on the #4 sieve. Use dual symbols (eg. GP-GM) for 5% to 12% fines.	GRAVEL (<5% fines)	GW	Well-graded GRAVEL
		GP	Poorly-graded GRAVEL
	GRAVEL (>12% fines)	GM	Silty GRAVEL
		GC	Clayey GRAVEL
Sand 50% or more of the coarse fraction passing the #4 sieve. Use dual symbols (eg. SP-SM) for 5% to 12% fines.	SAND (<5% fines)	SW	Well-graded SAND
		SP	Poorly-graded SAND
	SAND (>12% fines)	SM	Silty SAND
		SC	Clayey SAND
Silt and Clay 50%or more passing #200 sieve	Liquid Limit < 50	ML	SILT
		CL	Lean CLAY
		OL	Organic SILT or CLAY
	Liquid Limit > 50	MH	Elastic SILT
		CH	Fat CLAY
		OH	Organic SILT or CLAY
Highly Organic Soils		PT	PEAT

Notes: 1. Soil exploration logs contain material descriptions based on visual observation and field tests using a system modified from the Uniform Soil Classification System (USCS). Where necessary laboratory tests have been conducted (as noted in the "Other Tests" column), unit descriptions may include a classification. Please refer to the discussions in the report text for a more complete description of the subsurface conditions.

2. The graphic symbols given above are not inclusive of all symbols that may appear on the borehole logs. Other symbols may be used where field observations indicated mixed soil constituents or dual constituent materials.

DESCRIPTIONS OF SOIL STRUCTURES

Layered:	Units of material distinguished by color and/or composition from material units above and below
Laminated:	Layers of soil typically 0.05 to 1mm thick, max. 1 cm
Lens:	Layer of soil that pinches out laterally
Interlayered:	Alternating layers of differing soil material
Pocket:	Erratic, discontinuous deposit of limited extent
Homogeneous:	Soil with uniform color and composition throughout
Fissured:	Breaks along defined planes
Slickensided:	Fracture planes that are polished or glossy
Blocky:	Angular soil lumps that resist breakdown
Disrupted:	Soil that is broken and mixed
Scattered:	Less than one per foot
Numerous:	More than one per foot
BCN:	Angle between bedding plane and a plane normal to core axis

COMPONENT DEFINITIONS

COMPONENT	SIZE / SIEVE RANGE	COMPONENT	SIZE / SIEVE RANGE
Boulder:	> 12 inches	Sand	
Cobbles:	3 to 12 inches	Coarse Sand:	#4 to #10 sieve (4.5 to 2.0 mm)
Gravel		Medium Sand:	#10 to #40 sieve (2.0 to 0.42 mm)
Coarse Gravel:	3 to 3/4 inches	Fine Sand:	#40 to #200 sieve (0.42 to 0.074 mm)
Fine Gravel:	3/4 inches to #4 sieve	Silt	0.074 to 0.002 mm
		Clay	<0.002 mm

TEST SYMBOLS

for In Situ and Laboratory Tests listed in "Other Tests" column.

ATT	Atterberg Limit Test
Comp	Compaction Tests
Con	Consolidation
DD	Dry Density
DS	Direct Shear
%F	Fines Content
GS	Grain Size
Perm	Permeability
PP	Pocket Penetrometer
R	R-value
SG	Specific Gravity
TV	Torvane
TXC	Triaxial Compression
UCC	Unconfined Compression

SYMBOLS

Sample/In Situ test types and intervals

- 2-inch OD Split Spoon, SPT (140-lb. hammer, 30" drop)
- 3.25-inch OD Spilt Spoon (300-lb hammer, 30" drop)
- Non-standard penetration test (see boring log for details)
- Thin wall (Shelby) tube
- Grab
- Rock core
- Vane Shear

MONITORING WELL

- Groundwater Level at time of drilling (ATD)
- Static Groundwater Level
- Cement / Concrete Seal
- Bentonite grout / seal
- Silica sand backfill
- Slotted tip
- Slough
- Bottom of Boring

MOISTURE CONTENT

Dry	Dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water

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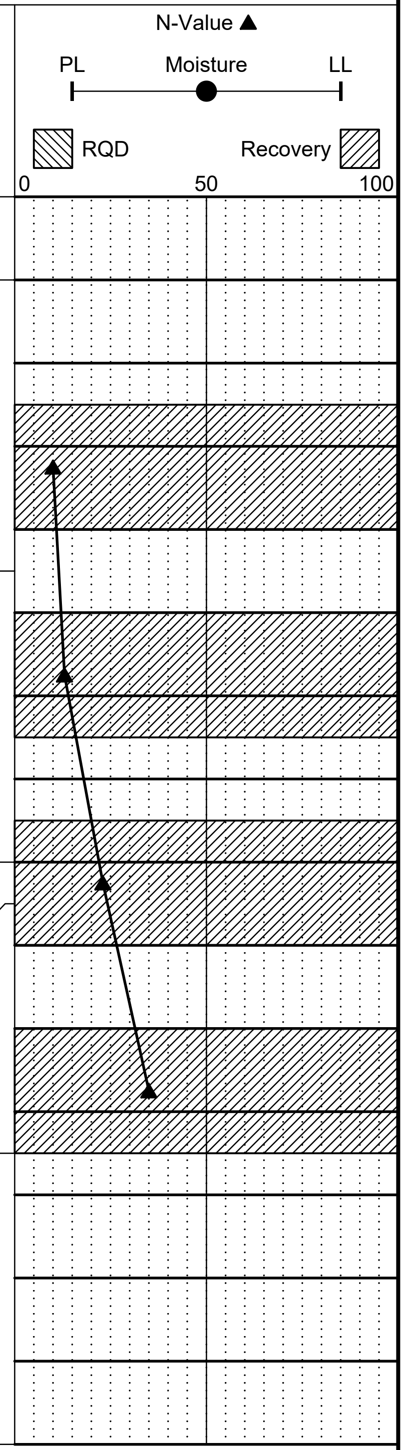
Terms and Symbols for Boring and Test Pit Logs

Figure A-1

Project:	Emergence Whidbey	Surface Elevation:	~106 ft
Job Number:	23-356	Top of Casing Elev.:	N/A
Location:	Clinton (Island County), WA	Drilling Method:	HSA
Coordinates:	Northing: 1252640, Easting: 362919	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0–1						**TOPSOIL** Approx 12 inches of topsoil.
1–4.5						**VASHON ADVANCE OUTWASH - Qva** Loose to medium dense, orange-brown to grey-brown, silty SAND, trace gravel; occasional iron-oxide banding, moist.
2.5–4	S-1		2, 4, 6	CEC OM USDA		***SAMPLE S1:*** *SAND 88%, SILT 5%, CLAY 7%;. OM 0.164%, CEC 3.61 mg/kg.*
4.5						Medium dense, grey-brown poorly graded SAND with silt, moist.
5–6.5	S-2		3, 5, 8	CEC OM USDA		***SAMPLE S2:*** *SAND 93%, SILT 1%, CLAY 6%;. OM 0.099%, CEC 3.75 mg/kg.*
7.5–9	S-3		8, 11, 12			*- approximately 6-inch thick lens of interbedded silts observed at approximately 8 feet.*
10–11.5	S-4		6, 10, 25			*- becomes dense; approximately 6-inch thick lens of interbedded silts observed at approximately 10.5 feet.*
11.5						Boring terminated at approximately 11.5 feet below grade. Groundwater was not observed at time of drilling.



Completion Depth:	11.5ft
Date Borehole Started:	12/19/23
Date Borehole Completed:	12/19/23
Logged By:	S. Scott
Drilling Company:	Geologic Drill Partners

Remarks: Boring drilled using a Bobcat tracked drill rig. Standard penetration test (SPT) sampler driven with a 140 lb. safety hammer. Hammer operated with rope and cathead. Surface elevation is approximate and based on their relative location to site features. This information is provided for relative information only and is not a substitution for field survey.

DATUM - WA STATE PLANE NORTH, NAVD88

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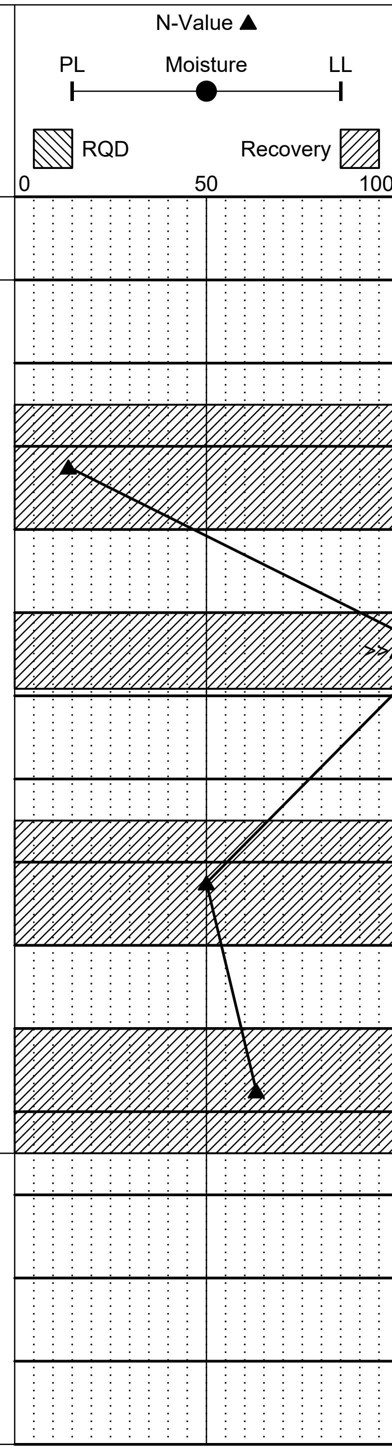
LOG OF TEST BORING PG-1

Figure A-2

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Emergence Whidbey	Surface Elevation:	~100 ft
Job Number:	23-356	Top of Casing Elev.:	N/A
Location:	Clinton (Island County), WA	Drilling Method:	HSA
Coordinates:	Northing: 1252536, Easting: 363111	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0–1						**TOPSOIL** Approx 12 inches of topsoil.
1–11.5						**VASHON TILL - Qvt** Medium dense to very dense, orange-brown to grey-brown, silty SAND, trace gravel, occasional iron-oxide staining; diamict texture, moist.
2.5–4	S-1		3 5 9	USDA		***SAMPLE S1:*** *SAND 88%, SILT 6%, CLAY 6%.*
5–5.9	S-2		22 50/5	USDA		***SAMPLE S2:*** *SAND 88%, SILT 6%, CLAY 6%.*
7						*- becomes grey and unweathered at about 7 feet.*
7.5–9	S-3		16 24 26			
10–11.5	S-4		25 37 26			
11.5						Boring terminated at approximately 11.5 feet below grade. Groundwater was not observed at time of drilling.



Completion Depth:	11.5ft
Date Borehole Started:	12/19/23
Date Borehole Completed:	12/19/23
Logged By:	S. Scott
Drilling Company:	Geologic Drill Partners

Remarks: Boring drilled using a Bobcat tracked drill rig. Standard penetration test (SPT) sampler driven with a 140 lb. safety hammer. Hammer operated with rope and cathead. Surface elevation is approximate and based on their relative location to site features. This information is provided for relative information only and is not a substitution for field survey.
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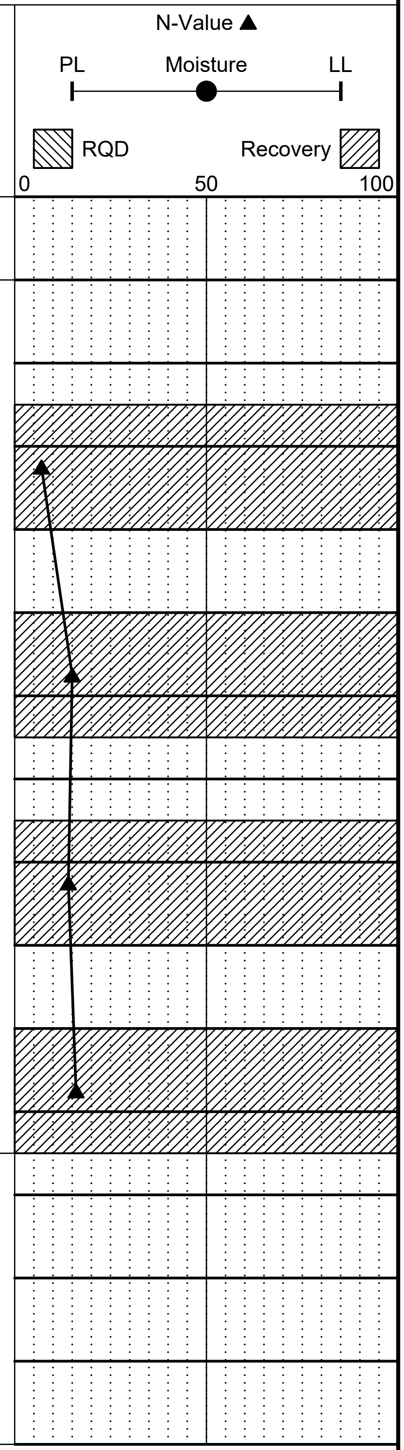
LOG OF TEST BORING PG-2

Figure A-3

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Emergence Whidbey	Surface Elevation:	~110 ft
Job Number:	23-356	Top of Casing Elev.:	N/A
Location:	Clinton (Island County), WA	Drilling Method:	HSA
Coordinates:	Northing: 1252535, Easting: 362578	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0–1						**TOPSOIL** Approx 12 inches of topsoil.
1						**VASHON ADVANCE OUTWASH - Qva** Loose to medium dense, orange-brown to grey-brown, SAND with silt, trace gravel; occasional iron-oxide banding, moist.
2.5–4	S-1		3, 3, 4	USDA		***SAMPLE S1:*** *SAND 94%, SILT 2%, CLAY 4%.*
5–6.5	S-2		5, 6, 9	USDA		***SAMPLE S2:*** *SAND 94%, SILT 2%, CLAY 4%.*
7						*- becomes grey and unweathered at about 7 feet.*
7.5–9	S-3		6, 7, 7			
10–11.5	S-4		5, 8, 8			
11.5						Boring terminated at approximately 11.5 feet below grade. Groundwater was not observed at time of drilling.



Completion Depth:	11.5ft
Date Borehole Started:	12/19/23
Date Borehole Completed:	12/19/23
Logged By:	S. Scott
Drilling Company:	Geologic Drill Partners

Remarks: Boring drilled using a Bobcat tracked drill rig. Standard penetration test (SPT) sampler driven with a 140 lb. safety hammer. Hammer operated with rope and cathead. Surface elevation is approximate and based on their relative location to site features. This information is provided for relative information only and is not a substitution for field survey.
DATUM - WA STATE PLANE NORTH, NAVD88

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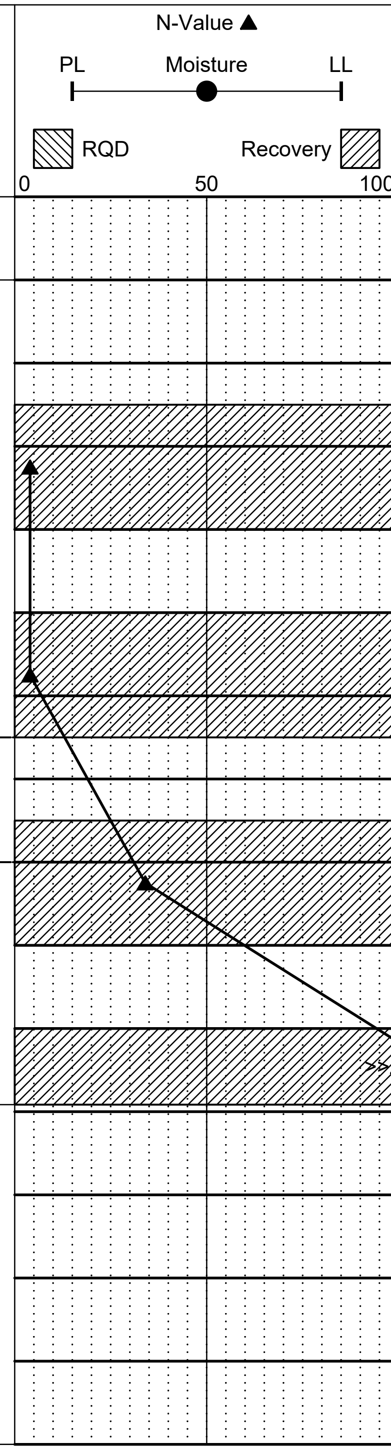
LOG OF TEST BORING PG-3

Figure A-4

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Emergence Whidbey	Surface Elevation:	~105 ft
Job Number:	23-356	Top of Casing Elev.:	N/A
Location:	Clinton (Island County), WA	Drilling Method:	HSA
Coordinates:	Northing: 1253000, Easting: 363189	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	MATERIAL DESCRIPTION
0–1					**TOPSOIL** Approx 12 inches of topsoil.
1–6.5					**WEATHERED ADVANCE OUTWASH - Qva** Loose, orange-brown to grey-brown, silty SAND, trace gravel, occasional silt interbed; iron-oxide staining, moist to wet.
2.5–4	S-1	SPT	1, 2, 2	USDA	***SAMPLE S1:*** *SAND 88%, SILT 7%, CLAY 5%.*
4.5					*- perched groundwater observed from approximately 4.5 to 8 feet below grade.*
5–6.5	S-2	SPT	2, 2, 2	USDA	***SAMPLE S2:*** *SAND 83%, SILT 9%, CLAY 8%.*
6.5–8					Loose, grey, SAND, trace silt; saturated (wet).
7.5–9	S-3	SPT	3, 5, 29		
8–11					**ADVANCE OUTWASH - Qva** Very dense, grey, silty SAND, trace gravel; diamict texture; moist.
10–11	S-4	SPT	22, 50/5		
11					Boring terminated at approximately 11 feet below grade. Perched groundwater observed from approximately 4.5 to 8 feet below grade at time of drilling.



Completion Depth:	10.9ft
Date Borehole Started:	12/19/23
Date Borehole Completed:	12/19/23
Logged By:	S. Scott
Drilling Company:	Geologic Drill Partners

Remarks: Boring drilled using a Bobcat tracked drill rig. Standard penetration test (SPT) sampler driven with a 140 lb. safety hammer. Hammer operated with rope and cathead. Surface elevation is approximate and based on their relative location to site features. This information is provided for relative information only and is not a substitution for field survey.

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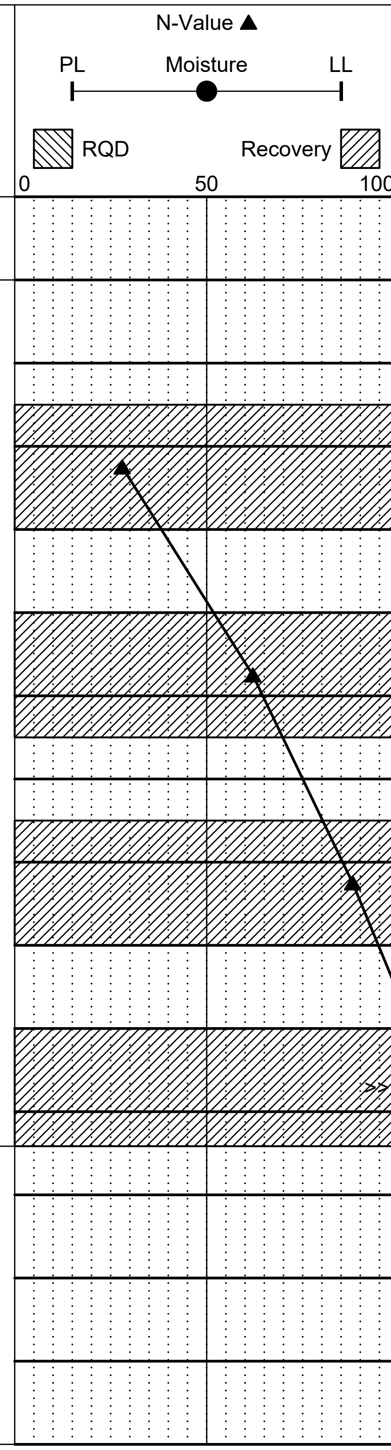
LOG OF TEST BORING PG-4

Figure A-5

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Emergence Whidbey	Surface Elevation:	~162 ft
Job Number:	23-356	Top of Casing Elev.:	N/A
Location:	Clinton (Island County), WA	Drilling Method:	HSA
Coordinates:	Northing: 1253483, Easting: 362971	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0–1						**TOPSOIL** Approx 12 inches of topsoil.
1						**VASHON TILL - Qvt** Medium dense to very dense, orange-brown to grey, silty SAND, trace gravel, occasional iron-oxide staining; diamict texture, moist.
2.5–4	S-1		6 12 16	USDA		***SAMPLE S1:*** *SAND 76%, SILT 14%, CLAY 10%.*
5–6.5	S-2		14 22 40	USDA		***SAMPLE S2:*** *SAND 58%, SILT 31%, CLAY 11%.*
7						*- becomes grey and unweathered at about 5.5 feet.*
7.5–9	S-3		17 40 48			
10–11.4	S-4		18 40 50/5			
11.4						Boring terminated at approximately 11.4 feet below grade. Groundwater was not observed at time of drilling.



Completion Depth:	11.4ft
Date Borehole Started:	12/19/23
Date Borehole Completed:	12/19/23
Logged By:	S. Scott
Drilling Company:	Geologic Drill Partners

Remarks: Boring drilled using a Bobcat tracked drill rig. Standard penetration test (SPT) sampler driven with a 140 lb. safety hammer. Hammer operated with rope and cathead. Surface elevation is approximate and based on their relative location to site features. This information is provided for relative information only and is not a substitution for field survey.

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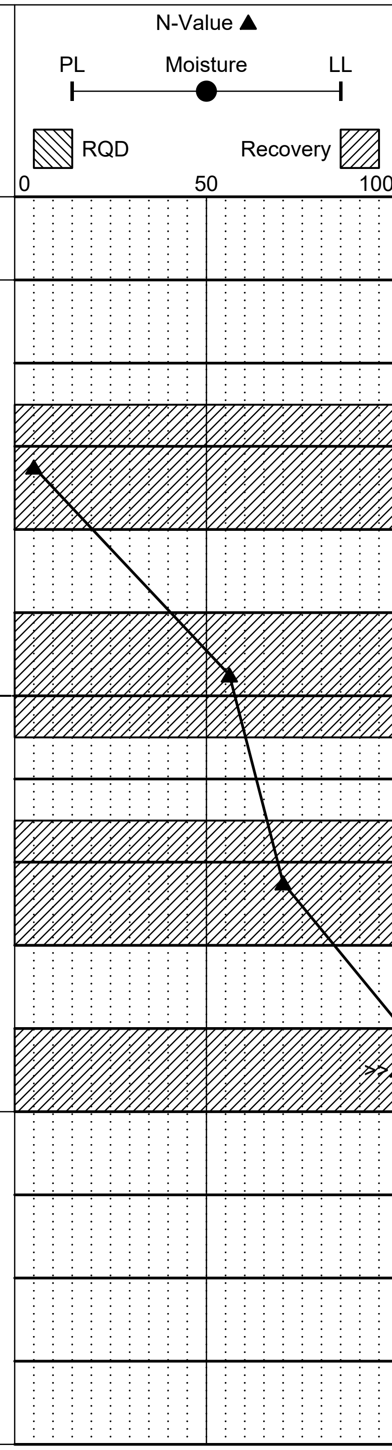
LOG OF TEST BORING PG-5

Figure A-6

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Emergence Whidbey	Surface Elevation:	~109 ft
Job Number:	23-356	Top of Casing Elev.:	N/A
Location:	Clinton (Island County), WA	Drilling Method:	HSA
Coordinates:	Northing: 1253037, Easting: 363033	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						**TOPSOIL** Approx 12 inches of topsoil.
1						**WEATHERED ADVANCE OUTWASH - Qva** Loose, orange-brown to grey-brown, SAND with, trace gravel, occasional silt interbed; iron-oxide staining, moist to wet.
3	S-1		3 3 2	USDA		***SAMPLE S1:*** *SAND 88%, SILT 6%, CLAY 6%.*
4						*- perched groundwater observed from approximately 5 to 6 feet below grade.*
5	S-2		6 23 33	USDA		***SAMPLE S2:*** *SAND 83%, SILT 10%, CLAY 7%.*
6						**ADVANCE OUTWASH - Qva** Very dense, grey, silty SAND, trace gravel; diamict texture; moist.
8	S-3		5 40 30			
10	S-4		34 50/6			
11						Boring terminated at approximately 11 feet below grade. Perched groundwater observed from approximately 5 to 6 feet below grade at time of drilling.
12–15						



Completion Depth:	11.0ft
Date Borehole Started:	12/19/23
Date Borehole Completed:	12/19/23
Logged By:	S. Scott
Drilling Company:	Geologic Drill Partners

Remarks: Boring drilled using a Bobcat tracked drill rig. Standard penetration test (SPT) sampler driven with a 140 lb. safety hammer. Hammer operated with rope and cathead. Surface elevation is approximate and based on their relative location to site features. This information is provided for relative information only and is not a substitution for field survey.

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LOG OF TEST BORING PG-6

Figure A-7

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Emergence Whidbey	Surface Elevation:	~123 ft
Job Number:	23-356	Top of Casing Elev.:	N/A
Location:	Clinton (Island County), WA	Drilling Method:	HSA
Coordinates:	Northing: 1253031, Easting: 362465	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION	N-Value ▲ / PL Moisture LL / RQD Recovery (0 50 100)
0–1						**TOPSOIL** Approx 12 inches of topsoil.	
1–2.5						**VASHON ADVANCE OUTWASH - Qva** Loose to medium dense, orange-brown to grey-brown, poorly graded SAND, trace silt, trace gravel; occasional iron-oxide banding, moist.	
2.5–4	S-1	SPT	4 4 3	CEC OM USDA		***SAMPLE S1:*** *SAND 95%, SILT 1%, CLAY 4%;.* *OM 0.059%, CEC 2.19 mg/kg.*	
5–6.5	S-2	SPT	5 5 9	CEC OM USDA		***SAMPLE S2:*** *SAND 96%, SILT 0%, CLAY 4%;.* *OM 0.134%, CEC 2.99 mg/kg.*	
7.5–9	S-3	SPT	9 11 12			*- increase in gravels observed at approximately 8 feet below grade.*	
10–11.5	S-4	SPT	7 9 10				
11.5						Boring terminated at approximately 11.5 feet below grade. Groundwater was not observed at time of drilling.	

Completion Depth:	11.5ft
Date Borehole Started:	12/19/23
Date Borehole Completed:	12/19/23
Logged By:	S. Scott
Drilling Company:	Geologic Drill Partners

Remarks: Boring drilled using a Bobcat tracked drill rig. Standard penetration test (SPT) sampler driven with a 140 lb. safety hammer. Hammer operated with rope and cathead. Surface elevation is approximate and based on their relative location to site features. This information is provided for relative information only and is not a substitution for field survey.
DATUM - WA STATE PLANE NORTH, NAVD88

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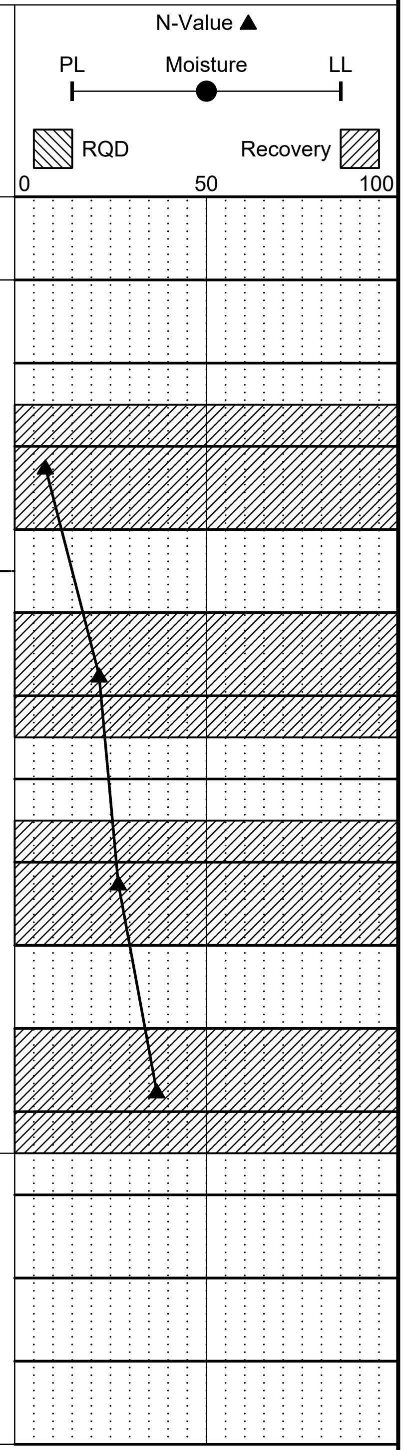
LOG OF TEST BORING PG-7

Figure A-8

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	Emergence Whidbey	Surface Elevation:	~146 ft
Job Number:	23-356	Top of Casing Elev.:	N/A
Location:	Clinton (Island County), WA	Drilling Method:	HSA
Coordinates:	Northing: 1253277, Easting: 362502	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0–1						**TOPSOIL** Approx 12 inches of topsoil.
1–4.5						**WEATHERED VASHON TILL - Qvt** Loose to medium dense, orange-brown to grey-brown, poorly graded SAND with silt, trace gravel; occasional iron-oxide banding, some root debris, moist.
2.5–4	S-1	SPT	6 5 3	USDA		***SAMPLE S1:*** *SAND 88%, SILT 7%, CLAY 5%;.*
4.5–11.5						**VASHON TILL - Qvt** Medium dense to dense, grey, silty SAND; laminated texture, moist.
5–6.5	S-2	SPT	8 10 12	USDA		***SAMPLE S2:*** *SAND 66%, SILT 28%, CLAY 6%;.*
7.5–9	S-3	SPT	7 12 15			
10–11.5	S-4	SPT	11 15 22			*- becomes dense at approximately 10 feet below grade.*
11.5						Boring terminated at approximately 11.5 feet below grade. Groundwater was not observed at time of drilling.



Completion Depth:	11.5ft
Date Borehole Started:	12/19/23
Date Borehole Completed:	12/19/23
Logged By:	S. Scott
Drilling Company:	Geologic Drill Partners

Remarks: Boring drilled using a Bobcat tracked drill rig. Standard penetration test (SPT) sampler driven with a 140 lb. safety hammer. Hammer operated with rope and cathead. Surface elevation is approximate and based on their relative location to site features. This information is provided for relative information only and is not a substitution for field survey.
DATUM - WA STATE PLANE NORTH, NAVD88

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LOG OF TEST BORING PG-8

Figure A-9

The stratification lines represent approximate boundaries. The transition may be gradual.

APPENDIX B

TEST PIT LOGS

Test Pit Logs

Project No: 23-356.300
Project Name: Emergence Whidbey Island
Project Location: 3691 Campbell Road & 6263 Maxwelton Road, Whidbey Island, WA
Excavated: 3/11/2025

Test Pit No. PIT-1

Location: 1253263, 363313 (Washington State Plane - North)

Approximate ground surface elevation: 118 feet (NAVD88 – Island 2014 LiDAR Dataset)

Depth (ft)	Material Description
0 - ½	**[Topsoil]** Loose, dark brown, silty sand with organics, moist
½ – 1½	**[Alluvium]** Medium dense, gray-brown, gravelly SAND trace silt; moist; trace roots
1½ – 5	**[Alluvium]** Medium dense, gray-brown, poorly graded GRAVEL with silt and sand; moist; trace roots
5 – 6	**[Vashon Till – Qvt]** Dense to very dense, gray, silty SAND; moist; trace roots • diamict (till-like) texture

Image of PIT-1 at approximately 5 feet below the existing ground surface. Groundwater seepage was not observed at the time of our excavation.

Logged by: J. Meissner

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Figure B-1

Test Pit Logs

Project No:	23-356.300
Project Name:	Emergence Whidbey Island
Project Location:	3691 Campbell Road & 6263 Maxwelton Road, Whidbey Island, WA
Excavated:	3/11/2025

Test Pit No. PIT-2

Location: 1253232, 363096 (Washington State Plane - North)

Approximate ground surface elevation: 115 feet (NAVD88 – Island 2014 LiDAR Dataset)

Depth (ft)	Material Description
0 - ½	**[Topsoil]** Loose, dark brown, silty sand with organics, moist
½ – 1½	**[Weathered Advance Outwash – Qva]** Medium dense gray-brown gravelly SAND trace silt; moist; trace roots
1½ – 8	**[Advance Outwash - Qva]** Medium dense, gray, poorly graded SAND with gravel; moist; trace roots

Image of PIT-2 at approximately 4 feet below the existing ground surface. Groundwater seepage was observed at approximately 7-8 feet during over-excavation.

Logged by: J. Meissner

PanGEO INCORPORATED Geotechnical & Earthquake Engineering Consultants

Figure B-2

Test Pit Logs

Project No: 23-356.300
Project Name: Emergence Whidbey Island
Project Location: 3691 Campbell Road & 6263 Maxwelton Road, Whidbey Island, WA
Excavated: 3/11/2025

Test Pit No. PIT-3

Location: 1253182, 363027 (Washington State Plane - North)

Approximate ground surface elevation: 113 feet (NAVD88 – Island 2014 LiDAR Dataset)

Depth (ft)	Material Description
0 - ½	**[Topsoil]** Loose, dark brown, silty sand with organics, moist
½ – 2	**[Weathered Advance Outwash – Qva]** Medium dense gray-brown gravelly SAND trace silt; moist; trace roots; trace organics
2 – 7	**[Advance Outwash - Qva]** Medium dense, gray, poorly graded SAND with gravel; moist; trace roots -- At 7 feet becomes with silt -- Diamict (till-like) texture

Image of PIT-3 at approximately 4 feet below the existing ground surface. Groundwater seepage was not encountered at the time of our excavation

Logged by: J. Meissner

Test Pit Logs

Project No: 23-356.300
Project Name: Emergence Whidbey Island
Project Location: 3691 Campbell Road & 6263 Maxwelton Road, Whidbey Island, WA
Excavated: 3/11/2025

Test Pit No. PIT-4

Location: 1253118, 362743 (Washington State Plane - North)

Approximate ground surface elevation: 121 feet (NAVD88 – Island 2014 LiDAR Dataset)

Depth (ft)	Material Description
0 - ½	**[Topsoil]** Loose, dark brown, silty sand with organics, moist
½ – 2½	**[Weathered Advance Outwash – Qva]** Medium dense, brown, gravelly SAND; moist; trace roots
2½ – 8	**[Advance Outwash - Qva]** Medium dense, gray-brown, poorly graded SAND with silt and gravel; moist; trace roots -- At 7 feet becomes silty and dense

Image of soils encountered approximately 4 feet below the existing ground surface during infiltration testing. Groundwater seepage was not encountered during excavation

Logged by: J. Meissner

PanGEO INCORPORATED Geotechnical & Earthquake Engineering Consultants

Figure B-4

Test Pit Logs

Project No: 23-356.300
Project Name: Emergence Whidbey Island
Project Location: 3691 Campbell Road & 6263 Maxwelton Road, Whidbey Island, WA
Excavated: 3/11/2025

Test Pit No. PIT-5

Location: 1253055, 362524 (Washington State Plane - North)

Approximate ground surface elevation: 123 feet (NAVD88 – Island 2014 LiDAR Dataset)

Depth (ft)	Material Description
0 – ¾	**[Topsoil]** Loose, dark brown, gravelly, silty SAND; moist; roots; organics
¾ – 2½	**[Weathered Advance Outwash – Qva]** Medium dense, gray-brown, poorly graded gravelly SAND trace silt; moist; trace roots
2½ – 8	**[Advance Outwash - Qva]** Medium dense to dense, gray-brown, poorly graded SAND; moist; trace roots; -- Becomes gray and gravelly at about 7 feet

Image of PIT-5 at approximately 8 feet below the existing ground surface. Groundwater seepage was not encountered at the time of our excavation

Logged by: J. Meissner

PanGEO INCORPORATED
Geotechnical & Earthquake Engineering Consultants

Figure B-5

Test Pit Logs

Project No:	23-356.300
Project Name:	Emergence Whidbey Island
Project Location:	3691 Campbell Road & 6263 Maxwelton Road, Whidbey Island, WA
Excavated:	3/11/2025

Test Pit No. PIT-6

Location: 1252570, 362658 (Washington State Plane - North)

Approximate ground surface elevation: 110 feet (NAVD88 – Island 2014 LiDAR Dataset)

Depth (ft)	Material Description
0 – ½	**[Topsoil]** Loose, dark brown, silty SAND; moist; roots
½ – 2½	**[Weathered Advance Outwash – Qva]** Medium loose to medium dense, gray-brown, poorly graded gravelly SAND trace silt; moist; trace roots
2½ – 8	**[Advance Outwash - Qva]** Medium dense, gray, poorly graded SAND with gravel; moist; trace roots -- Gravel lenses observed at below five feet

Image of PIT-6 at approximately 8 feet below the existing ground surface. Groundwater seepage was not encountered at the time of our excavation

Logged by: J. Meissner

PanGEO INCORPORATED
Geotechnical & Earthquake Engineering Consultants

Figure B-6

Test Pit Logs

Project No: 23-356.300
Project Name: Emergence Whidbey Island
Project Location: 3691 Campbell Road & 6263 Maxwelton Road, Whidbey Island, WA
Excavated: 3/11/2025

Test Pit No. PIT-7

Location: 47.72932, -122.25046 (WGS84)

Approximate ground surface elevation: 397 feet (NAVD88)

Depth (ft)	Material Description
0 – ¾	**[Topsoil]** Loose, brown, gravelly silty SAND; moist; roots; trace debris; organics
¾ – 4	**[Weathered Advance Outwash – Qva]** Medium dense, gray-brown to red-brown, gravelly SAND trace silt; moist; trace roots; weathered; iron oxide staining
4 – 8	**[Advance Outwash – Qva]** Loose to medium dense, gray to gray-brown, poorly graded SAND with silt and gravel; moist; trace roots.

Image of PIT-7 at approximately 8 feet below the existing ground surface. Groundwater seepage was not encountered at the time of our excavation.

Logged by: J. Meissner

Test Pit Logs

Project No: 23-356.300
Project Name: Emergence Whidbey Island
Project Location: 3691 Campbell Road & 6263 Maxwelton Road, Whidbey Island, WA
Excavated: 3/11/2025

Test Pit No. TP-1

Location: 1253311, 363325 (Washington State Plane - North)

Approximate ground surface elevation: 126 feet (NAVD88 – Island 2014 LiDAR Dataset)

Depth (ft)	Material Description
0 - ½	**[Topsoil]** Loose, dark brown, silty sand with organics, moist
½ – 2	**[Weathered Vashon Till - Qvt]** Loose to medium dense, orange-brown, silty fine SAND; trace gravel, scattered roots and organics; disturbed texture, iron-oxide staining; moist
2 – 6	**[Vashon Till - Qvt]** Dense to very dense, orange-brown to gray-brown, silty fine to medium SAND with gravel, trace cobble; trace iron-oxide staining; moist -- Diamict (till-like) texture

Image of Test Pit TP-1 at approximately 6 feet below the existing ground surface at practical digging refusal. Groundwater seepage was not observed at the time of our excavation.

Logged by: S. Scott

PanGEO INCORPORATED
Geotechnical & Earthquake Engineering Consultants

Figure B-8

Test Pit Logs

Project No: 23-356.300
Project Name: Emergence Whidbey Island
Project Location: 3691 Campbell Road & 6263 Maxwelton Road, Whidbey Island, WA
Excavated: 3/11/2025

Test Pit No. TP-2

Location: 1253274, 363067 (Washington State Plane - North)

Approximate ground surface elevation: 124 feet (NAVD88 – Island 2014 LiDAR Dataset)

Depth (ft)	Material Description
0 - ½	**[Topsoil]** Loose, dark brown, forest duff/organics, moist
½ – 6	**[Weathered Advance Outwash - Qva]** Medium dense, orange-brown to gray-brown, poorly-graded SAND with silt; trace gravel, scattered roots and organics; iron-oxide staining; moist
6 – 7	**[Advance Outwash - Qva]** Dense, gray-brown, silty fine to medium SAND with gravel; moist

Image of Test Pit TP-2 at approximately 7 feet below the existing ground surface at practical digging refusal. Groundwater seepage was not observed at the time of our excavation.

Logged by: S.Scott

PanGEO INCORPORATED
Geotechnical & Earthquake Engineering Consultants

Figure B-9

Test Pit Logs

Project No: 23-356.300
Project Name: Emergence Whidbey Island
Project Location: 3691 Campbell Road & 6263 Maxwelton Road, Whidbey Island, WA
Excavated: 3/11/2025

Test Pit No. TP-3

Location: 1253199, 362986 (Washington State Plane - North)

Approximate ground surface elevation: 123 feet (NAVD88 – Island 2014 LiDAR Dataset)

Depth (ft)	Material Description
0 - ½	**[Forest Duff]** Loose, dark brown, silty sand with leaf litter and organics, moist
½ – 2	**[Weathered Advance Outwash - Qva]** Approximately 6 inches of forest duff above: loose to medium dense, orange-brown, silty fine SAND; trace gravel, roots and organics; iron-oxide staining; moist
2 – 4	**[Advance Ourwash - Qva]** Dense to very dense, gray-brown, poorly graded SAND with silt and gravel; moist

Image of Test Pit TP-3 at approximately 4 feet below the existing ground surface at practical digging refusal. Groundwater seepage was not observed at the time of our excavation.

Logged by: S. Scott

PanGEO INCORPORATED
Geotechnical & Earthquake Engineering Consultants

Figure B-10

Test Pit Logs

Project No: 23-356.300
Project Name: Emergence Whidbey Island
Project Location: 3691 Campbell Road & 6263 Maxwelton Road, Whidbey Island, WA
Excavated: 3/11/2025

Test Pit No. TP-4

Location: 1253141, 362776 (Washington State Plane - North)

Approximate ground surface elevation: 129 feet (NAVD88 – Island 2014 LiDAR Dataset)

Depth (ft)	Material Description
0 - ½	**[Topsoil]** Loose, dark brown, silty sand with organics, moist
½ – 3	**[Weathered Advance Outwash – Qva]** Medium dense, orange-brown, silty fine SAND; trace gravel, scattered roots and organics; disturbed texture, iron-oxide staining; moist -- Relic soil horizon approximately 3 feet inches below surface
3 – 6	**[Advance OutwashAlluvium – Qal]** Medium dense, orange-brown to gray-brown, poorly grades SAND with silt, trace gravel, scattered roots and organics; iron-oxide staining; moist -- Becomes dense to very dense at 5 feet

Image of Test Pit TP-4 at approximately 6 feet below the existing ground surface at practical digging refusal. Groundwater seepage was not observed at the time of our excavation.

Logged by: S. Scott

APPENDIX C
WELL LOGS

WELL LOG 7B7
6104 MAXWELTON ROAD

29-3-22 Start Card No. W063697

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

ENTERED

WATER WELL REPORT

STATE OF WASHINGTON

UNIQUE WELL I.D. # ACS 102

Water Right Permit No. ______

(1) OWNER: Name Robert Olin Address 6104 S. Maxwelton Clinton

(2) LOCATION OF WELL: County Island ___ 1/4 NW 1/4 Sec 22 T 29 N., R 3 E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) 6104 S. Maxwelton Rd Clinton 98236

(3) PROPOSED USE: ☑ Domestic ☐ Irrigation ☐ DeWater ☐ Industrial ☐ Test Well ☐ Municipal ☐ Other

(4) TYPE OF WORK: Owner's number of well (If more than one) ______
☐ Abandoned ☐ New well ☑ Deepened ☐ Reconditioned
Method: ☐ Dug ☑ Cable ☐ Rotary ☐ Bored ☐ Driven ☐ Jetted

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 57 feet. Depth of completed well 55 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from 0 ft. to 45 ft.
☑ Welded ___" Diam. from ___ ft. to ___ ft.
☐ Liner installed ___" Diam. from ___ ft. to ___ ft.
☐ Threaded

Perforations: Yes ☐ No ☑
Type of perforator used ______
SIZE of perforations ___ in. by ___ in.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.

Screens: Yes ☑ No ☐
Manufacturer's Name Sinclair
Type Plastic Model No. ______
Diam. 4 Slot size 10 from 45 ft. to 55 ft.
Diam. ___ Slot size ___ from ___ ft. to ___ ft.

Gravel packed: Yes ☐ No ☑ Size of gravel ______
Gravel placed from ___ ft. to ___ ft.

Surface seal: Yes ☑ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name Flint Walling
Type: Submersible H.P. 3/4

(8) WATER LEVELS: Land-surface elevation above mean sea level 150 ft.
Static level 10 ft. below top of well Date 5/10/98
Artesian pressure ___ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☑ No ☐ If yes, by whom? Driller
Yield: 20 gal./min. with 30 ft. drawdown after 4 hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
0	45'	30 min	10'		
1 min	30'				
10 min	15'				

Date of test ______
Bailer test ___ gal./min. with ___ ft. drawdown after ___ hrs.
Airtest ___ gal./min. with stem set at ___ ft. for ___ hrs.
Artesian flow ___ g.p.m. Date ______
Temperature of water ___ Was a chemical analysis made? Yes ☐ No ☑

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Clay + hard pan BR	0	20
Layer + water gravel	20	45
Sand + gravel w/w gray	45	55

RECEIVED
MAY 18 1998
NWRO-WR
DEPT OF ECOLOGY

Work Started 5/5/98 19. Completed 5/10 1998

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Bobs Backhoe Service (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 6104 S. Maxwelton Rd
(Signed) [signature] (WELL DRILLER) License No. 0264
Contractor's Registration No. BOBSSBS101dd Date 5/12 1998

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

ECY 050-1-20 (9/93)

WELL LOG 78H
3710 CAMPBELL ROAD

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. 29/03-22
Permit No.

(1) OWNER: Name JIM MELTON Address CLINTON WA 98236

(2) LOCATION OF WELL: County ISLAND — NE ¼ SW ¼ Sec. 22 T. 29 N., R. 3E W.M.
Bearing and distance from section or subdivision corner 1320 SOUTH/1280 WEST FROM CENTER SEC 22

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)
New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 80 ft. Depth of completed well 80 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from 0 ft. to 75 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name COOK
Type 65 Model No.
Diam. 6 Slot size 10 from 75 ft. to 80 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name STA-RITE
Type: SUB H.P. 1½

(8) WATER LEVELS: Land-surface elevation above mean sea level 150 ft.
Static level 42'6" ft. below top of well Date 4-20-77
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? DRILLER
Yield: 20 gal./min. with 11 ft. drawdown after 24 hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:
Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
TOP SOIL	0	3
BROWN SAND MED	3	45
" SAND & CLAY WW	45	60
" SAND MED WW	60	80

Work started 4-14 1977. Completed 4-20 1977

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME B & W DRILLING CO (Person, firm, or corporation) (Type or print)
Address P.O. BOX 55 FREELAND WA. 98249
[Signed] (signature) (Well Driller)
License No. 265 Date 6-13, 1977

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

WELL LOG 78J
6312 MAXWELTON ROAD

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

ENTERED

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W 053622
UNIQUE WELL I.D. #
Water Right Permit No. 24/3E/21-R

(1) OWNER: Name Chad Larvig Address Maxwelton Rd

(2) LOCATION OF WELL: County Island - SE 1/4 SE 1/4 Sec 01 T. 29 N., R 3E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address)

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (If more than one)
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ] Method: Dug [ ] Cable [X] Rotary [ ] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 45 feet. Depth of completed well 45' ft.

(6) CONSTRUCTION DETAILS:
Casing Installed: 6" Diam. from +1 ft. to 40' ft.
Welded [X] " Diam. from ft. to ft.
Liner installed [ ] " Diam. from ft. to ft.
Threaded [ ]

Perforations: Yes [ ] No [ ]
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [X] No [ ]
Manufacturer's Name Nagaoka
Type Slotted Model No. SS
Diam. 3" Slot size 10 from 45 ft. to 40' ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes [ ] No [X] Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes [X] No [ ] To what depth? 19+ ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name F+W
Type: Submersible H.P. 3/4

(8) WATER LEVELS: Land-surface elevation above mean sea level 110' ft.
Static level 15 ft. below top of well Date 6-9-95
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [X] No [ ] If yes, by whom? Driller
Yield: 7 gal./min. with 10 ft. drawdown after 1 hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
0:00	25	0:15	20	0:35	15

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [ ]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown Soil	0	1'
Greenish Sand	1'	15'
Brown clay & Sand	15'	31'
Gray Clay	31'	36'
Brown Sand & Gravel w/water	36	45'
Silty Sand & Gravel	45'	

RECEIVED
JUN 15 1995
DEPT. OF ECOLOGY

Work Started June 6, 1995 Completed June 9, 1995

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Island Well Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 5463 Shoreview Pl Langley WA 98260
(Signed) (WELL DRILLER) License No. 0933
Contractor's Registration No. ISLANWD372MF Date June 9, 1995

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

WELL LOG 78K
3710 CAMPBELL ROAD

STATE OF WASHINGTON

Appli. #7737 DEPARTMENT OF CONSERVATION AND DEVELOPMENT

Permit #7399

WELL LOG

No. 29 / 13 E 22 E

Date June 6, 1967

Record by Whidbey Drillers

Source Driller's record

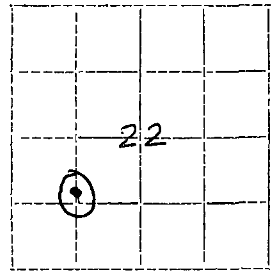

Diagram of Section

Location: State of WASHINGTON

County Island

Area

Map

NW¼ SW¼ sec. 22 T. 29 N., R. 3 E. W.

Drilling Co. Whidbey Drillers

Address P. O. Box 277 Oak Harbor, Washington

Method of Drilling Cable Date , 19

Owner Leo Lee and George Stockholm

Address Langley, Washington

Land surface, datum ft. above below

SWL: 47'4" Nov. 15, 1965 Dims: 8" x 106"

Correlation	Material	Thickness (feet)	Depth (feet)
	(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses If material water-bearing, so state and record static level if reported Give depths in feet below land-surface datum unless otherwise indicated Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc)		
	Industrial		
	Gravel	0	10
	Sand, dirty	10	54
	Water in sand	54	106
	Clay	106	?
	Casing: 8" from 0-84'8"		
	Screened from 80-106'		
	Yield: 150 gpm with 20' DD after 2 hrs.		
	full recovery in ten minutes		
	Bailer Test: 30 gpm with 0' DD after 2 min.		
	Temperature 56°		
	Pump: 5 h.p. Deep well turbine		
	Deming		

Turn up Sheet ... of ... sheets

File number 29/3E-22E

WELL LOG 79J
6364 MAXWELTON ROAD

2913-22M START CARD NO. 030161

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No.
Permit No.

(1) OWNER: Name Larry Long Address 6264 Maxwelton Rd

(2) LOCATION OF WELL: County Island — NW 1/4 SW 1/4 Sec. 12 T. 29 N., R. 2 E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☑ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 1
New well ☑ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 86 ft. Depth of completed well 85 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 81 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☑ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☑
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☑ No ☐
Manufacturer's Name Johnson
Type Stainless Model No. 304
Diam. 6 Slot size 18 from 80 ft. to 85 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☑ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☑ No ☐ To what depth? 18 ft.
Material used in seal Bentonite Cement
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name Gould
Type: Sub H.P. 1

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 28 1/2 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? Drillers
Yield: 15 gal./min. with 11 1/2 ft. drawdown after 1 hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 15 gal./min. with 10 ft. drawdown after 1 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
SAND	0	6
SANDY CLAY	7	12
Soupy SANDY CLAY	13	15
Brown Grey Clay	16	54
Moist Blue SANDY CLAY	55	74
BROWN WATER SAND	75	86

RECEIVED MAY 31 1989 DEPARTMENT OF ECOLOGY NORTHWEST REGION

JUN 13 1989 DEPARTMENT OF ECOLOGY NORTHWEST REGION

Work started May 1989 Completed May 1989

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Well Done Drillers (Person, firm, or corporation) (Type or print)

Address 429 N. Valley Dr

[Signed] [signature] (Well Driller)

License No. 1304 Date May, 1989

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

APPENDIX D

ANALYTICAL TEST RESULTS

ALLIANCE TECHNICAL GROUP

SAMPLE COLLECTED MARCH 11, 2025

3600 Fremont Ave N
Seattle, WA 98103
T: (206) 352-3790
F: (206) 352-7178
info@fremontanalytical.com

PanGEO Inc
Scott Dinkelman
3213 Easklake Ave E, Suite B
Seattle, WA 98102

RE: WHIDBEY, 23-356.300
Work Order Number: 2503178

March 18, 2025

Attention Scott Dinkelman:

Alliance Technical Group, LLC - Seattle received 4 sample(s) on 3/11/2025 for the analyses presented in the following report.

Conductivity by SM 2510B
Drinking Water Metals by EPA 200.8
Ion Chromatography by EPA 300.0
Total Coliform & E.coli by SM 9223B
Total Coliform & E.coli by SM 9223B (IDEXX)
Total Metals by EPA 200.8

All analyses were performed according to our accredited Quality Assurance program. Please contact the laboratory if you should have any questions about the results.

Alliance Technical Group is committed to accuracy, speed, and customer service. Thank you for choosing Alliance Technical Group's Seattle laboratory team for your analytical needs. We appreciate this opportunity to serve you!

Sincerely,

Kelley Lovejoy
Project Manager

CC:
Spenser Scott

DoD-ELAP Accreditation #79636 by PJLA, ISO/IEC 17025:2017 and QSM 5.4 for Environmental Testing
ORELAP Certification: WA 100009 (NELAP Recognized) for Environmental Testing
Washington State Department of Ecology Accredited for Environmental Testing, Lab ID C910

Revision v1

Date: *04/17/2025*

CLIENT:	PanGEO Inc	
Project:	WHIDBEY	
Work Order:	2503178	

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
2503178-001	S-1 'irrigation well'	03/11/2025 2:30 PM	03/11/2025 4:16 PM
2503178-002	S-2 'domestic well'	03/11/2025 2:25 PM	03/11/2025 4:16 PM
2503178-003	S-2 'creek up'	03/11/2025 1:45 PM	03/11/2025 4:16 PM
2503178-004	S-2 'creek down'	03/11/2025 2:15 PM	03/11/2025 4:16 PM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **2503178**

Date: **3/18/2025**

CLIENT: PanGEO Inc
Project: WHIDBEY

I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Prep Sample Comments:
2503178-001A 703472: Prep Comments for EPA200.8, Sample 2503178-001A: Turbidity = 0.14 NTU
2503178-002A 703476: Prep Comments for EPA200.8, Sample 2503178-002A: Turbidity = 0.07 NTU

4/17/2025: Rev1 includes updates to include the Maximum Contaminant Limit

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
DUP - Sample Duplicate
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MCL - Maximum Contaminant Level
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
REP - Sample Replicate
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Analytical Report

Alliance TECHNICAL GROUP

Work Order: **2503178**
Date Reported: **3/18/2025**

CLIENT: PanGEO Inc
Project: WHIDBEY

Lab ID: 2503178-001
Collection Date: 3/11/2025 2:30:00 PM
Client Sample ID: S-1 'irrigation well'
Matrix: Drinking Water

Analyses	Result	RL	MCL	Qual	Units	DF	Date Analyzed
Total Coliform & E.coli by SM 9223B (IDEXX)					Batch ID: R98211		Analyst: JH
Coliform, Total	13.4	1.0	1.0		MPN/100mL	1	3/11/2025 4:00:00 PM
E. coli	ND	1.0	1.0		MPN/100mL	1	3/11/2025 4:00:00 PM
Ion Chromatography by EPA 300.0					Batch ID: 47019		Analyst: OP
Chloride	11.1	0.600	250		mg/L	1	3/12/2025 11:45:00 AM
Nitrite (as N)	ND	0.250	1.00		mg/L	1	3/12/2025 11:45:00 AM
Nitrate (as N)	ND	0.150	10.0		mg/L	1	3/12/2025 11:45:00 AM
Drinking Water Metals by EPA 200.8					Batch ID: 47026		Analyst: SLL
Arsenic	0.00211	0.00100	0.0100		mg/L	1	3/18/2025 11:08:00 AM
Conductivity by SM 2510B					Batch ID: R98306		Analyst: BB
Specific Conductance (Conductivity)	284	1.00			µS/cm	1	3/18/2025 8:15:24 AM

Analytical Report

Work Order: **2503178**
Date Reported: **3/18/2025**

CLIENT: PanGEO Inc
Project: WHIDBEY

Lab ID: 2503178-002 **Collection Date:** 3/11/2025 2:25:00 PM
Client Sample ID: **S-2 'domestic well'** **Matrix:** Drinking Water

Analyses	Result	RL	MCL	Qual	Units	DF	Date Analyzed
Total Coliform & E.coli by SM 9223B (IDEXX)					Batch ID: R98211		Analyst: JH
Coliform, Total	ND	1.0	1.0		MPN/100mL	1	3/11/2025 4:00:00 PM
E. coli	ND	1.0	1.0		MPN/100mL	1	3/11/2025 4:00:00 PM
Ion Chromatography by EPA 300.0					Batch ID: 47019		Analyst: OP
Chloride	6.02	0.600	250		mg/L	1	3/12/2025 12:35:00 PM
Nitrite (as N)	ND	0.250	1.00		mg/L	1	3/12/2025 12:35:00 PM
Nitrate (as N)	0.499	0.150	10.0		mg/L	1	3/12/2025 12:35:00 PM
Drinking Water Metals by EPA 200.8					Batch ID: 47026		Analyst: SLL
Arsenic	0.00129	0.00100	0.0100		mg/L	1	3/18/2025 11:17:00 AM
Conductivity by SM 2510B					Batch ID: R98306		Analyst: BB
Specific Conductance (Conductivity)	194	1.00			µS/cm	1	3/18/2025 8:15:24 AM

Analytical Report

Work Order: **2503178**
Date Reported: **3/18/2025**

CLIENT: PanGEO Inc
Project: WHIDBEY

Lab ID: 2503178-003 **Collection Date:** 3/11/2025 1:45:00 PM
Client Sample ID: **S-2 'creek up'** **Matrix:** Groundwater

Analyses	Result	RL	MCL	Qual	Units	DF	Date Analyzed
Total Coliform & E.coli by SM 9223B					Batch ID: R98211		Analyst: JH
Coliform, Total	185.0	1.0			MPN/100mL	1	3/11/2025 4:00:00 PM
E. coli	ND	1.0			MPN/100mL	1	3/11/2025 4:00:00 PM
Ion Chromatography by EPA 300.0					Batch ID: 47019		Analyst: OP
Chloride	8.87	0.600	250		mg/L	1	3/12/2025 12:48:00 PM
Nitrite (as N)	ND	0.250	1.00		mg/L	1	3/12/2025 12:48:00 PM
Nitrate (as N)	0.968	0.150	10.0		mg/L	1	3/12/2025 12:48:00 PM
Total Metals by EPA 200.8					Batch ID: 47014		Analyst: ME
Arsenic	0.00271	0.000500	0.0100		mg/L	1	3/13/2025 2:01:00 PM
Conductivity by SM 2510B					Batch ID: R98306		Analyst: BB
Specific Conductance (Conductivity)	201	1.00			µS/cm	1	3/18/2025 8:15:24 AM

Analytical Report

Work Order: **2503178**
Date Reported: **3/18/2025**

CLIENT: PanGEO Inc
Project: WHIDBEY

Lab ID: 2503178-004 **Collection Date:** 3/11/2025 2:15:00 PM
Client Sample ID: **S-2 'creek down'** **Matrix:** Groundwater

Analyses	Result	RL	MCL	Qual	Units	DF	Date Analyzed
Total Coliform & E.coli by SM 9223B					Batch ID: R98211		Analyst: JH
Coliform, Total	248.1	1.0			MPN/100mL	1	3/11/2025 4:00:00 PM
E. coli	ND	1.0			MPN/100mL	1	3/11/2025 4:00:00 PM
Ion Chromatography by EPA 300.0					Batch ID: 47019		Analyst: OP
Chloride	8.75	0.600	250		mg/L	1	3/12/2025 1:00:00 PM
Nitrite (as N)	ND	0.250	1.00		mg/L	1	3/12/2025 1:00:00 PM
Nitrate (as N)	0.895	0.150	10.0		mg/L	1	3/12/2025 1:00:00 PM
Total Metals by EPA 200.8					Batch ID: 47023		Analyst: ME
Arsenic	0.00272	0.000500	0.0100		mg/L	1	3/13/2025 2:48:00 PM
Conductivity by SM 2510B					Batch ID: R98306		Analyst: BB
Specific Conductance (Conductivity)	200	1.00			µS/cm	1	3/18/2025 8:15:24 AM

Date: *3/18/2025*

Work Order: 2503178
CLIENT: PanGEO Inc
Project: WHIDBEY

QC SUMMARY REPORT

Conductivity by SM 2510B

Sample ID: **MB-R98306** SampType: **MBLK** Units: **µS/cm** Prep Date: **3/18/2025** RunNo: **98306**
Client ID: **MBLKW** Batch ID: **R98306** Analysis Date: **3/18/2025** SeqNo: **2048429**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Specific Conductance (Conductivity)	ND	1.00									

Sample ID: **LCS-R98306** SampType: **LCS** Units: **µS/cm** Prep Date: **3/18/2025** RunNo: **98306**
Client ID: **LCSW** Batch ID: **R98306** Analysis Date: **3/18/2025** SeqNo: **2048430**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Specific Conductance (Conductivity)	986	1.00	1,000	0	98.6	90	110				

Sample ID: **2503166-001ADUP** SampType: **DUP** Units: **µS/cm** Prep Date: **3/18/2025** RunNo: **98306**
Client ID: **BATCH** Batch ID: **R98306** Analysis Date: **3/18/2025** SeqNo: **2048432**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Specific Conductance (Conductivity)	934	1.00						926.0	0.860	20	

Sample ID: **2503300-003BDUP** SampType: **DUP** Units: **µS/cm** Prep Date: **3/18/2025** RunNo: **98306**
Client ID: **BATCH** Batch ID: **R98306** Analysis Date: **3/18/2025** SeqNo: **2048442**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Specific Conductance (Conductivity)	69.2	1.00						69.60	0.576	20	

Work Order: 2503178
CLIENT: PanGEO Inc
Project: WHIDBEY

QC SUMMARY REPORT

Ion Chromatography by EPA 300.0

Sample ID: **MB-47019** SampType: **MBLK** Units: **mg/L** Prep Date: **3/12/2025** RunNo: **98303**
Client ID: **MBLKW** Batch ID: **47019** Analysis Date: **3/12/2025** SeqNo: **2048402**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.600									
Nitrite (as N)	ND	0.250									
Nitrate (as N)	ND	0.150									

Sample ID: **LCS-47019** SampType: **LCS** Units: **mg/L** Prep Date: **3/12/2025** RunNo: **98303**
Client ID: **LCSW** Batch ID: **47019** Analysis Date: **3/12/2025** SeqNo: **2048403**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	10.3	0.600	10.00	0	103	90	110				
Nitrite (as N)	3.17	0.250	3.045	0	104	90	110				
Nitrate (as N)	2.33	0.150	2.259	0	103	90	110				

Sample ID: **2503178-001BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **3/12/2025** RunNo: **98303**
Client ID: **S-1 'irrigation well'** Batch ID: **47019** Analysis Date: **3/12/2025** SeqNo: **2048407**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	11.1	0.600						11.11	0.171	20	
Nitrite (as N)	ND	0.250						0		20	
Nitrate (as N)	ND	0.150						0		20	

Sample ID: **2503178-001BMS** SampType: **MS** Units: **mg/L** Prep Date: **3/12/2025** RunNo: **98303**
Client ID: **S-1 'irrigation well'** Batch ID: **47019** Analysis Date: **3/12/2025** SeqNo: **2048408**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	20.6	0.600	10.00	11.11	94.6	80	120				
Nitrite (as N)	3.09	0.250	3.045	0	101	80	120				
Nitrate (as N)	2.27	0.150	2.259	0.03700	98.9	80	120				

Work Order: 2503178
CLIENT: PanGEO Inc
Project: WHIDBEY

QC SUMMARY REPORT

Ion Chromatography by EPA 300.0

Sample ID: **2503178-001BMSD** SampType: **MSD** Units: **mg/L** Prep Date: **3/12/2025** RunNo: **98303**

Client ID: **S-1 'irrigation well'** Batch ID: **47019** Analysis Date: **3/12/2025** SeqNo: **2048409**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	21.0	0.600	10.00	11.11	99.0	80	120	20.57	2.14	20	
Nitrite (as N)	3.27	0.250	3.045	0	107	80	120	3.087	5.70	20	
Nitrate (as N)	2.40	0.150	2.259	0.03700	105	80	120	2.271	5.48	20	

Work Order: 2503178
CLIENT: PanGEO Inc
Project: WHIDBEY

QC SUMMARY REPORT

Drinking Water Metals by EPA 200.8

Sample ID: **MB-47026** SampType: **MBLK** Units: **mg/L** Prep Date: **3/13/2025** RunNo: **98316**
Client ID: **MBLKW** Batch ID: **47026** Analysis Date: **3/18/2025** SeqNo: **2048567**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	0.00100									

Sample ID: **LCS-47026** SampType: **LCS** Units: **mg/L** Prep Date: **3/13/2025** RunNo: **98316**
Client ID: **LCSW** Batch ID: **47026** Analysis Date: **3/18/2025** SeqNo: **2048568**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.0986	0.00100	0.100	0	98.6	85	115				

Sample ID: **2503178-001ADUP** SampType: **DUP** Units: **mg/L** Prep Date: **3/13/2025** RunNo: **98316**
Client ID: **S-1 'irrigation well'** Batch ID: **47026** Analysis Date: **3/18/2025** SeqNo: **2048570**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.00205	0.00100						0.00211	2.93	30	

Sample ID: **2503178-001AMS** SampType: **MS** Units: **mg/L** Prep Date: **3/13/2025** RunNo: **98316**
Client ID: **S-1 'irrigation well'** Batch ID: **47026** Analysis Date: **3/18/2025** SeqNo: **2048571**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.104	0.00100	0.100	0.00211	102	70	130				

Sample ID: **2503178-001AMSD** SampType: **MSD** Units: **mg/L** Prep Date: **3/13/2025** RunNo: **98316**
Client ID: **S-1 'irrigation well'** Batch ID: **47026** Analysis Date: **3/18/2025** SeqNo: **2048572**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.102	0.00100	0.100	0.00211	100	70	130	0.104	1.63	30	

Work Order: 2503178
CLIENT: PanGEO Inc
Project: WHIDBEY

QC SUMMARY REPORT

Total Metals by EPA 200.8

Sample ID: **MB-47014** SampType: **MBLK** Units: **mg/L** Prep Date: **3/12/2025** RunNo: **98218**
Client ID: **MBLKW** Batch ID: **47014** Analysis Date: **3/12/2025** SeqNo: **2046671**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	0.000500									

Sample ID: **LCS-47014** SampType: **LCS** Units: **mg/L** Prep Date: **3/12/2025** RunNo: **98218**
Client ID: **LCSW** Batch ID: **47014** Analysis Date: **3/12/2025** SeqNo: **2046675**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.104	0.000500	0.100	0	104	85	115				

Sample ID: **2503143-001ADUP** SampType: **DUP** Units: **mg/L** Prep Date: **3/12/2025** RunNo: **98218**
Client ID: **BATCH** Batch ID: **47014** Analysis Date: **3/12/2025** SeqNo: **2046677**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.000737	0.000500						0.000770	4.38	30	

Sample ID: **2503143-001AMS** SampType: **MS** Units: **mg/L** Prep Date: **3/12/2025** RunNo: **98218**
Client ID: **BATCH** Batch ID: **47014** Analysis Date: **3/12/2025** SeqNo: **2046678**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.100	0.000500	0.100	0.000770	99.4	70	130				

Sample ID: **2503189-001AMS** SampType: **MS** Units: **mg/L** Prep Date: **3/12/2025** RunNo: **98218**
Client ID: **BATCH** Batch ID: **47014** Analysis Date: **3/12/2025** SeqNo: **2046682**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.105	0.000500	0.100	0.00241	103	70	130				

Alliance TECHNICAL GROUP

Date: *3/18/2025*

Work Order: 2503178
CLIENT: PanGEO Inc
Project: WHIDBEY

QC SUMMARY REPORT

Total Metals by EPA 200.8

Sample ID: **MB-47023** SampType: **MBLK** Units: **mg/L** Prep Date: **3/12/2025** RunNo: **98257**
Client ID: **MBLKW** Batch ID: **47023** Analysis Date: **3/13/2025** SeqNo: **2047452**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	0.000500									

Sample ID: **LCS-47023** SampType: **LCS** Units: **mg/L** Prep Date: **3/12/2025** RunNo: **98257**
Client ID: **LCSW** Batch ID: **47023** Analysis Date: **3/13/2025** SeqNo: **2047453**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.0990	0.000500	0.100	0	99.0	85	115				

Sample ID: **2503177-001BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **3/12/2025** RunNo: **98257**
Client ID: **BATCH** Batch ID: **47023** Analysis Date: **3/13/2025** SeqNo: **2047455**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.00115	0.000500						0.00114	0.873	30	

Sample ID: **2503177-001BMS** SampType: **MS** Units: **mg/L** Prep Date: **3/12/2025** RunNo: **98257**
Client ID: **BATCH** Batch ID: **47023** Analysis Date: **3/13/2025** SeqNo: **2047456**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.0998	0.000500	0.100	0.00114	98.7	70	130				

Sample ID: **2503207-001BMS** SampType: **MS** Units: **mg/L** Prep Date: **3/12/2025** RunNo: **98257**
Client ID: **BATCH** Batch ID: **47023** Analysis Date: **3/13/2025** SeqNo: **2047477**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.0973	0.000500	0.100	0.00141	95.9	70	130				

Sample Log-In Check List

Client Name:	PANGEO	Work Order Number:	2503178
Logged by:	Morgan Wilson	Date Received:	3/11/2025 4:16:00 PM

Chain of Custody

1. Is Chain of Custody complete? — Yes ☑ No ☐ Not Present ☐
2. How was the sample delivered? — Client

Log In

3. Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact) — Yes ☐ No ☐ Not Present ☑
4. Was an attempt made to cool the samples? — Yes ☐ No ☑ NA ☐

   Unkown prior to receipt.
5. Were all items received at a temperature of >2°C to 6°C * — Yes ☐ No ☐ NA ☑
6. Sample(s) in proper container(s)? — Yes ☑ No ☐
7. Sufficient sample volume for indicated test(s)? — Yes ☑ No ☐
8. Are samples properly preserved? — Yes ☑ No ☐
9. Was preservative added to bottles? — Yes ☐ No ☑ NA ☐
10. Is there headspace in the VOA vials? — Yes ☐ No ☐ NA ☑
11. Did all samples containers arrive in good condition(unbroken)? — Yes ☑ No ☐
12. Does paperwork match bottle labels? — Yes ☑ No ☐
13. Are matrices correctly identified on Chain of Custody? — Yes ☑ No ☐
14. Is it clear what analyses were requested? — Yes ☑ No ☐
15. Were all hold times (except field parameters, pH e.g.) able to be met? — Yes ☑ No ☐

Special Handling (if applicable)

16. Was client notified of all discrepancies with this order? — Yes ☐ No ☐ NA ☑

Person Notified: Date:
By Whom: Via: ☐ eMail ☐ Phone ☐ Fax ☐ In Person
Regarding:
Client Instructions:

17. Additional remarks:

Item Information

Item #	Temp ºC
Sample	15.2

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Alliance TECHNICAL GROUP

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790

Chain of Custody Record & Laboratory Services Agreement

Date: 3/11/25 Page: 1 of: 1

Laboratory Project No (internal): 2503187 ~~7~~ 78 BLR 3/14

Project Name: WHIDBEY

Project No: 23-356.300

Collected by: S. SCOTT

Location:

Report To (PM): SCOTT DINKELMAN

Special Remarks:

Disposal: Samples will be disposed in 30 days unless otherwise requested.
☐ Retain volume (specify above) ☐ Return to client

Client: PANGEO

Address: 3213 EASTLAKE AVE E

City, State, Zip: SEATTLE, WA 98102

Telephone: 206-262-0370

Email(s): SDINKELMAN@PANGEOINC.COM + SSCOTT@PANGEOINC.COM

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	# of Cont.	VOCs (EPA 8260 / 624)	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) / Dissolved (D)	Anions (IC)***	EDB (8011)	Conductivity	Total Coliform	Comments
1	S-1 'irrigation well'	3/11/25	2:30p	DW	3									X		X		X		Conductivity SM2510B
2	S-2 'domestic well'	3/11/25	2:25p	DW	3									X		X		X		"
3	S-3 'Creek up'	3/11/25	1:45p	GW	3									X		X		X		"
4	S-4 'creek down'	3/11/25	2:15p	GW	3									X		X		X		"
5																				
6																				
7																				
8																				
9																				
10																				

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

**Metals (Circle): MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag Al (As) B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl V Zn

***Anions (Circle): (Nitrate) (Nitrite) (Chloride) Sulfate Bromide O-Phosphate Fluoride Nitrate+Nitrite

Turn-around Time:
☒ Standard ☐ Next Day
☐ 3 Day ☐ Same Day
☐ 2 Day ______ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above, that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished (Signature)	Print Name	Date/Time	Received (Signature)	Print Name	Date/Time
x [signature]	SPENSER P SCOTT	3/11/25 4:15	x [signature]	Briana Ballard	3/11 4:16pm
x			x		

ALLIANCE TECHNICAL GROUP

SAMPLE COLLECTED AUGUST 19, 2024

3600 Fremont Ave N
Seattle, WA 98103
T: (206) 352-3790
F: (206) 352-7178
info@fremontanalytical.com

PanGEO Inc
Scott Dinkelman
3213 Easklake Ave E, Suite B
Seattle, WA 98102

RE: Whidbey, 23-256.200
Work Order Number: 2408282

August 26, 2024

Attention Scott Dinkelman:

Alliance Technical Group, LLC - Seattle received 9 sample(s) on 8/19/2024 for the analyses presented in the following report.

Conductivity by SM 2510B
Drinking Water Metals by EPA 200.8
Ion Chromatography by EPA 300.0
Total Coliform & E.coli by SM 9223B
Total Coliform & E.coli by SM 9223B (IDEXX)
Total Metals by EPA 200.8

All analyses were performed according to our accredited Quality Assurance program. Please contact the laboratory if you should have any questions about the results.

Alliance Technical Group is committed to accuracy, speed, and customer service. Thank you for choosing Alliance Technical Group's Seattle laboratory team for your analytical needs. We appreciate this opportunity to serve you!

Sincerely,

Brianna Barnes
Project Manager

CC:
Spenser Scott

DoD-ELAP Accreditation #79636 by PJLA, ISO/IEC 17025:2017 and QSM 5.4 for Environmental Testing
ORELAP Certification: WA 100009 (NELAP Recognized) for Environmental Testing
Washington State Department of Ecology Accredited for Environmental Testing, Lab ID C910

Revision v2

CLIENT:	PanGEO Inc
Project:	Whidbey
Work Order:	2408282

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
2408282-001	S-1	08/19/2024 8:45 AM	08/19/2024 11:20 AM
2408282-002	S-2	08/19/2024 8:45 AM	08/19/2024 11:20 AM
2408282-003	S-3	08/19/2024 8:45 AM	08/19/2024 11:20 AM
2408282-004	S-4	08/19/2024 9:00 AM	08/19/2024 11:20 AM
2408282-005	S-5	08/19/2024 9:00 AM	08/19/2024 11:20 AM
2408282-006	S-6	08/19/2024 9:00 AM	08/19/2024 11:20 AM
2408282-007	S-7	08/19/2024 8:25 AM	08/19/2024 11:20 AM
2408282-008	S-8	08/19/2024 8:25 AM	08/19/2024 11:20 AM
2408282-009	S-9	08/19/2024 8:25 AM	08/19/2024 11:20 AM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **2408282**

Date: **8/26/2024**

CLIENT: PanGEO Inc
Project: Whidbey

WorkOrder Narrative:
I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Prep Sample Comments:
2408282-001A 669989: Prep Comments for EPA200.8, Sample 2408282-001A: Turbidity = 0.22 NTU
2408282-007A 669990: Prep Comments for EPA200.8, Sample 2408282-007A: Turbidity = 0.06 NTU

4/17/2025:Rev1 includes update to Drinking Water units per client request.
4/17/2025:Rev2 includes update to enter Maximum Contaminant Level per client request.

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
DUP - Sample Duplicate
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MCL - Maximum Contaminant Level
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
REP - Sample Replicate
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Analytical Report

Alliance Technical Group

Work Order: **2408282**
Date Reported: **8/26/2024**

CLIENT: PanGEO Inc
Project: Whidbey Irrigation Well

Lab ID: 2408282-001 **Collection Date:** 8/19/2024 8:45:00 AM
Client Sample ID: **S-1** **Matrix:** Drinking Water

Analyses	Result	RL	MCL	Qual	Units	DF	Date Analyzed
Drinking Water Metals by EPA 200.8					Batch ID: 44924		Analyst: ME
Arsenic	0.00181	0.00100	0.0100		mg/L	1	8/22/2024 11:11:00 AM

Lab ID: 2408282-002 **Collection Date:** 8/19/2024 8:45:00 AM
Client Sample ID: **S-2** **Matrix:** Drinking Water

Analyses	Result	RL	MCL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA 300.0					Batch ID: 44911		Analyst: OP
Chloride	10.7	0.400	250	D	mg/L	2	8/20/2024 6:12:00 PM
Nitrite (as N)	ND	0.200	1.00		mg/L	1	8/19/2024 7:38:00 PM
Nitrate (as N)	0.408	0.200	10.0		mg/L	1	8/19/2024 7:38:00 PM
Conductivity by SM 2510B					Batch ID: R93900		Analyst: OP
Specific Conductance (Conductivity)	287	1.00			µS/cm	1	8/26/2024 4:07:58 PM

Lab ID: 2408282-003 **Collection Date:** 8/19/2024 8:45:00 AM
Client Sample ID: **S-3** **Matrix:** Drinking Water

Analyses	Result	RL	MCL	Qual	Units	DF	Date Analyzed
Total Coliform & E.coli by SM 9223B (IDEXX)					Batch ID: R93776		Analyst: BB
Coliform, Total	ND	1.0			MPN/100mL	1	8/19/2024 4:23:00 PM
E. coli	ND	1.0			MPN/100mL	1	8/19/2024 4:23:00 PM

Analytical Report

Alliance TECHNICAL GROUP

Work Order: **2408282**
Date Reported: **8/26/2024**

CLIENT: PanGEO Inc
Project: Whidbey

Creek - Downstream of Culvert Crossing

Lab ID: 2408282-004 **Collection Date:** 8/19/2024 9:00:00 AM
Client Sample ID: **S-4** **Matrix:** Groundwater

Analyses	Result	RL	MCL	Qual	Units	DF	Date Analyzed
Total Metals by EPA 200.8					Batch ID: 44932		Analyst: ME
Arsenic	0.00387	0.000500	0.0100		mg/L	1	8/22/2024 1:51:00 PM

Lab ID: 2408282-005 **Collection Date:** 8/19/2024 9:00:00 AM
Client Sample ID: **S-5** **Matrix:** Groundwater

Analyses	Result	RL	MCL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA 300.0					Batch ID: 44911		Analyst: OP
Chloride	9.70	0.400	250	D	mg/L	2	8/20/2024 6:35:00 PM
Nitrite (as N)	ND	0.200	1.00		mg/L	1	8/19/2024 8:01:00 PM
Nitrate (as N)	0.436	0.200	10.0		mg/L	1	8/19/2024 8:01:00 PM
Conductivity by SM 2510B					Batch ID: R93900		Analyst: OP
Specific Conductance (Conductivity)	223	1.00			µS/cm	1	8/26/2024 4:07:58 PM

Lab ID: 2408282-006 **Collection Date:** 8/19/2024 9:00:00 AM
Client Sample ID: **S-6** **Matrix:** Groundwater

Analyses	Result	RL	MCL	Qual	Units	DF	Date Analyzed
Total Coliform & E.coli by SM 9223B					Batch ID: R93776		Analyst: BB
Coliform, Total	1,011.2	1.0			MPN/100mL	1	8/19/2024 4:23:00 PM
E. coli	870.4	1.0			MPN/100mL	1	8/19/2024 4:23:00 PM

Alliance TECHNICAL GROUP

Analytical Report

Work Order: **2408282**
Date Reported: **8/26/2024**

CLIENT: PanGEO Inc
Project: Whidbey

Domestic Well

Lab ID: 2408282-007 **Collection Date:** 8/19/2024 8:25:00 AM
Client Sample ID: **S-7** **Matrix:** Drinking Water

Analyses	Result	RL	MCL	Qual	Units	DF	Date Analyzed
Drinking Water Metals by EPA 200.8					Batch ID: 44924		Analyst: ME
Arsenic	ND	0.00100	0.0100		mg/L	1	8/22/2024 11:13:00 AM

Lab ID: 2408282-008 **Collection Date:** 8/19/2024 8:25:00 AM
Client Sample ID: **S-8** **Matrix:** Drinking Water

Analyses	Result	RL	MCL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA 300.0					Batch ID: 44911		Analyst: OP
Chloride	6.23	0.400	250	D	mg/L	2	8/20/2024 6:58:00 PM
Nitrite (as N)	ND	0.200	1.00		mg/L	1	8/19/2024 8:24:00 PM
Nitrate (as N)	0.565	0.200	10.0		mg/L	1	8/19/2024 8:24:00 PM
Conductivity by SM 2510B					Batch ID: R93900		Analyst: OP
Specific Conductance (Conductivity)	206	1.00			µS/cm	1	8/26/2024 4:07:58 PM

Lab ID: 2408282-009 **Collection Date:** 8/19/2024 8:25:00 AM
Client Sample ID: **S-9** **Matrix:** Drinking Water

Analyses	Result	RL	MCL	Qual	Units	DF	Date Analyzed
Total Coliform & E.coli by SM 9223B (IDEXX)					Batch ID: R93776		Analyst: BB
Coliform, Total	ND	1.0			MPN/100mL	1	8/19/2024 4:23:00 PM
E. coli	ND	1.0			MPN/100mL	1	8/19/2024 4:23:00 PM

Date: *8/26/2024*

Work Order: 2408282
CLIENT: PanGEO Inc
Project: Whidbey

QC SUMMARY REPORT

Conductivity by SM 2510B

Sample ID: **MB-R93900**	SampType: **MBLK**			Units: **µS/cm**		Prep Date: **8/26/2024**			RunNo: **93900**		
Client ID: **MBLKW**	Batch ID: **R93900**					Analysis Date: **8/26/2024**			SeqNo: **1961265**		
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Specific Conductance (Conductivity)	ND	1.00									

Sample ID: **LCS-R93900**	SampType: **LCS**			Units: **µS/cm**		Prep Date: **8/26/2024**			RunNo: **93900**		
Client ID: **LCSW**	Batch ID: **R93900**					Analysis Date: **8/26/2024**			SeqNo: **1961266**		
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Specific Conductance (Conductivity)	968	1.00	1,000	0	96.8	90	110				

Sample ID: **LCSD-R93900**	SampType: **LCSD**			Units: **µS/cm**		Prep Date: **8/26/2024**			RunNo: **93900**		
Client ID: **LCSW02**	Batch ID: **R93900**					Analysis Date: **8/26/2024**			SeqNo: **1961267**		
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Specific Conductance (Conductivity)	969	1.00	1,000	0	96.9	90	110	968.0	0.103	20	

Date: *8/26/2024*

Work Order: 2408282
CLIENT: PanGEO Inc
Project: Whidbey

QC SUMMARY REPORT

Ion Chromatography by EPA 300.0

Sample ID: **MB-44911** SampType: **MBLK** Units: **mg/L** Prep Date: **8/19/2024** RunNo: **93731**
Client ID: **MBLKW** Batch ID: **44911** Analysis Date: **8/19/2024** SeqNo: **1957526**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.200									
Nitrite (as N)	ND	0.200									
Nitrate (as N)	ND	0.200									

Sample ID: **LCS-44911** SampType: **LCS** Units: **mg/L** Prep Date: **8/19/2024** RunNo: **93731**
Client ID: **LCSW** Batch ID: **44911** Analysis Date: **8/19/2024** SeqNo: **1957530**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	0.723	0.200	0.7500	0	96.4	90	110				
Nitrite (as N)	0.680	0.200	0.7500	0	90.7	90	110				
Nitrate (as N)	0.715	0.200	0.7500	0	95.3	90	110				

Sample ID: **2408281-003ADUP** SampType: **DUP** Units: **mg/L** Prep Date: **8/19/2024** RunNo: **93731**
Client ID: **BATCH** Batch ID: **44911** Analysis Date: **8/19/2024** SeqNo: **1957532**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	4.69	0.200						4.670	0.491	20	Q
Nitrite (as N)	ND	0.200						0		20	
Nitrate (as N)	4.03	0.200						4.020	0.273	20	

NOTES:
Q - Associated calibration verification is above acceptance criteria. Result may be high-biased.

Sample ID: **2408281-003AMS** SampType: **MS** Units: **mg/L** Prep Date: **8/19/2024** RunNo: **93731**
Client ID: **BATCH** Batch ID: **44911** Analysis Date: **8/19/2024** SeqNo: **1957533**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	5.39	0.200	0.7500	4.670	96.3	80	120				
Nitrite (as N)	0.692	0.200	0.7500	0	92.3	80	120				
Nitrate (as N)	4.72	0.200	0.7500	4.020	93.5	80	120				

Work Order: 2408282
CLIENT: PanGEO Inc
Project: Whidbey

QC SUMMARY REPORT
Ion Chromatography by EPA 300.0

Sample ID: **2408281-003AMSD** SampType: **MSD** Units: **mg/L** Prep Date: **8/19/2024** RunNo: **93731**

Client ID: **BATCH** Batch ID: **44911** Analysis Date: **8/19/2024** SeqNo: **1957534**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	5.42	0.200	0.7500	4.670	99.6	80	120	5.392	0.463	20	
Nitrite (as N)	0.710	0.200	0.7500	0	94.7	80	120	0.6920	2.57	20	
Nitrate (as N)	4.74	0.200	0.7500	4.020	96.5	80	120	4.721	0.486	20	

Alliance TECHNICAL GROUP

Work Order: 2408282
CLIENT: PanGEO Inc
Project: Whidbey

QC SUMMARY REPORT

Drinking Water Metals by EPA 200.8

Sample ID: **MB-44924** SampType: **MBLK** Units: **mg/L** Prep Date: **8/20/2024** RunNo: **93825**
Client ID: **MBLKW** Batch ID: **44924** Analysis Date: **8/22/2024** SeqNo: **1959387**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	0.00100									

Sample ID: **LCS-44924** SampType: **LCS** Units: **mg/L** Prep Date: **8/20/2024** RunNo: **93825**
Client ID: **LCSW** Batch ID: **44924** Analysis Date: **8/22/2024** SeqNo: **1959388**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.0968	0.00100	0.100	0	96.8	85	115				

Sample ID: **2408241-004ADUP** SampType: **DUP** Units: **mg/L** Prep Date: **8/20/2024** RunNo: **93825**
Client ID: **BATCH** Batch ID: **44924** Analysis Date: **8/22/2024** SeqNo: **1959390**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	0.00100						0		30	

Sample ID: **2408241-004AMS** SampType: **MS** Units: **mg/L** Prep Date: **8/20/2024** RunNo: **93825**
Client ID: **BATCH** Batch ID: **44924** Analysis Date: **8/22/2024** SeqNo: **1959391**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.110	0.00100	0.100	0	110	70	130				

Sample ID: **2408282-007AMS** SampType: **MS** Units: **mg/L** Prep Date: **8/20/2024** RunNo: **93825**
Client ID: **S-7** Batch ID: **44924** Analysis Date: **8/22/2024** SeqNo: **1959417**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.0959	0.00100	0.100	0.000774	95.2	70	130				

Work Order: 2408282
CLIENT: PanGEO Inc
Project: Whidbey

QC SUMMARY REPORT

Drinking Water Metals by EPA 200.8

Sample ID: **MB-44924** SampType: **MBLK** Units: **mg/L** Prep Date: **8/20/2024** RunNo: **93825**
Client ID: **MBLKW** Batch ID: **44924** Analysis Date: **8/22/2024** SeqNo: **1959421**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	0.00100									

Alliance TECHNICAL GROUP

Work Order: 2408282
CLIENT: PanGEO Inc
Project: Whidbey

QC SUMMARY REPORT

Total Metals by EPA 200.8

Sample ID: **MB-44932** SampType: **MBLK** Units: **mg/L** Prep Date: **8/21/2024** RunNo: **93836**
Client ID: **MBLKW** Batch ID: **44932** Analysis Date: **8/22/2024** SeqNo: **1959633**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	0.000500									

Sample ID: **LCS-44932** SampType: **LCS** Units: **mg/L** Prep Date: **8/21/2024** RunNo: **93836**
Client ID: **LCSW** Batch ID: **44932** Analysis Date: **8/22/2024** SeqNo: **1959634**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.103	0.000500	0.100	0	103	85	115				

Sample ID: **2408275-001ADUP** SampType: **DUP** Units: **mg/L** Prep Date: **8/21/2024** RunNo: **93836**
Client ID: **BATCH** Batch ID: **44932** Analysis Date: **8/22/2024** SeqNo: **1959636**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	0.0100						0		30	D

Sample ID: **2408275-001AMS** SampType: **MS** Units: **mg/L** Prep Date: **8/21/2024** RunNo: **93836**
Client ID: **BATCH** Batch ID: **44932** Analysis Date: **8/22/2024** SeqNo: **1959637**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.117	0.0100	0.100	0.00322	114	70	130				D

Sample ID: **2408338-001AMS** SampType: **MS** Units: **mg/L** Prep Date: **8/22/2024** RunNo: **93836**
Client ID: **BATCH** Batch ID: **44932** Analysis Date: **8/22/2024** SeqNo: **1959672**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.106	0.000500	0.100	0.00116	105	70	130				

Alliance TECHNICAL GROUP

Sample Log-In Check List

Client Name:	PANGEO	Work Order Number:	2408282
Logged by:	Morgan Wilson	Date Received:	8/19/2024 11:20:00 AM

Chain of Custody

1. Is Chain of Custody complete? — Yes ☑ No ☐ Not Present ☐
2. How was the sample delivered? — Client

Log In

3. Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact) — Yes ☐ No ☐ Not Present ☑
4. Was an attempt made to cool the samples? — Yes ☑ No ☐ NA ☐
5. Were all items received at a temperature of >2°C to 6°C * — Yes ☑ No ☐ NA ☐
6. Sample(s) in proper container(s)? — Yes ☑ No ☐
7. Sufficient sample volume for indicated test(s)? — Yes ☑ No ☐
8. Are samples properly preserved? — Yes ☑ No ☐
9. Was preservative added to bottles? — Yes ☐ No ☑ NA ☐
10. Is there headspace in the VOA vials? — Yes ☐ No ☐ NA ☑
11. Did all samples containers arrive in good condition(unbroken)? — Yes ☑ No ☐
12. Does paperwork match bottle labels? — Yes ☑ No ☐
13. Are matrices correctly identified on Chain of Custody? — Yes ☑ No ☐
14. Is it clear what analyses were requested? — Yes ☑ No ☐
15. Were all hold times (except field parameters, pH e.g.) able to be met? — Yes ☑ No ☐

Special Handling (if applicable)

16. Was client notified of all discrepancies with this order? — Yes ☑ No ☐ NA ☐

Person Notified:	Spenser Scott	Date:	8/19/2024
By Whom:	Morgan Wilson	Via:	☑ eMail ☑ Phone ☐ Fax ☐ In Person
Regarding:	Samples 3-6 Matrix, Mislabels on Bacteria Bottles		
Client Instructions:	GW from Creek, Each Set is from same source, assign bottles as needed		

17. Additional remarks:

Item Information

Item #	Temp ºC
Sample	5.6

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Fremont Analytical — An Alliance Technical Group Company
3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790

Chain of Custody Record & Laboratory Services Agreement

Date: 8/19/24 Page: 1 of: 3
Laboratory Project No (internal): 2408281
Special Remarks:

Project Name: WHIDBEY
Project No: 23-256.200
Collected by: SPENSER SCOTT
Location: STINKY WELL
Report To (PM): SCOTT DINKELMAN

Client: PANGEO
Address: 3213 EASTLAKE AVE E
City, State, Zip: SEATTLE, WA 98102
Telephone: 206-262-0370
Email(s): SDINKELMAN@PANGEOINC.COM + SSCOTT@PANGEOINC.COM

Disposal: Samples will be disposed in 30 days unless otherwise requested.
☐ Retain volume (specify above) ☐ Return to client

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	# of Cont.	VOCs (EPA 8260 / 624)	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) / Dissolved (D)	Anions (IC)*** 300.0	EDB (8011)	Bacteriological SM 9223B				Comments
1	S-1	8/19/24	8:45	DW	1									X								
2	S-2	8/19/24	8:45	DW	1											X						Conductivity SM2510B
3	S-3	8/19/24	8:45	DW	1													X				
4																						
5																						
6																						
7																						
8																						
9																						
10																						

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

**Metals (Circle): MTCA-5 RCRA-8 Priority Pollutants TAL Individual: Ag Al (As) B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl V Zn

***Anions (Circle): (Nitrate) (Nitrite) (Chloride) Sulfate Bromide O-Phosphate Fluoride Nitrate+Nitrite

Turn-around Time: ☒ Standard ☐ Next Day ☐ 3 Day ☐ Same Day ☐ 2 Day ____ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above, that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished (Signature)	Print Name	Date/Time	Received (Signature)	Print Name	Date/Time
x [signature]	SPENSER P SCOTT	8/19/24 11:20	x [signature]	Jack Hawthorne	8/19/24 1120
x			x		

Fremont Analytical
An Alliance Technical Group Company

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790

Chain of Custody Record & Laboratory Services Agreement

Date: 8/19/24	Page: 2 of: 3
Laboratory Project No (internal): 2408281	
Project Name: WHIDBEY	Special Remarks:
Client: PANGEO	Project No: 23-356.200
Address: 3213 EASTLAKE AVE E	Collected by: SPENSER SCOTT
City, State, Zip: SEATTLE, WA 98102	Location: CREEK
Telephone: 206-262-0370	Report To (PM): SCOTT DINKELMAN
Email(s): SDINKELMAN@PANGEOINC.COM + SSCOTT@PANGEOINC.COM	

Disposal: Samples will be disposed in 30 days unless otherwise requested. ☐ Retain volume (specify above) ☐ Return to client

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	# of Cont.	VOCs (EPA 8260 / 624)	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / (200.8))	Total (T) | Dissolved (D)	Anions (IC)*** 300.0	EDB (8011)	Bacteriological SM 9223B				Comments
1	S-4	8/19/24	9:00	GW	1									X								
2	S-5	8/19/24	9:00	GW	1											X						Conductivity SM 2510B
3	S-6	8/19/24	9:00	GW	1													X				
4																						
5																						
6																						
7																						
8																						
9																						
10																						

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

**Metals (Circle): MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag Al (As) B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl V Zn

***Anions (Circle): (Nitrate) (Nitrite) (Chloride) Sulfate Bromide O-Phosphate Fluoride Nitrate+Nitrite

Turn-around Time: ☒ Standard ☐ Next Day ☐ 3 Day ☐ Same Day ☐ 2 Day ____ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above, that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished (Signature)	Print Name	Date/Time	Received (Signature)	Print Name	Date/Time
x [signature]	SPENSER SCOTT	11:20 8/19/24	x [signature]	Jack Hawthorne	8/19/24 1120
x			x		

Chain of Custody Record & Laboratory Services Agreement

Fremont Analytical — An Alliance Technical Group Company
3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790

Date: 8/19/24 Page: 3 of: 3
Laboratory Project No (internal): 2408281

Project Name: WHIDBEY
Project No: 23-356.200
Collected by: SPENSER SCOTT
Location: BARN TAP
Report To (PM): SCOTT DINKELMAN

Client: PANGEO
Address: 3213 EASTLAKE AVE E
City, State, Zip: SEATTLE, WA 98102
Telephone: 206-262-0370
Email(s): SDINKELMAN@PANGEOINC.COM + SSCOTT@PANGEOINC.COM

Special Remarks:

Disposal: Samples will be disposed in 30 days unless otherwise requested.
☐ Retain volume (specify above) ☐ Return to client

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	# of Cont.	VOCs (EPA 8260 / 624)	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 (200.8))	Total (T) | Dissolved (D)	Anions (IC)*** 300.0	EDB (8011)	Bacteriological SM 9223B			Comments
1	S7	8/19/24	8:25	DW	1									X							
2	S-8	8/19/24	8:25	DW	1											X					Conductivity SM2510B
3	S-9	8/19/24	8:25	DW	1													X			
4																					
5																					
6																					
7																					
8																					
9																					
10																					

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

**Metals (Circle): MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag Al (As) B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl V Zn

***Anions (Circle): (Nitrate) (Nitrite) (Chloride) Sulfate Bromide O-Phosphate Fluoride Nitrate+Nitrite

Turn-around Time: ☒ Standard ☐ Next Day ☐ 3 Day ☐ Same Day ☐ 2 Day ____ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above, that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished (Signature)	Print Name	Date/Time	Received (Signature)	Print Name	Date/Time
x [signature]	SPENSER SCOTT	11:20 8/19/24	x [signature]	Jack Hawthorne	8/19/24 1120
Relinquished (Signature) x	Print Name	Date/Time	Received (Signature) x	Print Name	Date/Time

ALLIANCE TECHNICAL GROUP

SAMPLE COLLECTED MAY 7, 2024

3600 Fremont Ave N
Seattle, WA 98103
T: (206) 352-3790
F: (206) 352-7178
info@fremontanalytical.com

PanGEO Inc.
Scott Dinkelman
3213 Easklake Ave E. Suite B
Seattle, WA 98102

RE: Whidbey, 23-356.200
Work Order Number: 2405124

May 14, 2024

Attention Scott Dinkelman:

Fremont Analytical, Inc, an Alliance Technical Group company, received 3 sample(s) on 5/7/2024 for the analyses presented in the following report.

Conductivity by SM 2510B
Drinking Water Metals by EPA 200.8
Ion Chromatography by EPA 300.0
Total Coliform & E.coli by SM 9223B (IDEXX)

All analyses were performed according to our accredited Quality Assurance program. Please contact the laboratory if you should have any questions about the results.

Please note, while the appearance of our logo and branding will update, our commitment to accuracy, speed, and customer service remain values celebrated and shared by Alliance Technical Group. Thank you for the opportunity to serve you.

Sincerely,

Brianna Barnes
Project Manager

DoD-ELAP Accreditation #79636 by PJLA, ISO/IEC 17025:2017 and QSM 5.4 for Environmental Testing
ORELAP Certification: WA 100009 (NELAP Recognized) for Environmental Testing
Washington State Department of Ecology Accredited for Environmental Testing, Lab ID C910

Original

Date: *05/14/2024*

CLIENT:	PanGEO Inc.
Project:	Whidbey
Work Order:	2405124

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
2405124-001	S-1	05/07/2024 9:48 AM	05/07/2024 12:23 PM
2405124-002	S-2	05/07/2024 9:48 AM	05/07/2024 12:23 PM
2405124-003	S-3	05/07/2024 9:48 AM	05/07/2024 12:23 PM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **2405124**
Date: **5/14/2024**

CLIENT: PanGEO Inc.
Project: Whidbey

I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Information about the National Primary Drinking Water Regulations and their Maximum Contaminant Levels (MCLs) can be found at: https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

Prep Sample Comments:
2405124-002A 652056: Prep Comments for EPA200.8, Sample 2405124-002A: Turbidity = 0.07 NTU

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
DUP - Sample Duplicate
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MCL - Maximum Contaminant Level
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
REP - Sample Replicate
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Analytical Report

Alliance TECHNICAL GROUP

Work Order: **2405124**
Date Reported: **5/14/2024**

CLIENT: PanGEO Inc.
Project: Whidbey

Lab ID: 2405124-001 **Collection Date:** 5/7/2024 9:48:00 AM
Client Sample ID: **S-1** **Matrix:** Drinking Water

Analyses	Result	RL	MCL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA 300.0					Batch ID: 43820		Analyst: FG
Chloride	5.93	0.200	250		mg/L	1	5/8/2024 8:14:00 PM
Nitrite (as N)	ND	0.200	1.00		mg/L	1	5/8/2024 8:14:00 PM
Nitrate (as N)	0.514	0.200	10.0		mg/L	1	5/8/2024 8:14:00 PM
Conductivity by SM 2510B					Batch ID: R91552		Analyst: FG
Specific Conductance (Conductivity)	201	1.00			µS/cm	1	5/8/2024 2:29:14 PM

Lab ID: 2405124-002 **Collection Date:** 5/7/2024 9:48:00 AM
Client Sample ID: **S-2** **Matrix:** Drinking Water

Analyses	Result	RL	MCL	Qual	Units	DF	Date Analyzed
Drinking Water Metals by EPA 200.8					Batch ID: 43844		Analyst: ME
Arsenic	0.00115	0.00100	0.0100		mg/L	1	5/9/2024 9:52:00 AM

Lab ID: 2405124-003 **Collection Date:** 5/7/2024 9:48:00 AM
Client Sample ID: **S-3** **Matrix:** Drinking Water

Analyses	Result	RL	MCL	Qual	Units	DF	Date Analyzed
Total Coliform & E.coli by SM 9223B (IDEXX)					Batch ID: R91619		Analyst: BB
Coliform, Total	ND	1.0			MPN/100mL	1	5/7/2024 3:45:00 PM
E. coli	ND	1.0			MPN/100mL	1	5/7/2024 3:45:00 PM

Date: *5/14/2024*

Work Order: 2405124
CLIENT: PanGEO Inc.
Project: Whidbey

QC SUMMARY REPORT

Conductivity by SM 2510B

Sample ID: **MB-R91552**	SampType: **MBLK**			Units: **µS/cm**		Prep Date: **5/8/2024**			RunNo: **91552**		
Client ID: **MBLKW**	Batch ID: **R91552**					Analysis Date: **5/8/2024**			SeqNo: **1909236**		
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Specific Conductance (Conductivity)	ND	1.00									

Sample ID: **LCS-R91552**	SampType: **LCS**			Units: **µS/cm**		Prep Date: **5/8/2024**			RunNo: **91552**		
Client ID: **LCSW**	Batch ID: **R91552**					Analysis Date: **5/8/2024**			SeqNo: **1909237**		
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Specific Conductance (Conductivity)	995	1.00	1,000	0	99.5	90	110				

Sample ID: **2405124-001ADUP**	SampType: **DUP**			Units: **µS/cm**		Prep Date: **5/8/2024**			RunNo: **91552**		
Client ID: **S-1**	Batch ID: **R91552**					Analysis Date: **5/8/2024**			SeqNo: **1909239**		
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Specific Conductance (Conductivity)	201	1.00						201.0	0	20	

Alliance TECHNICAL GROUP

Work Order: 2405124
CLIENT: PanGEO Inc.
Project: Whidbey

QC SUMMARY REPORT

Ion Chromatography by EPA 300.0

Sample ID: **MB-43820** SampType: **MBLK** Units: **mg/L** Prep Date: **5/8/2024** RunNo: **91595**
Client ID: **MBLKW** Batch ID: **43820** Analysis Date: **5/8/2024** SeqNo: **1910504**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.200									
Nitrite (as N)	ND	0.200									
Nitrate (as N)	ND	0.200									

Sample ID: **LCS-43820** SampType: **LCS** Units: **mg/L** Prep Date: **5/8/2024** RunNo: **91595**
Client ID: **LCSW** Batch ID: **43820** Analysis Date: **5/8/2024** SeqNo: **1910505**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	0.726	0.200	0.7500	0	96.8	90	110				
Nitrite (as N)	0.707	0.200	0.7500	0	94.3	90	110				
Nitrate (as N)	0.720	0.200	0.7500	0	96.0	90	110				

Sample ID: **2405118-001BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **5/8/2024** RunNo: **91595**
Client ID: **BATCH** Batch ID: **43820** Analysis Date: **5/8/2024** SeqNo: **1910507**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	7.68	0.200						7.620	0.797	20	E
Nitrite (as N)	0.347	0.200						0.3470	0	20	
Nitrate (as N)	ND	0.200						0		20	

Sample ID: **2405118-001BMS** SampType: **MS** Units: **mg/L** Prep Date: **5/8/2024** RunNo: **91595**
Client ID: **BATCH** Batch ID: **43820** Analysis Date: **5/8/2024** SeqNo: **1910508**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	8.32	0.200	0.7500	7.620	92.8	80	120				E
Nitrite (as N)	1.14	0.200	0.7500	0.3470	106	80	120				
Nitrate (as N)	0.736	0.200	0.7500	0	98.1	80	120				

Alliance TECHNICAL GROUP

Work Order: 2405124
CLIENT: PanGEO Inc.
Project: Whidbey

QC SUMMARY REPORT
Ion Chromatography by EPA 300.0

Sample ID: **2405118-001BMSD** SampType: **MSD** Units: **mg/L** Prep Date: **5/8/2024** RunNo: **91595**
Client ID: **BATCH** Batch ID: **43820** Analysis Date: **5/8/2024** SeqNo: **1910509**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	8.32	0.200	0.7500	7.620	93.2	80	120	8.316	0.0361	20	E
Nitrite (as N)	1.15	0.200	0.7500	0.3470	107	80	120	1.142	0.698	20	
Nitrate (as N)	0.734	0.200	0.7500	0	97.9	80	120	0.7360	0.272	20	

Work Order: 2405124
CLIENT: PanGEO Inc.
Project: Whidbey

QC SUMMARY REPORT

Drinking Water Metals by EPA 200.8

Sample ID: **MB-43844** SampType: **MBLK** Units: **mg/L** Prep Date: **5/9/2024** RunNo: **91574**
Client ID: **MBLKW** Batch ID: **43844** Analysis Date: **5/9/2024** SeqNo: **1909886**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	0.00100									

Sample ID: **2405124-002ADUP** SampType: **DUP** Units: **mg/L** Prep Date: **5/9/2024** RunNo: **91574**
Client ID: **S-2** Batch ID: **43844** Analysis Date: **5/9/2024** SeqNo: **1909889**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.00113	0.00100						0.00115	1.93	30	

Sample ID: **2405124-002AMS** SampType: **MS** Units: **mg/L** Prep Date: **5/9/2024** RunNo: **91574**
Client ID: **S-2** Batch ID: **43844** Analysis Date: **5/9/2024** SeqNo: **1909890**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.0974	0.00100	0.100	0.00115	96.2	70	130				

Sample ID: **2405124-002AMSD** SampType: **MSD** Units: **mg/L** Prep Date: **5/9/2024** RunNo: **91574**
Client ID: **S-2** Batch ID: **43844** Analysis Date: **5/9/2024** SeqNo: **1909891**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.0988	0.00100	0.100	0.00115	97.7	70	130	0.0974	1.49	30	

Sample ID: **LCS-43844** SampType: **LCS** Units: **mg/L** Prep Date: **5/9/2024** RunNo: **91574**
Client ID: **LCSW** Batch ID: **43844** Analysis Date: **5/9/2024** SeqNo: **1909873**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	0.0907	0.00100	0.100	0	90.7	85	115				

Alliance TECHNICAL GROUP

Sample Log-In Check List

Client Name:	PANGEO	Work Order Number:	2405124
Logged by:	Morgan Wilson	Date Received:	5/7/2024 12:23:00 PM

Chain of Custody

1.	Is Chain of Custody complete?	Yes ☑	No ☐	Not Present ☐
2.	How was the sample delivered?	Client		

Log In

3.	Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact)	Yes ☐	No ☐	Not Present ☑
4.	Was an attempt made to cool the samples?	Yes ☑	No ☐	NA ☐
5.	Were all items received at a temperature of >2°C to 6°C *	Yes ☑	No ☐	NA ☐
6.	Sample(s) in proper container(s)?	Yes ☑	No ☐	
7.	Sufficient sample volume for indicated test(s)?	Yes ☑	No ☐	
8.	Are samples properly preserved?	Yes ☑	No ☐	
9.	Was preservative added to bottles?	Yes ☐	No ☑	NA ☐
10.	Is there headspace in the VOA vials?	Yes ☐	No ☐	NA ☑
11.	Did all samples containers arrive in good condition(unbroken)?	Yes ☑	No ☐	
12.	Does paperwork match bottle labels?	Yes ☑	No ☐	
13.	Are matrices correctly identified on Chain of Custody?	Yes ☑	No ☐	
14.	Is it clear what analyses were requested?	Yes ☑	No ☐	
15.	Were all hold times (except field parameters, pH e.g.) able to be met?	Yes ☑	No ☐	

Special Handling (if applicable)

16.	Was client notified of all discrepancies with this order?	Yes ☑	No ☐	NA ☐

Person Notified:	Scott Dinkelman	Date:	5/7/2024
By Whom:	Morgan Wilson	Via:	☑ eMail ☑ Phone ☐ Fax ☐ In Person
Regarding:	Confirm Analyses vs Bottle Order Request		
Client Instructions:	Updated COC to Include Conductivity		

17. Additional remarks:

Item Information

Item #	Temp ºC
Sample	5.1

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Fremont Analytical
An Alliance Technical Group Company

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790

Chain of Custody Record & Laboratory Services Agreement

Date: 5/7/24 Page: 1 of: 1

Laboratory Project No (internal): 2405104

Project Name: WHIDBEY

Project No: 23-356.200

Collected by: SCOTT DINKELMAN

Location: WELL AKY-721

Report To (PM): SCOTT DINKELMAN

Special Remarks:

Disposal: Samples will be disposed in 30 days unless otherwise requested.
☐ Retain volume (specify above) ☐ Return to client

Client: PANGEO

Address: 3213 EASTLAKE AVE E

City, State, Zip: SEATTLE, WA 98102

Telephone: (206) 262-0370

Email(s): SDINKELMAN@PANGEOINC.COM

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	# of Cont.	VOCs (EPA 8260 / 624)	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) / Dissolved (D)	Anions (IC)***	EDB (8011)	BACTERIALOGICAL			Comments
1	S-1	5/7/24	9:48	DW	1											X					
2	S-2	5/7/24	9:48	DW	1									X		~~X~~					
3	S-3	5/7/24	9:48	DW	1											~~X~~		X			
4																					
5																					
6																					
7																					
8																					
9																					
10																					

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

**Metals (Circle): MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag Al (As) B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl V Zn

***Anions (Circle): Nitrate Nitrite (Chloride) Sulfate Bromide O-Phosphate Fluoride (Nitrate+Nitrite)

Turn-around Time:
☒ Standard ☐ Next Day
☐ 3 Day ☐ Same Day
☐ 2 Day ______ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above, that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished (Signature)	Print Name	Date/Time	Received (Signature)	Print Name	Date/Time
x [signature]	SCOTT DINKELMAN	5/7/24 12:22	x [signature]	G Hein-Gipson	5/7/24 12:23
x			x		

Fremont Analytical

An Alliance Technical Group Company

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790

Chain of Custody Record & Laboratory Services Agreement

Date: 5/7/24 Page: 1 of: 1

Laboratory Project No (internal): 2405104

Client: PANGEO

Address: 3213 EASTLAKE AVE E

City, State, Zip: SEATTLE, WA 98102

Telephone: (206) 262-0370

Email(s): SDINKELMAN@PANGEOINC.COM

Project Name: WHIDBEY

Project No: 23-356.200

Collected by: SCOTT DINKELMAN

Location: WELL AKY-721

Report To (PM): SCOTT DINKELMAN

Special Remarks:
Update per SD -mw 5/7/24

Disposal: Samples will be disposed in 30 days unless otherwise requested.
☐ Retain volume (specify above) ☐ Return to client

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	# of Cont.	VOCs (EPA 8260 / 624)	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8) Total (T) / Dissolved (D)	Anions (IC)***	EDB (8011)	BACTERIALOGICAL				Comments
1	S-1	5/7/24	9:48	DW	1										X						Conductivity
2	S-2	5/7/24	9:48	DW	1									X	~~X~~						
3	S-3	5/7/24	9:48	DW	1										~~X~~		X				
4																					
5																					
6																					
7																					
8																					
9																					
10																					

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

**Metals (Circle): MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag Al As B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl V Zn

***Anions (Circle): Nitrate Nitrite Chloride Sulfate Bromide O-Phosphate Fluoride ~~Nitrate+Nitrite~~

Turn-around Time:
☒ Standard ☐ Next Day
☐ 3 Day ☐ Same Day
☐ 2 Day ____ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above, that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished (Signature)	Print Name	Date/Time	Received (Signature)	Print Name	Date/Time
x [signature]	SCOTT DINKELMAN	5/7/24 12:22	x [signature]	G Hein-Gipson	5/7/24 12:23
x			x		

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COC 1.3 - 11.06.20

EDGE ANALYTICAL

DRINKING WATER QUALITY REPORT

SAMPLE COLLECTED

FEBRUARY 16, 2021

Burlington, WA *Corporate Laboratory (a)*
1620 S Walnut St - Burlington, WA 98233 - **800.755.9295** • 360.757.1400

Bellingham, WA *Microbiology (b)*
805 Orchard Dr Ste 4 - Bellingham, WA 98225 - 360.715.1212

Portland, OR *Microbiology/Chemistry (c)*
9150 SW Pioneer Ct Ste W - Wilsonville, OR 97070 - 503.682.7802

Corvallis, OR *Microbiology/Chemistry (d)*
1100 NE Circle Blvd, Ste 130 - Corvallis, OR 97330 - 541.753.4946

Bend, OR *Microbiology (e)*
20332 Empire Blvd Ste 4 - Bend, OR 97701 - 541.639.8425

Drinking Water Quality Report

Client Name: Bryant Plumbing
PO Box 622
Clinton, WA 98236

Project: EWS Well Report

Reference Number: **21-05439**
Report Date: 2/26/21
Approved By: bj,bsp,rml

Authorized by:

Lawrence J Henderson, PhD
Director of Laboratories, Vice President

Lab Number: 046-10612
Date Received: 2/16/21
Sampled By: Josh
Sampler Phone:

Field ID:
Sample Description: Well Head
Sample Date: 2/16/21 10:00

CAS Number	Analyte	Result	MCL	Pass^	Lab	QL	Units	Analyzed	Comments
Primary Drinking Water Standards									
7440-38-2	ARSENIC	**0.0011**	0.010	Pass	a	0.001	mg/L	2/22/21	
7439-97-6	MERCURY	**ND**	0.002	Pass	a	0.0001	mg/L	2/19/21	
7439-92-1	LEAD	**0.0123**	0.015	Pass	a	0.001	mg/L	2/22/21	
16984-48-8	FLUORIDE	**ND**	4	Pass	a	0.1	mg/L	2/16/21	
14797-55-8	NITRATE-N	**0.44**	10	Pass	a	0.1	mg/L	2/16/21	
14797-65-0	NITRITE-N	**ND**	1.0	Pass	a	0.1	mg/L	2/16/21	
E-10128	TOTAL NITRATE+NITRITE as N	**0.44**	10	Pass	a	0.1	mg/L	2/16/21	
Secondary Drinking Water Standards									
7439-96-5	MANGANESE	**0.0104**	0.05	Pass	a	0.001	mg/L	2/22/21	
7439-89-6	IRON	**0.27**	0.3	Pass	a	0.05	mg/L	2/18/21	
E-11778	HARDNESS as Calcium Carbonate	**78.7**			a	10	mg/L	2/18/21	
E-10184	ELECTRICAL CONDUCTIVITY	**186**	700	Pass	a	10	uS/cm	2/17/21	
E-10173	TOTAL DISSOLVED SOLIDS (TDS)	**122**	500	Pass	a	10	mg/L	2/19/21	
16887-00-6	CHLORIDE	**6.02**	250	Pass	a	0.1	mg/L	2/16/21	
14808-79-8	SULFATE	**4.87**	250	Pass	a	0.2	mg/L	2/16/21	
Aesthetic Drinking Water Standards									
7631-86-9	*SILICA	**36.3**			a	0.05	mg/L	2/18/21	
E-14506	ALKALINITY	**81.1**			a	1	mg CaCC	2/18/21	
7440-23-5	SODIUM	**7.2**			a	0.5	mg/L	2/18/21	
E-10139	HYDROGEN ION (pH)	**7.15**			a		pH Units	2/16/21	Temp (C) : 25.1
Microbiology									
	*IRON RELATED BACTERIA	**POS**			b	P/A	CFU/mL	2/22/21	Density: 500-2200 cfu/mL; Moderate

Notation:
MCL = Maximum Contaminant Level, maximum permissible level of a contaminant in water established by EPA; Federal Action Levels are 0.015 mg/L for Lead and 1.3 mg/L for Copper. Sodium has a recommended limit of 20 mg/L. A blank MCL value indicates a level is not currently established.
QL = Quantitation Limit is the lower calibration cpncentration.
ND = Not detected above the listed specified reporting limit (QL).
CAS Number = Chemical Abstract Service Number is an unique identifier of the Analyte tested.
^ = 'PASS', indicates that the parameter tested meets EPA, State, or local jurisdiction MCL.
An * in front of the parameter name indicates it is not NELAP accredited but it is accredited through OR DEQ or USEPA Region 10.

These test results meet all the requirements of NELAC, unless otherwise stated in writing, and relate only to these samples.
If you have any questions concerning this report contact Lawrence J Henderson at the above phone number.

ATTACHMENT B

DOH Nitrate Loading Worksheets for West OSS and East OSS

Large On-Site Sewage System (LOSS) Level 1 Nitrate Balance

Project name:	**20250119 - Emergence Whidbey**
Address, city and county:	**Campbell Road, Island County**
Completed by (name and title):	**Chris Allen - Associate Hydrogeologist**
Date:	**9/9/2025**

WEST DRAINFIELD (Dining Hall, Laundry Facility, and Farmhouse)

Input Values	Factor	Units	Values	Information Source
Nitrate concentration in precipitation	N_R	mg/l as N	0.24	DOH Default Value
Total nitrogen concentration in wastewater	N_W	mg/l	30	Advantex System (50% reducition from residential strength)
Soil denitrification	d	unitless	0.1	DOH Default Value
Aquifer thickness	b	ft	20	Onsite Subsurface Information / PanGeo Rpt (2025a)
Drainfield area	A_D	ft^2	3,510	MW Works Site Plan (See Fig. 1)
Distance from drainfield to property boundary	D_{pb}	ft	140	MW Works Site Plan (See Fig. 1)
Aquifer width	W_A	ft	140	MW Works Site Plan (See Fig. 1)
Aquifer hydraulic conductivity	K	ft/day	74	Onsite PIT results & King Cty Surface Water Manual
Hydraulic gradient	i	ft/ft	0.010	DOH Default Value
Recharge	R	in/yr	12.8	PRISM, Oregon State University database
Nitrate concentration of upgradient ground water	N_B	mg/l	0.565	PanGeo Report (2025a), onsite well sample results
Wastewater volume	V_W	gpd	1,111	MW Works

Output Values				
Groundwater nitrate value	N_{GW}	mg/l as N	2.32	**Point of Compliance (POC)**
Groundwater nitrate value above background	N_{GW}	mg/l as N	1.76	**Point of Compliance (POC)**
Groundwater nitrate value	$N_{GW\ ALT}$	mg/l as N	2.27	**Alternative POC**
Groundwater nitrate value above background	$N_{GW\ ALT}$	mg/l as N	1.71	**Alternative POC**

Large On-Site Sewage System (LOSS) Level 1 Nitrate Balance

Project name:	**20250119 - Emergence Whidbey**
Address, city and county:	**Campbell Road, Island County**
Completed by (name and title):	**Chris Allen - Associate Hydrogeologist**
Date:	**9/9/2025**

EAST OSS DRAINFIELD (CABINS)

Input Values	Factor	Units	Values	Information Source
Nitrate concentration in precipitation	N_R	mg/l as N	0.24	DOH Default Value
Total nitrogen concentration in wastewater	N_W	mg/l	30	Advantex System (50% reducition from residential strength)
Soil denitrification	d	unitless	0.1	DOH Default Value
Aquifer thickness	b	ft	20	Onsite Subsurface Information / PanGeo Rpt (2025a)
Drainfield area	A_D	ft^2	3,132	MW Works Site Plan (See Fig. 1)
Distance from drainfield to property boundary	D_{pb}	ft	110	MW Works Site Plan (See Fig. 1)
Aquifer width	W_A	ft	210	MW Works Site Plan (See Fig. 1)
Aquifer hydraulic conductivity	K	ft/day	45	Onsite PIT results & King Cty Surface Water Manual
Hydraulic gradient	i	ft/ft	0.010	DOH Default Value
Recharge	R	in/yr	12.8	PRISM, Oregon State University database
Nitrate concentration of upgradient ground water	N_B	mg/l	0.565	PanGeo Report (2025a), onsite well sample results
Wastewater volume	V_W	gpd	750	MW Works

Output Values				
Groundwater nitrate value	N_{GW}	mg/l as N	1.89	Point of Compliance (POC)
Groundwater nitrate value above background	N_{GW}	mg/l as N	1.32	Point of Compliance (POC)
Groundwater nitrate value	$N_{GW\ ALT}$	mg/l as N	1.83	Alternative POC
Groundwater nitrate value above background	$N_{GW\ ALT}$	mg/l as N	1.27	Alternative POC

ATTACHMENT C

Advantex® Information

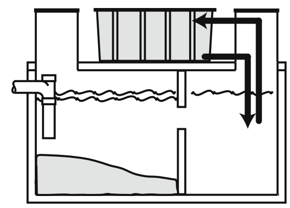
AdvanTex® Performance Summary #2

Nutrient Reduction: TN, NH_3, TP

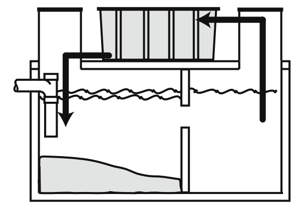
AdvanTex® Treatment Systems — Manufactured by Orenco Systems®, Inc.

Since 2001, the performance of AdvanTex® Treatment Systems has been tested in a dozen different programs. Tests have been performed both in test centers and in the field. These include testing performed by outside companies or agencies (third-party); contract testing performed by Orenco distributors (second-party); and Orenco's own testing (first-party). More than 1000 data points have been collected.

This performance summary documents the performance of AdvanTex Treatment Systems relative to nutrient reduction . . . specifically, reductions in Total Nitrogen (TN), Ammonia (NH_3), and Total Phosphorous (TP). The results show that AdvanTex systems easily meet advanced treatment standards for nitrogen and total phosphorous.



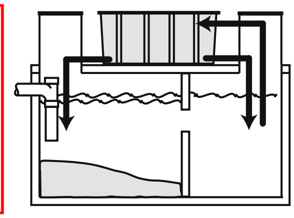
Mode 1 with processing tank



Mode 3 with processing tank (Optimized for denitrification)

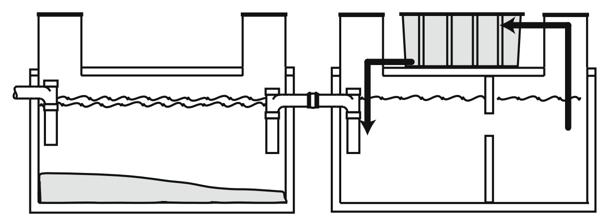
About System Configurations

As shown in the illustrations on the right, AdvanTex systems can be configured in several ways depending on the degree of total nitrogen reduction required. In Mode 1, filtrate from the AdvanTex pod is recirculated to the secondary chamber of the septic tank. In Mode 3, the filtrate is recirculated to the primary chamber, where the environment favors further denitrification. In Combo mode, the filtrate is recirculated to both chambers, in controlled proportions.



Combo Mode with processing tank

In Virginia, North Carolina, and Rhode Island, some of the systems tested in Mode 1 incorporated two tanks: a primary tank and a recirculation tank. In the primary tank, sludge and scum are separated from liquid effluent, which then flows into a separate recirculation tank, into which the AdvanTex filtrate is recirculated.



Mode 1 with primary tank and recirculation tank

About the Results

The table below summarizes effluent testing results for Total Nitrogen, Ammonia, and Total Phosphorous, both from test center programs and field testing programs. The pages that follow provide more specific results of these testing programs. For ease of comparison, we have also included information about the circumstances of each test. If you have any questions regarding this summary, please contact Sam Carter, Government Relations Manager, Orenco Systems, Inc., (800) 536-4192, scarter@orenco.com.

TEST CENTERS SUMMARY

AdvanTex Effluent Averages	*Total N (mg/L)* [a]	*NH_3 (mg/L)*	*Total P (mg/L)*	*Duration*
NSF/ANSI Standard 40 Testing	12 (64%)[b]	0.9 (96%)	-	7 months
NSF/ANSI Standard 40 Testing with UV Disinfection	13 (66%)	1.1	-	6 months
Rotorua District Council Approval Testing	13 (82%)	0.2 (99%)	8 (33%)	13 months
New Zealand OSET Testing Programme	12 (80%)	0.6 (99%)	-	10 months

FIELD TESTING SUMMARY

AdvanTex Effluent Averages (# of SFRs) [c]	*Total N (mg/L)*	*NH_3 (mg/L)*	*Total P (mg/L)*	*Duration*
Roger Shafer, P.E., "Testing in Fractured Bedrock" (1)	14 (63%)	-	6 (33%)	8 months
NSF Pennsylvania Testing Program (11)	17 (68%)	1.7 (96%)	-	1-3 years
Virginia Approval Testing Program (13)	15	1.8	-	18 months
Jefferson County Health Dept. Permit Testing (43)	15	-	-	2 years, 7 months
Skaneateles Demonstration Project (2)	14	0.9	10	2 years, 2 months
La Pine National Demonstration Project (3)	17 (74%)	1.9	9 (18%)	2 years, 7 months
Rhode Island Demonstration Project (5)	18	-	9	1 year, 4 months
North Carolina Approval Testing Program— Mode 1 (14)[d]	26 (63%)	-	-	2 years, 10 months
North Carolina Approval Testing Program — Mode 3 (1)	15	-	-	2 years, 10 months
Maryland Best Available Technology Field Verification (12)[e]	18 (68%)	-	-	1 year
Maryland Best Available Technology Field Verification (12)[f]	15 (82%)	1.4	-	1 year

[a] TN = TKN + NO_3-N + NO_2-N
[b] Percent Reduction
[c] SFR = Single-family residences
[d] Includes single-family residences and vacation rentals
[e] AdvanTex AX20
[f] AdvanTex AX20-RT

TEST CENTERS

NSF/ANSI Standard 40 Testing

(Third-Party)

About the Testing: Orenco contracted with Novatec to test an AX20 Mode 1 system in support of its application for NSF approval. Novatec conducts official NSF/ANSI Standard 40 testing under contract to manufacturers at its facility in Squamish, British Columbia. Although the NSF/ANSI Standard 40 protocol does not require it, Orenco elected to sample for total nitrogen.

Testing is done at a wastewater facility that serves a residential subdivision. Composite sampling was used throughout this evaluation.

Dates: August 2001-February 2002*

Location: British Columbia

Average Daily Flow: 500 gpd

System Configuration: AX20 Mode 1 recirculating into the second compartment of a 1500-gallon tank

*Note: Nitrogen results are from July to February, which allows for a two-month start-up period.

Processing Tank Influent

	Total N (mg/L)	NH_3 (mg/L)
Mean	**34**	**22**
Median	33	23
Number of Samples	21	21

AdvanTex Effluent

	Total N (mg/L)	NH_3 (mg/L)
Mean	**12**	**0.9**
Median	13	0.6
Number of Samples	27	19
Percent Reduction	64%	96%

NSF/ANSI Standard 40 Testing with UV Disinfection

(Third-Party)

About the Testing: Orenco contracted with Novatec to test an AX20N Mode 1 system with UV disinfection to determine its capabilities for reducing fecal coliform. Novatec conducts official NSF/ANSI Standard 40 testing under contract to manufacturers at its facility in Squamish, British Columbia. Although the NSF/ANSI Standard 40 protocol does not require it, Orenco elected to sample for total nitrogen.

Testing is done at a wastewater facility that serves a residential subdivision. Composite sampling was used throughout this evaluation.

Dates: July 2006-December 2006

Location: British Columbia

Average Daily Flow: 500 gpd

System Configuration: AX20 Mode 1 recirculating into the second compartment of a 1500-gallon tank with UV disinfection

Note: See *AdvanTex Performance Summary — General Reduction (AHO-ATX-PERF-1)* for fecal coliform results.

Processing Tank Influent

	TKN (mg/L)
Mean	**38**
Median	40
Number of Samples	22

AdvanTex Effluent

	Total N (mg/L)	NH_3 (mg/L)
Mean	**13**	**1.1**
Median	12	0.6
Number of Samples	20	22
Percent Reduction	66%	-

Rotorua District Council Approval Testing

(Third-Party)

About the Testing: Testing of residential wastewater treatment systems was initiated by the Rotorua District Council and Environment Bay of Plenty, the Regional Council. The purpose was to preapprove manufacturers that meet the counsils' specifications. The primary focus of the 13-month trial was nitrogen reduction.

Dates: May 2005-June 2006*

Location: New Zealand

Average Daily Flow: 265 gpd

System Configuration: AX20 Mode 3

* Note: Nitrogen results are from September to June, which allows for a four-month start-up period (starting in winter).

Processing Tank Influent

	Total N (mg/L)	NH_3 (mg/L)	Total P (mg/L)
Mean	**72**	**49**	**12**
Median	71	49	12
Number of Samples	-	-	-

AdvanTex Effluent

	Total N (mg/L)	NH_3 (mg/L)	Total P (mg/L)
Mean	**13**	**0.2**	**8**
Median	13	0.2	8
Number of Samples	41	-	-
Percent Reduction	82%	99%	33%

New Zealand On-Site Effluent Treatment National Testing Program

(Third-Party)

About the Testing: In 2009, New Zealand released a national standard and testing protocol for on-site effluent treatment. Tests of AdvanTex AX20 systems were carried out at the Rotorua Testing Facility, and measured BOD_5, TSS, and Total Nitrogen reduction, as well as electrical power consumption.

Dates: November 2009-August 2010

Location: New Zealand

Average Daily Flow: 287 gpd

System Configuration: AX20 Mode 3

Processing Tank Influent

	Total N (mg/L)	NH_3 (mg/L)	Total P (mg/L)
Mean	**60**	**41**	**-**
Median	60	43	-
Number of Samples	46	46	-

AdvanTex Effluent

	Total N (mg/L)	NH_3 (mg/L)	Total P (mg/L)
Mean	**13**	**0.6**	**-**
Median	12	1	-
Number of Samples	43	43	-
Percent Reduction	80%	96%	-

FIELD TESTING

Roger Shafer, P.E., Testing in Fractured Bedrock*

(Second-Party)

About the Testing: The test involved one AdvanTex system at a single-family home.

Dates: Summer 2001, Winter 2002, Winter 2007/2008

Location: Colorado

Average Daily Flow: 209 gpd (April 2001 and August 2001)

System Configuration: This system consisted of two AX10s (which together have the same treatment capacity as an AX20), configured in Mode 3, recirculating to the primary compartment of a 1500-gallon processing tank

*Septic Tank Effluent***

	Total N (mg/L)	*Total P (mg/L)*
Mean	**38**	**9**
Number of Samples	5	5

AdvanTex Effluent

	Total N (mg/L)	*Total P (mg/L)*
Mean	**14**	**6**
Number of Samples	13	13
Percent Reduction	63%	33%

** Roger Shafer, "Use of a Recirculating Textile Filter followed by a Polishing Sand Filter for Onsite Wastewater Treatment in Colorado's Fractured Bedrock Environment," presented at the Colorado Professional Onsite Wastewater 2008 Education Conference.*

*** Five septic effluent samples were collected from the system between April and May 2001 using a 3/4-in. clear plastic tank sampler. Samples were collected from the outlet tee of the septic tank before installation of the AdvanTex system.*

Pennsylvania Testing Program

(Third-Party)

About the Testing: This test was performed as required by the State of Pennsylvania under its Technology Verification Program. NSF International is the third party that was contracted with to oversee the testing. The test involved AX20 systems installed at 11 single-family homes.

Dates: September 2005-2008

Location: Pennsylvania

Average Daily Flow: 100-300 gpd

System Configuration: AX20 Combo Mode recirculating into the primary compartment and secondary compartment of a 1500-gallon processing tank

Processing Tank Influent

	Total N (mg/L)	*NH_3 (mg/L)*
Mean	**54**	**42**
Median	43	31
Number of Samples	42	38

AdvanTex Effluent

	Total N (mg/L)	*NH_3 (mg/L)*
Mean	**17**	**1.7**
Median	16	0.6
Number of Samples	212	213
Percent Reduction	68%	96%

Virginia Approval Testing Program

(Third-Party)

About the Testing: Conducted by Mark Gross, P.E., Ph.D., of the University of Arkansas Department of Civil Engineering, this testing program involved AX20 systems installed at 13 single-family homes, which were sampled for 18 months.

Dates: October 2002-2006

Location: Virginia

Average Daily Flow: 90-308 gpd

System Configuration: AX20 Mode 1 (1 site) recirculating into a recirculating tank located after a separate primary septic tank; AX20 Mode 3 (12 sites) recirculating into the primary compartment of a 1500-gallon processing tank

AdvanTex Effluent

	Total N (mg/L)	*NH_3 (mg/L)*
Mean	**15**	**1.8**
Median	12	0.4
Number of Samples	84	84

Jefferson County Health Department Operating Permit Testing

(Second-Party)

About the Testing: Orenco distributor Roger Shafer sampled 43 systems at single-family residences as required by the Jefferson County (Colorado) Health Department as an operating permit requirement.

Dates: October 2003-May 2006

Location: Colorado

System Configuration: Four AX20 systems and thirty-nine AX30 (AX20 and AX10) systems were all configured as Mode 3, recirculating into the primary compartment of a processing tank

*AdvanTex Effluent**	*AX30*	*AX20*
	Total N (mg/L)	*Total N (mg/L)*
Mean	**15**	**15**
Median	16	14
Number of Samples	124	16

** For the 41 sites that have more than one sample*

Skaneateles Demonstration Project

(Third-Party)

About the Testing: This testing was performed as part of the Skaneateles Demonstration Project. The purpose of this project was to evaluate the performance and management of innovative technologies on single-family residences. As part of this project, two AX20 systems were installed at single-family residences and tested.

Dates: November 2004-January 2007

Location: New York

Average Daily Flow: 106 gpd

System Configuration: AX20 Mode 1 recirculating into the second compartment of a 1500-gallon processing tank

Mode 1 Systems, AdvanTex Effluent

	Total N (mg/L)	*NH3 (mg/L)*	*Total P (mg/L)*
Mean	**14**	**0.9**	**10**
Median	14	0.9	10
Number of Samples	18	18	18

FIELD TESTING

La Pine National Demonstration Project

(Third-Party and First-Party)

About the Testing: The project was a cooperative effort by the Deschutes County Environmental Health Division, the Oregon Department of Environmental Quality, and the U.S. Geological Survey. The purpose was to evaluate innovative denitrification technologies in an area of the state where climate and soil conditions are unfavorable for denitrification and the risk of groundwater contamination is high. As part of the project, three AX20 systems were installed at single-family residences. In addition to the required project samples, some samples were collected by Orenco.

Dates: January 2002-July 2004

Location: Oregon

Average Daily Flow: 108-334 gpd

System Configuration: AX20 Mode 3 recirculating into the primary compartment of a 1500-gallon processing tank

Septic Tank Effluent*

	Total N (mg/L)	NH_3 (mg/L)	Total P (mg/L)
Mean	**66**	**-**	**11**
Median	63	-	10
Number of Samples	427	-	429

** Average of all other sites when the septic tank effluent is being sampled.*

Mode 3 Systems, AdvanTex Effluent

	Total N (mg/L)	NH_3 (mg/L)	Total P (mg/L)
Mean	**17**	**1.9**	**9**
Median	16	0.8	9
Number of Samples	57	57	68
Percent Reduction	74%	-	18%

Rhode Island Demonstration Project — Green Hill Pond Watershed

(Third-Party)

About the Testing: The University of Rhode Island Cooperative Extension On-Site Wastewater Training Center constructed and tested several innovative septic systems, including five AdvanTex systems, in the Green Hill Pond Watershed. The Training Center evaluated the systems' performance and used the installations to train installers, homeowners, designers, and regulators.

Dates: August 2003-December 2004

Location: Rhode Island

System Configuration: The project includes five AX20s at single-family homes, all configured as Mode 3, recirculating into the primary compartment of a 1500-gallon processing tank.

Mode 3 Systems, AdvanTex Effluent(

	Total N (mg/L)	Total P (mg/L)
Mean (all sites)	**18**	**9**
Median	17	10
Number of Samples	24	24

North Carolina Approval Testing Program

(Second-Party)

About the Testing: This test, conducted under state oversight, involves 15 AdvanTex systems at single-family homes and vacation rentals. The data include results from both AX20 and AX100 systems.

Dates: August 2003-June 2006

Location: North Carolina

Average Daily Flow: 75-2200 gpd

System Configuration: AX20 Mode 1 and Mode 3 and AX100. All systems except ones were configured as Mode 1 with recirculation into a recirculation tank located after a separate primary septic tank. A single system was configured as Mode 3 with a single processing tank.

Mode 1 Systems, Septic Tank Effluent

	TKN (mg/L)
Mean	**66**
Median	68
Number of Samples	26

Mode 1 Systems, AdvanTex Effluent

	Total N (mg/L)
Mean	**26**
Median	25
Number of Samples	95
Percent Reduction	63%

Mode 3 Systems, AdvanTex Effluent

	Total N (mg/L)
Mean	**15**
Median	13
Number of Samples	5

Maryland Best Available Technology Field Verification, AX20 & AX20-RT

(Third-Party)

About the Testing: As part of Marlyand's "Best Available Technology" program, field verification testing was performed on AdvanTex AX20 and AX20-RT treatment systems to qualify them for the "Best Available Technology for Nitrogen Removal" designation. As part of this testing, twelve single-family residences were selected for installation of AX20 systems and twelve single-family residences were selected for installation of AX20-RT systems. Individual systems were sampled on a quarterly basis for one year.

Dates: May 2008-March 2010 (AX20), August 2010-March 2012 (AX20-RT)

Location: Maryland

Average Daily Flow: 90-400 gpd (AX20), 100-400 gpd (AX20-RT)

System Configuration: Mode 3 (AX20 and AX20-RT)

Mode 3 Systems, AdvanTex Effluent (AX20)

	Total N (mg/L)
Mean	**18**
Median	14
Number of Samples	48

Mode 3 Systems, AdvanTex Effluent (AX20-RT)

	Total N (mg/L)
Mean	**15**
Median	14
Number of Samples	48

FINAL REPORT

Acknowledgements

The La Pine National Decentralized Wastewater Treatment Demonstration Project was funded by the US Environmental Protection Agency and completed through a cooperative and collaborative effort between the Deschutes County Environmental Health Division, Oregon Department of Environmental Quality and US Geological Survey.

The principal author of this document was Barbara Rich, La Pine Project Coordinator. Significant contributions to this report and the overall the project were provided by *(in alphabetical order):* Todd Cleveland, Deschutes County EH; Mark Cullington, Oregon DEQ; Dan Haldeman, Deschutes County EH; Steve Hinkle, US Geological Survey; Jill Johnson, Deschutes County EH; Janice Leber, Oregon DEQ; Dave Morgan, US Geological Survey; and Rod Weick, Oregon DEQ.

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Particular thanks go to Didi Malarkey for her thoughts, support and consideration throughout the years.

Graphics in this report were prepared by Barbara Rich during the La Pine Project and by the participating vendors.

Abbreviations and Acronyms

BOD_5	5-day biochemical oxygen demand
DEQ	Oregon Department of Environemental Quality
mg/L	milligrams per liter
NH_4	ammonium
NO_3	nitrate
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
USEPA	Environmental Protection Agency
USGS	US Geological Survey

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Chapter 1: Abstract

The La Pine region of south Deschutes County and northern Klamath County in Central Oregon has seen significant increases in development pressures particularly over the last twenty years. Part of the pressure stems from the platting of large subdivisions made up of small one-half to one-acre lots that were marketed with no promise of basic services like improved roads or assurance that wastewater could be treated on site. Deschutes County Community Development Department recognized the issues facing the region and undertook an in-depth planning process, the Regional Problem Solving Project (RPS) in 1996. One of the issues discussed and investigated during this time was the issue of how do deal with wastewater treatment regionally and the effects of development on the prime drinking water aquifer underlying the region. As a result of the significant public opinion that onsite wastewater treatment options should be pursued instead of centralized sewer options because of economic, social and environmental reasons, Deschutes County, the Oregon Department of Environmental Quality (Oregon DEQ) and the US Geological Survey developed the work program that became the La Pine National Decentralized Wastewater Treatment Demonstration Project. The US Environmental Protection Agency funded Oregon DEQ to undertake the project with $5.5 million in 1999 to complete four main tasks:

1. field test denitrifying onsite wastewater treatment systems;
2. develop an onsite system maintenance structure;
3. perform groundwater investigations and develop a three-dimensional (3-D) groundwater and nutrient fate and transport model; and
4. establish a loan program to replace or retrofit failing or inappropriately located onsite systems.

This report includes the findings of the tasks listed above in addition to detailing the organizational and administrative work involved in completing the tasks. Describing the organizational and administrative work was seen as potentially beneficial to other organizations or agencies wishing to undertake similar activities.

The groundwater investigations have found significant existing nitrogen pollution and the 3-D model has predicted extensive future contamination of the aquifer. The model also predicted, based on the field performance of denitrifying systems in the project, that contamination could be slowed or stopped using onsite wastewater treatment technologies, and that, as the region is retrofitted with denitrifying technologies, the existing contamination would be flushed from the groundwater system via existing natural discharge points.

The field test program, in addition to identifying systems that can remove a large proportion of the nitrogen in residential wastewater, found that conventional systems are not protecting the aquifer from nitrate contamination. Conventional systems that were previously thought to denitrify up to 50% of the nitrate discharged from septic tanks were found to achieve significantly less denitrification when process and environmental variables were accounted for. Onsite systems were the focus of this project because of existing public feedback specifying the use of onsite systems and state rules which significantly limit the extension or creation of sewers outside urban growth boundaries.

The maintenance program structure developed by the county/state appointed advisory committee paralleled EPA's level 3 program from the voluntary national decentralized system management guidelines. As a result, critics may question the need to engage in such a lengthy process to develop a structure that had already been imagined. In this case, the value of the public process is in reaching and engaging a set of stakeholders that will ultimately help support regulatory proposals as they move through the public participation process related to rulemaking and then implementation.

The development of a loan program was dependent upon all of the preceding tasks. The field test identified systems that were available to solve groundwater problems and that would meet the intent of the loan program to protect and improve groundwater quality by upgrading failing or inappropriately located systems. However, state rules that allowed the use of nitrogen reducing systems for single family residences were not effective until March 2005 . Technologies and systems approved for use under the new rule did not start entering the market until after the effective date of the rule. The maintenance program, while the structure has been identified and portions placed into statewide rule, was not fully functional at the local level until at least a year after the effective date of the portion of the rule that requires certification of maintenance providers (March 1, 2006). The groundwater study and model have identified potential high risk areas, and the optimization model has undergone updates so that it will more accurately identify appropriate treatment standards for the 96 management areas in the sub-basin.

Overall, the La Pine National Decentralized Demonstration Project experienced tremendous success in the tasks that have been completed. Project staff have received positive feedback from the numerous presentations on the project and its findings at venues around the country. Future work planned for the region includes further work with the groundwater/optimization model as a planning/management tool, implementation of a pollution credit trading program, and expansion of the loan program. Information from this project contributed to revisions to the statewide onsite rule to allow more options for onsite systems used at the residential scale, implement maintenance requirements, and require certification of service providers. The region and the variety of issues involved warrant continued observation and attention as the tools and experience gained from the national demonstration project are applied locally.

Chapter 2: Executive Summary

The region encompassed by southern Deschutes County and northern Klamath County in Central Oregon has seen significant increases in development pressures over the last twenty years. Part of the pressure stems from the platting of large subdivisions prior to the development of land use regulations in Oregon. The subdivisions consist of small one-half to one-acre lots that were originally marketed nationally with no promise of basic services like improved roads, fire protection, or assurance that wastewater could be treated on site. The mere platting of these lots has created unrealistic expectations about the intensity or type of development that can be supported by the physical environment of the region.

Deschutes County Community Development Department recognized the issues facing the region and initiated an in-depth planning process, the Regional Problem Solving Project (RPS), in 1996. One of the issues discussed and investigated during this time was the issue of onsite wastewater treatment and the effects of development on the high quality drinking water aquifer (shallow and unconfined) underlying the region. During this process, public opinion clearly stated that onsite wastewater treatment options should be pursued instead of centralized sewers because of economic, social and environmental reasons. Further, in 1997, the US Environmental Protection Agency stated in a report to the US Congress that, "adequately managed decentralized wastewater treatment systems can be a cost-effective and long-term option for meeting public health and water quality goals, particularly for small towns and rural areas." (US EPA, 1997) As a result, the Oregon Department of Environmental Quality, Deschutes County, and the US Geological Survey developed the work program that became the La Pine National Decentralized Wastewater Treatment Demonstration Project. The US Environmental Protection Agency funded the project with $5.5 million in 1999 to undertake four main tasks:

1. field test denitrifying onsite wastewater treatment systems;
2. develop an onsite system maintenance structure;
3. perform groundwater investigations and develop a three-dimensional groundwater and nutrient fate and transport model; and
4. establish a loan program to replace or retrofit failing or inappropriately located onsite systems.

The project's final report includes findings of the tasks listed above in addition to detailing the organizational and administrative work involved in completing the tasks. Describing the organizational and administrative work was seen as potentially beneficial to other organizations or agencies wishing to undertake similar activities in other areas.

The Problem

The La Pine Project study is located in an area where nitrogen contamination is a concern because of rapidly draining soils overlying a shallow, unconfined aquifer that is the only source of drinking water for the region. To further study the effects of onsite systems on groundwater quality, monitoring well networks of three to four wells were installed around each onsite system participating in the field test. The Oregon Department of Environmental Quality monitored these wells monthly for a year and then quarterly for the remaining two years of the test period. The monitoring well network associated with the field test system included almost 200 wells. The information provided by these wells was augmented by data from a drinking water well monitoring network that was slightly over 200 wells during the largest sampling event. The wells in the drinking water network were sampled between two and four times during the project.

The groundwater investigation showed that groundwater in the region is becoming contaminated by discharges from residential onsite systems and, particularly, that nitrate levels in the groundwater are increasing and that the source of nitrate is human residential sewage. (Hinkle, 2007)

Groundwater investigations have shown that by 2005 the amount of nitrogen loaded to groundwater by the existing population of conventional onsite systems already exceeded the sustainable loading for a maximum nitrate concentration of 10 mg/L NO_3-N. In other words, by 2005, there was already enough pollution in the groundwater that drinking water wells will exceed 10 mg/L NO_3-N in many portions of the region. The 3-D model developed for the region has shown that contamination of the aquifer will continue to increase over time. The model also predicted that, based on the field performance of denitrifying systems in the project, contamination could be slowed or stopped using onsite wastewater treatment technologies, and that, as the region is retrofitted with denitrifying technologies, the existing contamination would be flushed from the groundwater system via existing natural discharge points or attenuation mechanisms. (Morgan, 2007)

A Solution

The innovative system field test program comprised one of the largest efforts of the La Pine Project in terms of funds, personnel and time. The program ultimately included 49 sites that were sampled monthly for a year and bimonthly or quarterly for an additional two years. Sample parameters for the field test included field and analytical parameters with a focus on nitrogen species. Therefore, the sampling plan included total Kjeldahl nitrogen, ammonium, and nitrate-nitrite. The separate nitrogen species show how well the treatment system accomplishes the different stages of the primary treatment and nitrification/denitrification processes.

The 5-day bio-chemical oxygen demand (BOD_5), total suspended solids (TSS) and bacteria analyses provide a basic characterization of wastewater quality. The chloride analysis provided a way to account for dilution (from precipitation or irrigation) or concentration (by evaporation) in systems that are open to the atmosphere. Chloride data can also provide an indication that residential sewage is the source of the nitrogen because humans are a significant source of chloride. Chloride's utility may be limited in those areas near saltwater bodies or where roadway salting is common in the winter. Total alkalinity is a useful diagnostic parameter because the nitrification process for a milligram (mg) of ammonia consumes a maximum of 7.14 mg of alkalinity. (Crites and Tchobanoglous, 1998; Burks and Minnis, 1994)

Fats, oils and grease samples were taken from septic tanks but no other location in the treatment stream because the project team used this parameter primarily in the evaluation of septic tank effluent against the definition of residential waste strength that was currently in the Oregon regulations (Oregon DEQ, 2000). This parameter was also used when troubleshooting systems' performance, however, the advanced treatment systems were not required to reduce fats, oils and grease as part of the demonstration project.

Performance data from the field test of conventional systems illustrate that sand filter systems are not capable of reducing total nitrogen in septic tank effluent more than about 25%. Several innovative systems tested during the La Pine Project showed significant nitrogen reducing capabilities, including one system that achieved a maximum reduction of about 95% from septic tank effluent.

The sampling program included a small demonstration of the efficacy of sampling from the collection chamber following treatment units versus the discharge pipe of the units themselves. The findings of this portion of the sampling program indicate that the nitrogen species taken from the pump chamber following a treatment unit are representative of the effluent sampled directly from the treatment unit effluent pipe.

On average, the waste strength from twenty households falls within the Oregon definition for residential septic tank effluent on all parameters except oil and grease (O&G). The maximum concentrations recorded, however, greatly exceed the definition and the magnitude of the mean concentrations for BOD_5 and TSS indicate that a significant number of samples exceed Oregon's residential waste strength definition. The statistics for the different tank designs indicates that two-compartment tanks perform significantly better (99% confidence level) than single-compartment tanks for TSS reduction. BOD_5 reduction in two-compartment tanks is slightly better than single compartment tanks but only to the 70% confidence level. The O&G concentrations in the two compartment tanks are actually significantly higher than in single compartment tanks.

Insurance for the Onsite Solution

The maintenance program structure developed by the county/state appointed advisory committee appeared to be similar to the EPA's level 3 program from the voluntary national decentralized system management guidelines. As a result, critics may question the need to engage in such a lengthy process to develop a structure that had already been imagined. In this case, the value of the public process is in reaching and engaging a set of stakeholders that will ultimately help support concepts and ideals of the structure as it moves forward to rulemaking and then implementation.

During the demonstration project, the development of a robust maintenance program was identified as an important component of any water quality protection program using advanced treatment systems to achieve environmental goals. The maintenance program not only serves to ensure that program goals are met over the long term but also as an insurance policy for the homeowner to help protect their significant investment in an essential household service.

The maintenance program, while the structure was identified and portions placed into rule, is not a holistic program at the local level. One of the primary gaps is the lack of required maintenance for all onsite systems. For example, sand filters and pressure distribution systems have been left out of the maintenance program, which creates a disincentive for homeowners to use systems with added treatment capabilities. This also makes it difficult for potential service providers to enter the profession because the population of systems that they would serve has been limited by not requiring maintenance on these systems, even though the control panels and pumps are similar to what are commonly used in advanced treatment systems.

One Way to Make the Solution Viable

The development of a loan program was dependent upon all of the preceding tasks. The field test identified systems that were capable of solving groundwater problems. One way to encourage homeowners to protect groundwater is to create financial incentives, including low-interest loans, to use advanced treatment systems. Two factors delayed the implementation of the loan program. First, widespread use and access to advanced treatment systems did not begin until implementation amendments to the statewide onsite rules beginning in 2005. Since that time, the market for advanced treatment systems providing nitrogen reduction has developed slowly, and currently, Deschutes County has listed two proprietary and one non-proprietary systems as nitrogen-reducing systems. Second, Deschutes County undertook a work program in 2005 to adopt a county rule to require the use of nitrogen-reducing systems in the region. This effort diverted significant staff time that would otherwise have established the loan program. The county is currently planning to establish the loan program in coordination with a third party administrator that also uses Community Development Block Grants to fund low-income housing rehabilitation. This existing program also issues loans for onsite system repairs and upgrades and was seen as a natural partner for the county in issuing low interest loans in keeping with the La Pine Project goals and objectives.

Conclusion

Overall, the La Pine National Decentralized Demonstration Project experienced tremendous success from the work undertaken. Project staff have received positive feedback from the numerous presentations on the project and its findings at venues around the country. Future work planned for the region includes further work with the groundwater/optimization model as a planning/management tool, implementation of a pollution credit trading program, development of local maintenance program, and expansion of the loan program. Information from this project contributed to allowing more innovative onsite systems, maintenance requirements, and certification of service providers by state rule in December 2004. In addition, this project will continue to provide critical information that may affect regulatory standards in the future. The region and the variety of issues involved warrant continued observation and attention as the tools and experience gained from the national demonstration project are applied locally.

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Chapter 6: Innovative Onsite Wastewater Treatment Systems

Introduction

One of the primary goals of the La Pine National Demonstration Project is to identify onsite wastewater treatment systems that remove nitrogen from the wastewater prior to dispersal in the environment. The impetus for this task is the shallow unconfined aquifer that is the primary drinking water source for the region. Work performed by the project team to monitor and evaluate groundwater impacts and the fate on contaminants in the environment has shown the vulnerability of this aquifer to discharges from onsite wastewater treatment systems. The performance of the systems participating in the project is therefore presented first in terms of nitrogen reduction and then in terms of other wastewater treatment parameters. The work plan proposed to "install and retrofit 200 or more, if possible, onsite wastewater systems." Of these, 40 representative systems will be selected for detailed performance analyses. The project ultimately installed 49 systems for detailed performance analyses and, because the lab analyses were significantly more expensive than anticipated at the time of work plan development, the funds for additional installations were limited. Additionally, Oregon rules did not change to facilitate installation of innovative systems at the local level (i.e. without using the more expensive permit process of the Water Pollution Control Facility permit) until 2005 when the La Pine Project was about to close. As a result, funds remaining for additional installations were directed towards use by Deschutes County in implementing a low-interest loan program.

Nitrogen-reducing systems

The focus of the La Pine Project was nitrogen reduction because of the demonstrated effects of conventional onsite systems on the shallow unconfined aquifer that serves as the region's drinking water supply. Nitrogen-reducing onsite systems add treatment processes to what is achieved in conventional systems to facilitate the biological processes for nitrogen reduction. These biochemical processes are described in more detail in texts like Burks & Minnis (1994) and Crites & Tchobanoglous (1998). Figure 6-1 provides a simplified illustration of the process steps required to facilitate denitrification. The nitrification and denitrification processes are dependent upon specific chemical and physical conditions in which to occur, including alkalinity, pH, temperature, and dissolved oxygen. For example, the process of transforming ammonium to nitrate (nitrification) consumes alkalinity (measured as $CaCO_3$). Each gram of ammonium transformed to nitrate requires about 7.14g of alkalinity. If enough alkalinity is not present in the wastewater, then the biological process is limited in terms of how much of the ammonium can be converted. Similarly, the biological organisms responsible for converting ammonium to nitrate or nitrate to nitrogen gas (denitrification) are sensitive to the level of dissolved oxygen and/or temperature in the waste stream. If too much dissolved oxygen is available in the denitrification process tank, then the facultative bacteria relied upon for denitrification will preferentially choose the dissolved oxygen for their metabolic processes instead of the oxygen attached to the nitrogen in nitrate (NO_3). The balance between the various needs of the biologic organisms used to perform wastewater treatment functions are embodied with the design of the treatment systems and these processes must be understood by any professional seeking to design, install, or maintain a wastewater treatment system appropriate to the needs of the locale.

Performance results

The performance of the systems participating in the La Pine Project is summarized in Figures 6-2 through 6-7. These charts provide the ranks of all the systems participating in the La Pine Project by Total Nitrogen (TN), 5-day Bio-chemical Oxygen Demand (BOD_5), Total Suspended Solids (TSS) and fecal and E. coli bacteria reduction. Each chart also indicates the systems' performance in relation to the project's performance criteria for that parameter (Table 6-1). Each chart provides the systems' rank by mean and median performance of the two or three systems of each type in the study except the bacteria charts, which rank the systems by median and geometric mean performance. The NITREX™ filter is excluded from the TSS and bacteria reduction charts because the lined sand filter preceding the units in this field test significantly influenced the performance of this system for these parameters.

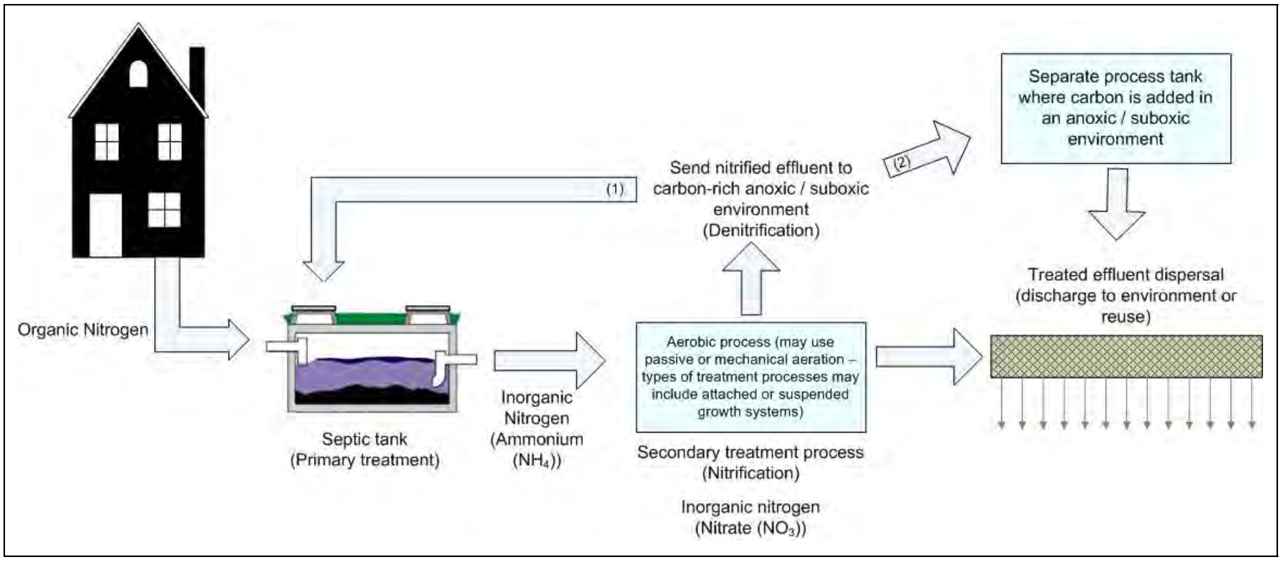

Figure 6-1. Wastewater treatment process in nitrogen-reducing systems using (1) the septic tank as an oxygen-poor, carbon-rich environment or (2) a separate process tank with an oxygen-poor, carbon-enriched environment.

Table 6-1. La Pine Project performance criteria.

Parameter	Standard
5-day Bio-chemical Oxygen Demand (BOD_5)	≤10 mg/L
Total Suspended Solids (TSS)	≤10 mg/L
Total Nitrogen (TN)	≤10 mg/L
Fecal & E. coli bacteria	≥ 2 log reduction

The best performing systems in terms of nitrogen reduction are identified in this section by averaging the data from the field test program to obtain the total nitrogen concentration discharged from the effluent pipe of the treatment unit. Any apparent maturation period data was eliminated from the statistics. These maturation periods, for the purposes of this field test, were identified as those periods at the beginning of system operation when the NH_4 concentrations in the effluent declined as nitrate-nitrite (NO_3) increased. The systems were considered mature when the treatment process established complete or nearly complete nitrification. The denitrification process may or may not establish itself concurrently or subsequently to the nitrification process depending on the efficacy of the particular system being examined. An example of a system with a clearly defined maturation period without an apparent accompanying denitrification process being established is presented in Figure 6-85. An example of a system that established denitrification after the nitrification process established itself is presented in Figure 6-26. This maturation period also defines the period of evaluation for removal of other parameters of concern (BOD_5, TSS, and fecal and E. coli bacteria), which may skew the results for these other parameters because, for example, some systems discharged elevated BOD_5 levels for a period after the nitrification or denitrification processes established themselves (Figure 6-80).

The TN ranking chart (Figure 6-2) appears to illustrate the challenge faced by denitrifying onsite systems to meet the 10 mg/L performance standard. The one system that consistently met the standard included a secondary carbon source and anoxic environment in which to reduce the nitrate to nitrogen gas. Most of the other systems relied on recirculation to the primary clarifier in order to promote denitrification. The exception is the NiteLess system, which also added a carbon source; the performance of that system is discussed below. Figure 6-3 shows the TN ranking in terms of Total Kjeldahl Nitrogen (TKN) and Nitrate-Nitrite as N (NO_3-N) to represent nitrification efficiency. The systems with robust nitrification processes but little denitrification (examples are the sand filters) discharge effluent that is therefore predominantly NO_3 within a high overall TN value. The systems that did not nitrify well discharged effluent dominated by TKN with a corresponding a high TN value on par or higher than septic tank effluent. The systems that achieved some level of denitrification discharge effluent characterized by a mix of TKN and NO_3 and lower overall TN results than the controls (septic tanks and sand filters).

In most instances the mean and median TN values reported for the systems in Figure 6-2 are quite similar. The extreme difference between the mean and median for the IDEA system illustrates the variability in those systems' performance. The mean values plotted in both Figures 6-2 and 6-3 include any adjustment for dilution or evaporation that occurred because the treatment system was open to the environment. The bottomless sand filter column shows the mean TN value above the top of the bar in Figure 6-3 because only the TN value is corrected for dilution, not the individual nitrogen species. The effects of dilution can be corrected by comparing the TN/Cl ratio of the septic tank effluent and to the TN/Cl ratio from the treatment unit discharge pipe. The ratio of these ratios is then multiplied by the average septic tank effluent for the system. In some instances, the correction indicates more nitrogen is discharged from the unit than enters it from the septic tank. This indicates possible concentration of nitrogen due to evaporation or transpiration.

The charts providing the BOD_5 and TSS ranking (Figures 6-4 and 6-5) summarize the performance of all the participating systems against the performance standard for the field test (10 mg/L). Here, several systems appear capable of achieving good performance in relation to this standard. Here again the median values provide an indication of the variability in performance or extremes in the data produced by each system type. For example, the FAST TSS columns show a high mean TSS value over three systems but a very low median value. This suggests that the data is skewed, and, in review of the data provided in the discussion on the FAST system below (section 7), there is a single extremely high TSS value (2,300 mg/L) that has a significant impact on the calculation of the mean. The standard error bars also provide an indication of the systems' variability. For example, the standard error of the TSS results for the FAST system is smaller than that for the NiteLess system even though the average TSS discharged for the NiteLess is lower that that of the FAST. In general, the review of both the mean and median values provides the most comprehensive indication of the overall performance of the systems in terms of typical effluent quality and the variability thereof.

The TSS chart truncates the upper section of the IDEA mean value from the ranking because the magnitude of this value (1,075 mg/L) obscures the results for the other systems. The performance of the NITREX™ filter for TSS reduction is excluded from this chart because a sand filter precedes the unit and confounds the performance of this unit. Also, the lined sand filter is excluded from the TSS ranking due to problems with obtaining a representative sample for TSS for these systems. The bottomless sand filter data is used as an approximation of the lined sand filter performance.

The charts illustrating the bacteria reduction achieved by the systems (Figures 6-6 and 6-7) provide the geometric means and the medians for each system type in order to account for what is the typically highly skewed nature of bacterial data. The charts present the bacteria statistics on a logarithmic scale in order to discern differences between the ranks of the best performing systems. Several systems have shown that they are capable of achieving the two-log reduction contained in the performance standard without an added disinfection process or unit. The performance of the NITREX™ filter is excluded from these charts because a sand filter precedes the unit and the bacteria reduction achieved by the sand filter is very high. While the NITREX™ does achieve an additional level of reduction above that of the sand filter, this product's overall capacity for reducing bacteria is masked by the performance of the sand filter.

The results for phosphorus concentrations discharged from each system are reported in the performance statistics and in the data reported in Appendix B. While the impacts of phosphorus on the water supply aquifer in the La Pine region were not a concern because of the adsorption capacity of the soils in the area, the systems' performance for this parameter is reported because of the national interest in this nutrient and because of potential exhaustion of the soils' adsorption capacity in the future.

Each system type is discussed in more detail in the sections that follow including basic system design, performance data charted over time, and overall performance statistics.

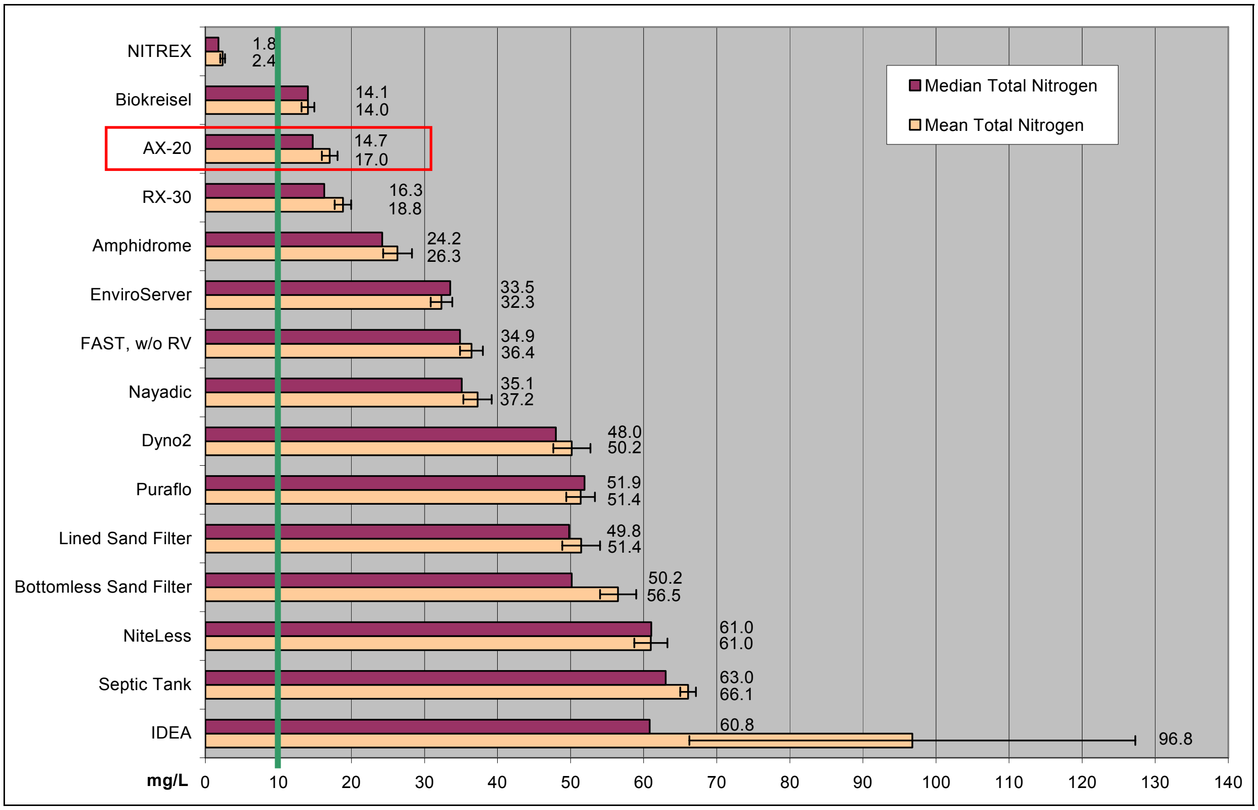

Figure 6-2. Rank, by Total Nitrogen, of all systems in the La Pine Project.

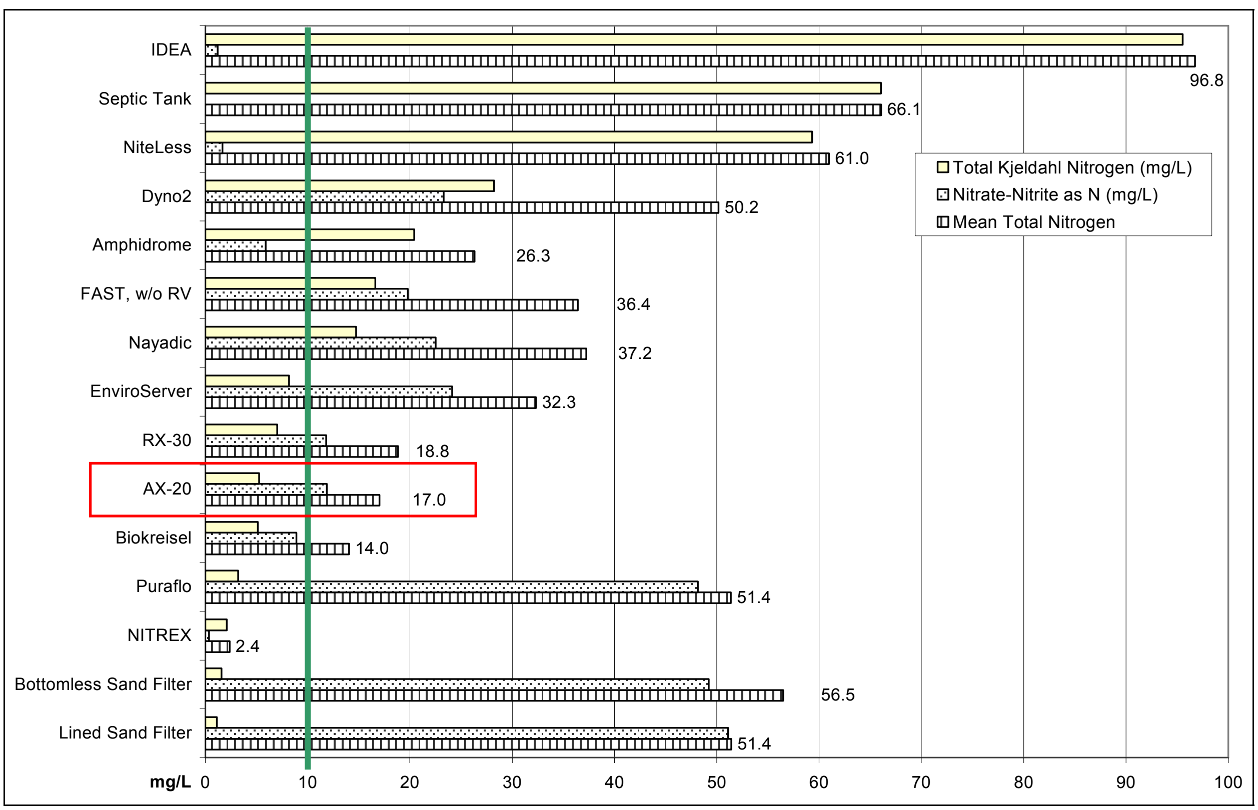

Figure 6-3. Rank of all systems by Total Nitrogen, including TKN and Nitrate-Nitrite.

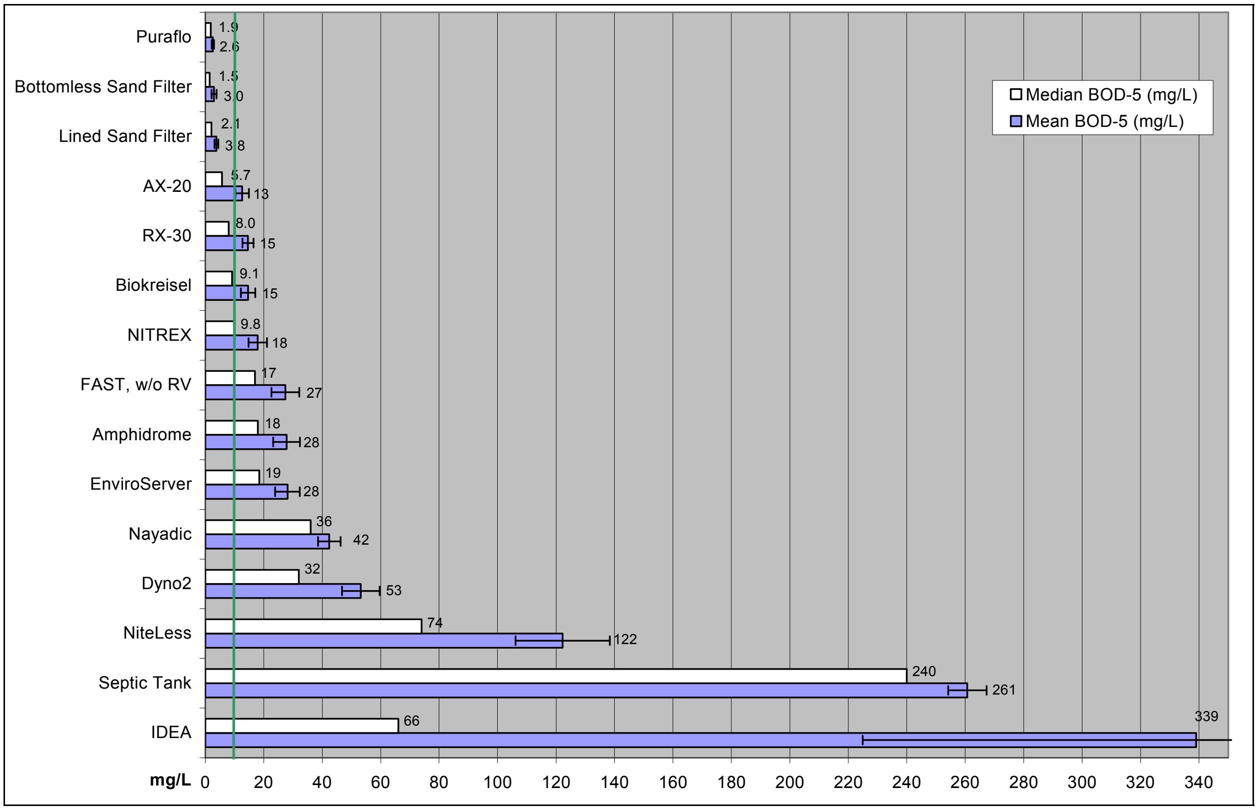

Figure 6-4. Rank, by BOD_5, of the systems in the La Pine Project.

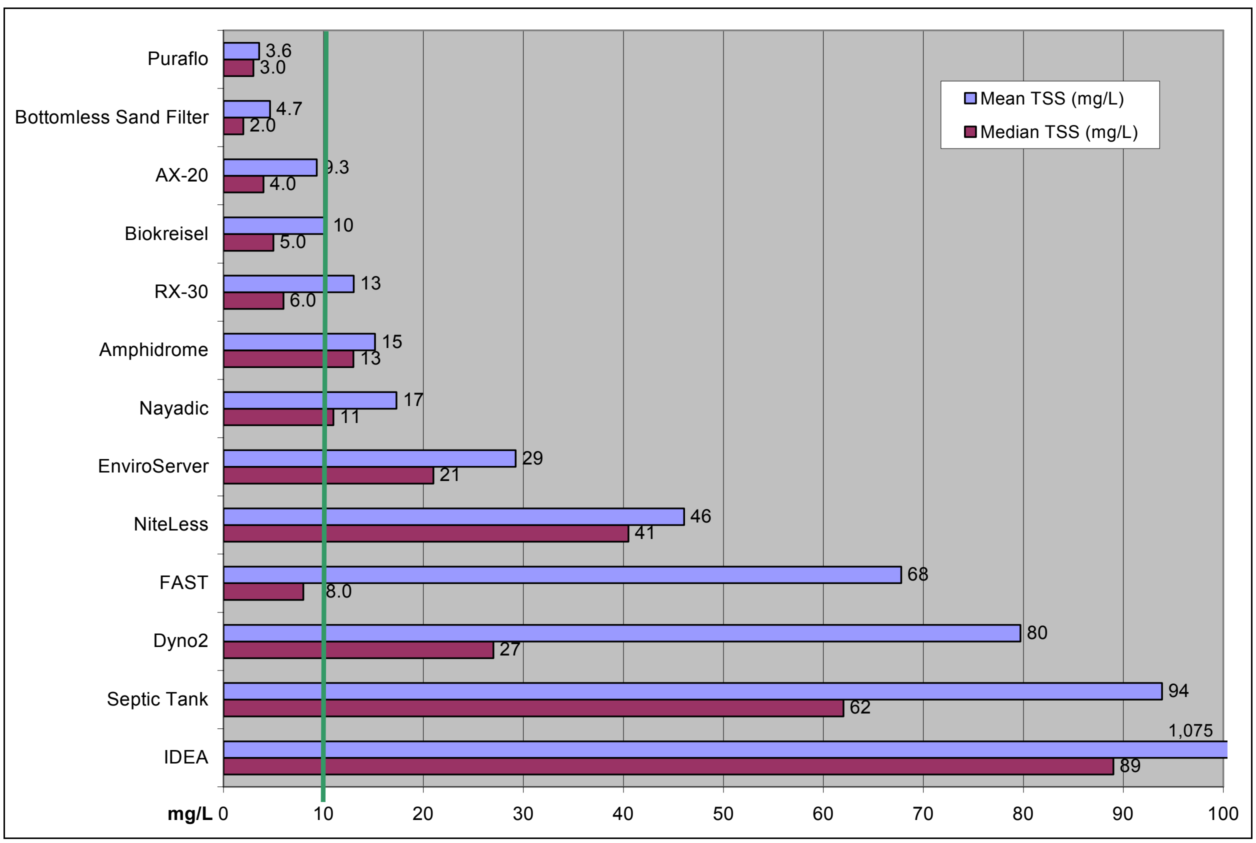

Figure 6-5. Rank, by Total Suspended Solids, of the systems in the La Pine Project.

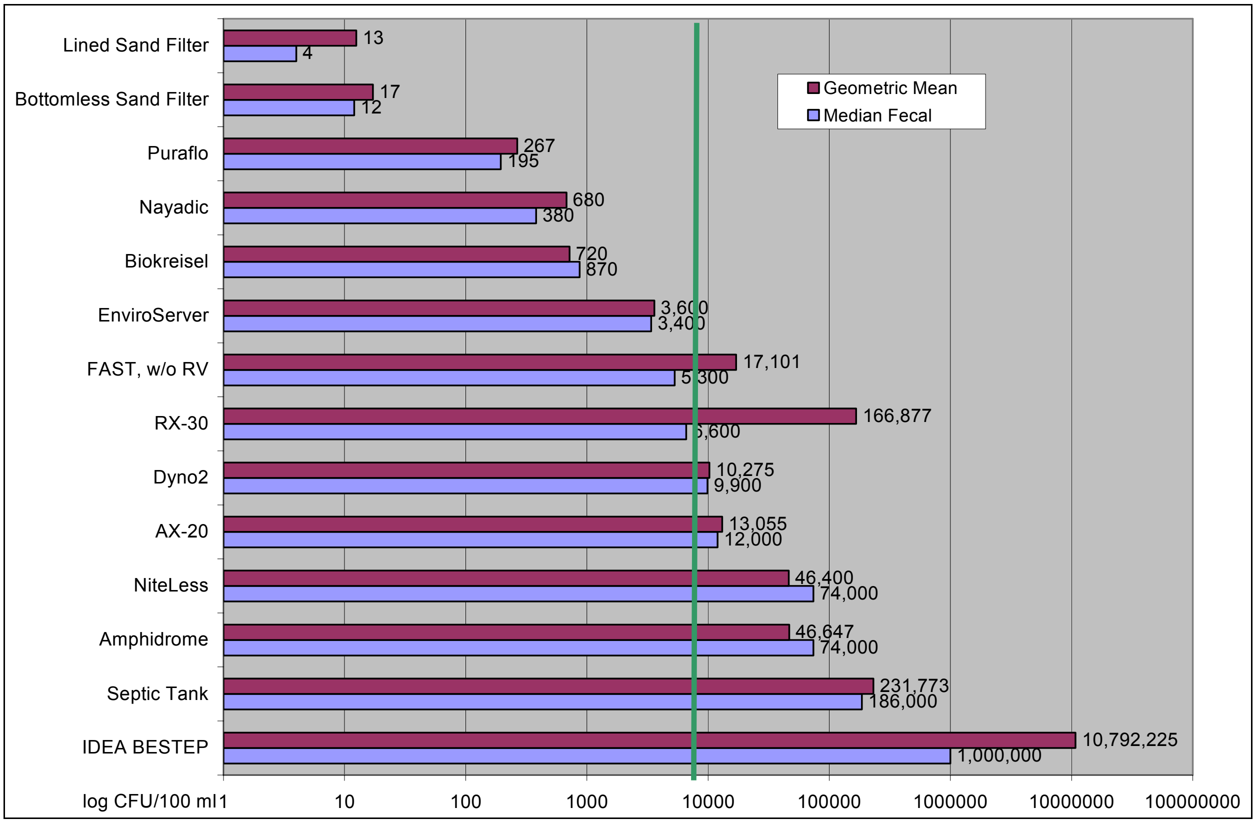

Figure 6-6. Systems ranked by median fecal coliform reduction.

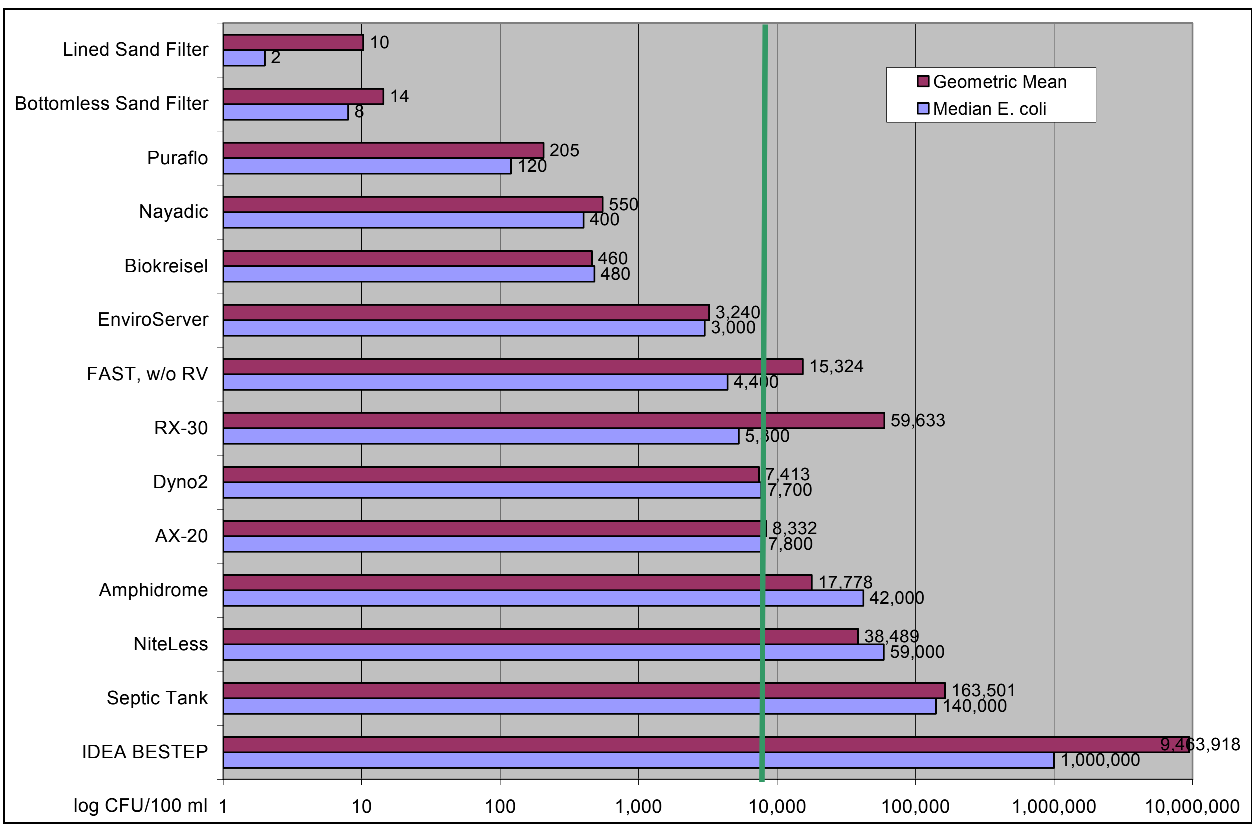

Figure 6-7. Systems ranked by median E. coli reduction.

(1) AdvanTex™ AX-20, Orenco Systems, Inc.

The AX-20 system (http://www.orenco.com/ots/ots_index.asp) uses textile in the packed bed filter as a replacement for sand or gravel. The higher surface area to volume ratio of the textile allows the reduction in size for the textile filter over sand or gravel. The textile is arranged within the filter in hanging sheets (Figure 6-8) and wastewater percolates both through and between the sheets, as the filter is time-dosed.

The AX-20 system recirculates effluent to either the primary clarifier or a pump tank. The La Pine Project systems recirculate the effluent to the primary clarifier in order to maximize nitrogen reduction (Mode 3) and each system discharges to a drip distribution field. Sampling locations for this system include the primary clarifier effluent and the textile filter discharge pipe or pump chamber following the discharge pipe. (Figure 6-9)

Figure 6-8. AdvanTex™ AX-20 filter media.

Figures 6-10 through 6-12 show the performance over time of three AX-20 systems in Mode 3. In general, the effluent is nitrified and BOD_5 and TSS concentrations are reduced early in the operating period. BOD_5 and TSS levels averaged 13 and 9 mg/L respectively over the three systems. (Table 6-2) The median values for BOD_5 and TSS were lower, 6 and 4 mg/L respectively, indicating possible outliers in the performance data. However, each system experienced some kind of upset or change in the treatment quality towards the end of the sampling period. Records of field observations during sampling indicate possible operational issues with each system at these times with symptoms of the issues including effluent ponding on the filter sheets, solids sloughing into the pump chamber following the filter and low dissolved oxygen readings.

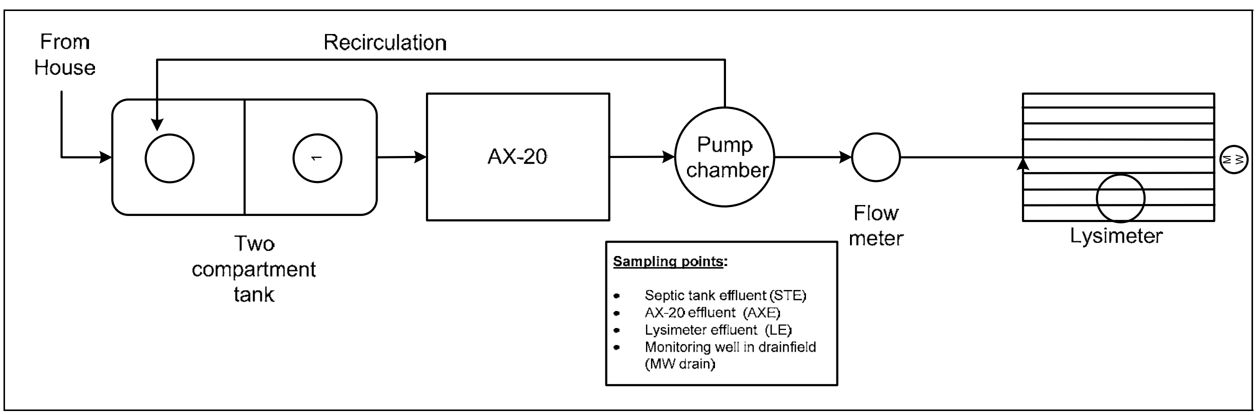

Figure 6-9. Schematic of AdvanTex™ AX-20 system in Mode 3.

Denitrification over the three systems varied somewhat in that TN concentrations from two of the systems averaged between 11 and 17 mg/L (median values were similar to the means) and the third averaged 24 mg/L over the same period. System-T nitrified and otherwise operated similarly to the other two systems but the denitrification process did not respond to the same level. The reason for the difference in performance for the third system was not clear based on homeowner surveys, flow records or system operation.

The three systems overall achieved about 1.1 to 1.3 log reduction in fecal and E. coli bacteria based on the geometric means; System-I achieved the best bacteria reduction with a 1.7-1.8-log reduction. This relatively low reduction rate is possibly due to the large pore spaces present in the textile media, which allow the passage of bacteria while trapping the larger solids.

The project team planned to measure flow at each of these residences using an in-line water meter on the pressurized line feeding the drip field. However, this approach produced only an estimate of water use because each time the drip distribution field was dosed there was some return flow to help flush the drip lines. The return flow can cause the meter to run backward and the returned effluent is also pumped forward to the drip field multiple times. While the return flow can be measured and the total calculated, an easier method of measuring flow might be to install the meter on the incoming water line and accounting for irrigation by monitoring water usage during non-irrigation months.

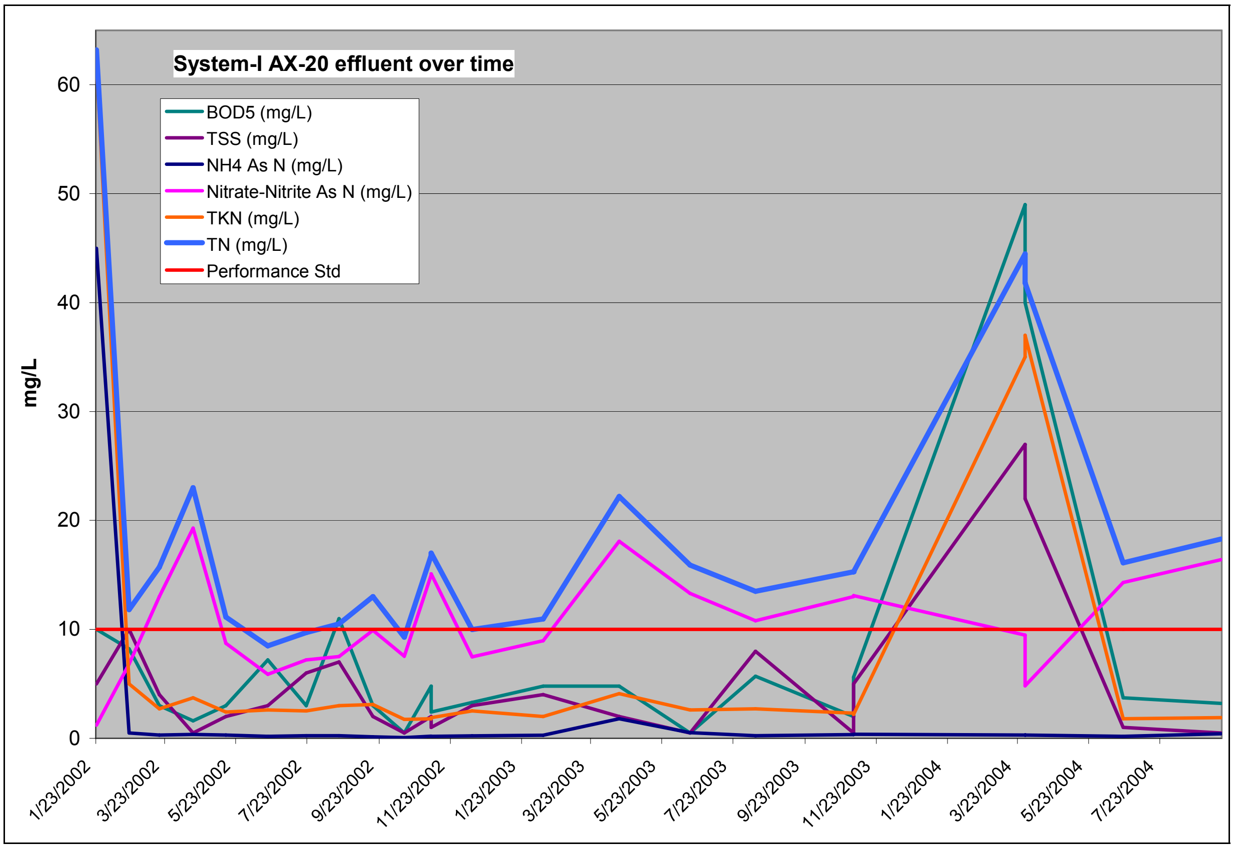

Figure 6-10. System-I AX-20 (Mode 3) effluent over time.

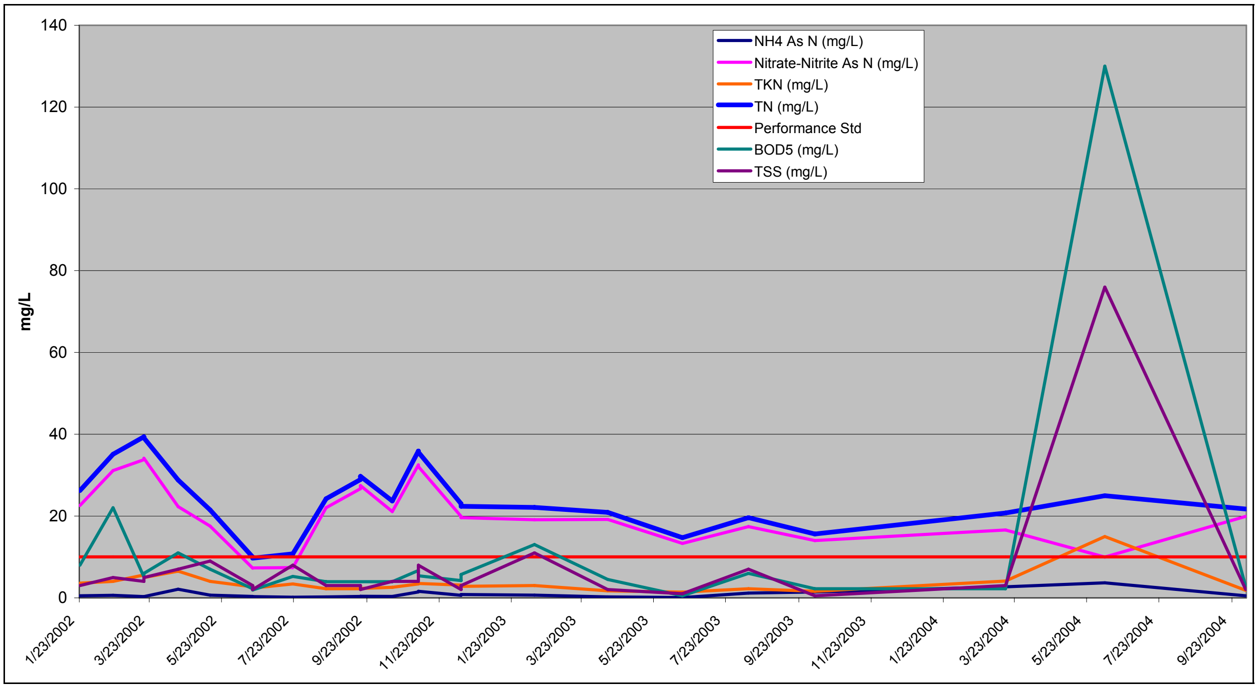

Figure 6-11. System-T AX-20 (Mode 3) effluent over time.

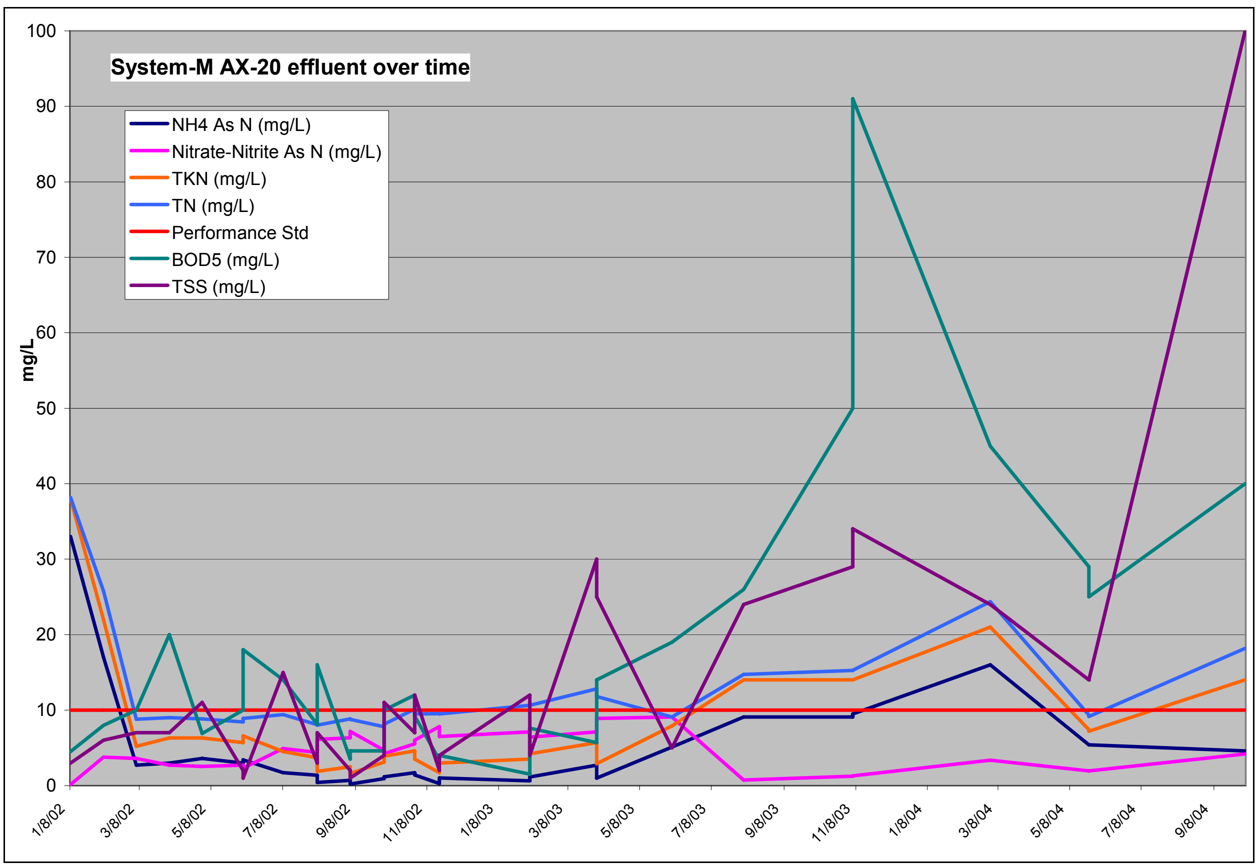

Figure 6-12. System-M AX-20 (Mode 3) effluent over time.

Table 6-2. AX-20 performance statistics.

All systems AX-20 effluent after maturation	BOD_5 (mg/L)	TSS (mg/L)	TN (mg/L)	Total Phosphorus (mg/L)	Fecal Coliform	Log Fecal	E. coli	Log E. coli	GPD
Mean	13	9.3	17	11	5.0E+05	4.2	4.7E+05	3.9	208
Geometric Mean					1.3E+04	4.0	8.3E+03	3.7	
Median	5.7	4.0	15	8.8	1.2E+04	4.1	7.8E+03	3.9	232
Standard Deviation	20	15	9.2	19	2.6E+06	1.1	2.7E+06	1.2	102
Minimum	ND	ND	7.8	2.2	200	2.3	10	1.0	96
Maximum	130	100	44	168	2.2E+07	7.3	2.3E+07	7.4	295
Count	75	75	75	75	75	75	75	75	3
95% Confidence Level	4.6	3.5	2.1	4.4	6.0E+05	0.3	6.2E+05	0.3	253
99% Confidence Level	6.1	4.7	2.8	5.8	8.0E+05	0.3	8.2E+05	0.4	583

System-M AX-20 effluent after maturation	BOD_5 (mg/L)	TSS (mg/L)	TN (mg/L)	Total Phosphorus (mg/L)	Fecal Coliform	Log Fecal	E. coli	Log E. coli	GPD
Mean	18	15	11	3.8	4.7E+04	4.2	2.2E+04	3.8	295
Geometric Mean					1.4E+04	4.1	6.4E+03	3.7	
Median	11	9.0	9.4	3.4	1.8E+04	4.3	8.7E+03	3.9	300
Standard Deviation	19	19	3.7	2.1	7.1E+04	0.7	4.2E+04	0.7	124
Minimum	1.5	1.0	7.8	2.2	660	2.8	200	2.3	89
Maximum	91	100	24	14	2.7E+05	5.4	1.6E+05	5.2	546
Count	28	28	28	28	28	28	28	28	21
95% Confidence Level	7.4	7.5	1.4	0.8	2.8E+04	0.3	1.6E+04	0.3	57
99% Confidence Level	10	10	1.9	1.1	3.7E+04	0.4	2.2E+04	0.4	77

System-T AX-20 effluent after maturation	BOD_5 (mg/L)	TSS (mg/L)	TN (mg/L)	Total Phosphorus (mg/L)	Fecal Coliform	Log Fecal	E. coli	Log E. coli	GPD
Mean	11	7.1	24	8.9	1.4E+06	4.7	1.4E+06	4.6	232
Geometric Mean					5.3E+04	4.5	4.2E+04	4.3	
Median	5.1	3.0	23	9.0	4.6E+04	4.7	3.6E+04	4.6	229
Standard Deviation	25	15	8.5	1.0	4.4E+06	1.4	4.6E+06	1.6	39
Minimum	ND	ND	9.7	7.0	200	2.3	10	1.0	159
Maximum	130	76	39	11	2.2E+07	7.3	2.3E+07	7.4	326
Count	25	25	25	25	25	25	25	25	19
95% Confidence Level	10	6.0	3.5	0.4	1.8E+06	0.6	1.9E+06	0.6	19
99% Confidence Level	14	8.2	4.8	0.6	2.5E+06	0.8	2.6E+06	0.9	26

System-I AX-20 effluent after maturation	BOD_5 (mg/L)	TSS (mg/L)	TN (mg/L)	Total Phosphorus (mg/L)	Fecal Coliform	Log Fecal	E. coli	Log E. coli	GPD
Mean	7.7	5.1	17	23	1.9E+04	3.4	1.2E+04	3.3	96
Geometric Mean					3.0E+03	3.4	2.1E+03	3.2	
Median	3.5	2.5	15	16	1.6E+03	3.2	1.5E+03	3.2	95
Standard Deviation	12	6.9	9.4	32	5.1E+04	0.8	3.2E+04	0.8	29
Minimum	ND	ND	8.5	13	240	2.4	140	2.1	25
Maximum	49	27	44	168	2.1E+05	5.3	1.4E+05	5.1	167
Count	22	22	22	22	22	22	22	22	19
95% Confidence Level	5.4	3.0	4.2	14	2.2E+04	0.3	1.4E+04	0.3	14
99% Confidence Level	7.4	4.1	5.7	20	3.1E+04	0.5	1.9E+04	0.5	19

ND = Non detect

Bay Restoration Fund (BRF) Best Available Technology for Removing Nitrogen from Onsite Systems

The following systems have undergone the Environmental Protection Agency's - Environmental Technology Verification (ETV) Program, NSF 245 Certification or other equivalent third party testing and are considered grant eligible. In addition, certain technologies are also field verified by the Maryland Department of the Environment for performance. Until completion of the field verification, the technologies are given a conditional approval which can be revoked based upon analyses performed by the Department and the Bay Restoration Fund Review Committee.

As required by legislation approved from the 2011 legislative session, effective June 1, 2011, the Department must rank all best available technology systems (BAT) for removing nitrogen for onsite sewage disposal systems. Rankings are to be provided for the following factors:

- Total Nitrogen reduction for the technologies
- Total Cost of the technology to include operation/maintenance and electrical consumption
- Cost per pound for nitrogen reduction.

BRF Ranking Document: CLICK HERE

The Department is to provide to the public this ranking of BAT systems. This ranking is largely based on information provided by the vendors. The Department strongly advises the applicant to contact each vendor directly for more information.

The BAT Review Team is accepting applications for determining systems for consideration as BAT and eligibility for Bay Restoration Funds. Click here for more information about the application process.

The following technologies have successfully completed the field verification:

Model	Contact Information	Certifications	MDE Field Performance Analysis for Total Nitrogen
Advantex®-RT	**Manufacturer** Orenco Systems®, Inc. www.orenco.com/ **Local Distributor** **Eastern Region -** Service Energy Paul Hufschmidt – 302-734-7433 phuffy@serviceenergy.com **Central, Southern, Western -** Atlantic Solutions Bob Johnson- 1-877-214-9283 bjohnson@septicsystems.net	Other 3rd Party	Mean % Reduction of TN: 76% Mean Effluent Concentration: 14 mg/l Data & Analysis
Advantex®-AX20	**Manufacturer** Orenco Systems®, Inc. www.orenco.com/ **Local Distributor** **Eastern Region -** Service Energy Paul Hufschmidt – 302-734-7433 phuffy@serviceenergy.com **Central, Southern, Western -** Atlantic Solutions Bob Johnson- 1-877-214-9283 bjohnson@septicsystems.net	Other 3rd Party	Mean % Reduction of TN: 71% Mean Effluent Concentration: 17 mg/l Data & Analysis
Hoot® BNR	**Manufacturer** Hoot Aerobic Systems, Inc. www.hootsystems.com **Local Distributor -** Mayer Bros. Nancy Mayer- (410) 796-1434 mayerbro@connext.net	Other 3rd Party	Mean % Reduction of TN: 64% Mean Effluent Concentration: 21 mg/l Data & Analysis
RetroFAST	**Manufacturer** Bio-Microbics, Inc. http://www.biomicrobics.com **Local Distributors** **Eastern Region -** Gillespie & Sons, Inc. Jim Gillespie- (410) 778-0900 jimg@gillespieandson.com **Central Region -** Maryland Concrete Septic Tank, Inc. Trent Glace- (443) 491-3598 trent@marylandconcreteinc.com	ETV	Mean % Reduction of TN: 57% Mean Effluent Concentration: 25 mg/l Data & Analysis Limited to households of 1 to 4 occupants and 3 bedroom or less
	Manufacturer		

SeptiTech®	SeptiTech, Inc. www.septitech.com **Local Distributors** **Eastern Region -** Gillespie & Sons Inc. Jim Gillespie - (410) 778-0900 jimg@gillespieandson.com **Central Region -** Maryland Concrete Septic Tank Inc. Trent Glace- (443) 491-3598 trent@marylandconcreteinc.com	ETV And NSF 245	Mean % Reduction of TN: 67% Mean Effluent Concentration: 20 mg/l Data & Analysis
Singulair TNT & Singulair Green (plastic tank)	**Manufacturer** Norweco, Inc. www.norweco.com **Local Distributors** **Eastern Shore -** Towers Concrete Products John Short- (443) 786-0594 btowers62@gmail.com **Southern Region -** Superior Tank Jeff Earnshaw- (301) 274-3772 superiortank@olg.com **Western Region -** C.R. Semler Charlie Semler- (301) 824-2780 crsemler@crsemler.com **Western Region -** Garrett & Allegany Co. Pile's Concrete Products Co. Inc. Brett Zimmerman- (814) 445-6619 brett_zimmerman@hotmail.com **Central Region -** Back River Pre-Cast LLC Matt Geckle- (410) 833-3394	Other 3rd Party And NSF 245	Mean % Reduction of TN: 55% Mean Effluent Concentration: 27 mg/l Data & Analysis

Listed below are the approved technologies that are currently under field verification:

Model	Contact Information	Certifications	Comments
Bionest SOLO OT-40	**Manufacturer** Bionest Technologies, Inc. http://www.bionest.ca/en **Local Distributor -** Bay Area Environmental Don Jones (410) 836-9206 manager@jonespumpservice.com	Other 3rd Party And NSF 245	Under Field Verification
Clear Rex Bubbler CRB 1	**Manufacturer** PekaSys, Inc. www.pekasys.com **Local Distributor -** Eastern Shore and Anne Arundel County Innovative Building Solutions www.buildingsolution.net Larry Price - (410) 643-6161 mail@buildingsolution.net	NSF 245 And other	Under Field Verification
Ecopod E-N-[1]	**Manufacturer** Delta Environmental http://www.deltaenvironmental.com/ **Local Distributor -** 'e3 Environmental Eric Valentine (302) 725-0788 www.e3onsite.com	NSF 245 And other	Under Field Verification
Hydro-Action® - AN Series	**Manufacturer** Hydro-Action/AK Industries Inc. www.hydro-action.com **Local Distributor -** Blue Water Environmental, LLC Mark O'Rourke – (240) 444-6401 Mark@BWEnvironmental.com	NSF 245	Under Field Verification
	Manufacturer Bio-Microbics, Inc. http://www.biomicrobics.com **Local Distributors** **Eastern Region -**		Under Field

MicroFAST	Gillespie & Sons Inc. Jim Gillespie - (410) 778-0900 jimg@gillespieandson.com **Central Region -** Maryland Concrete Septic Tank Inc. Trent Glace- (443) 491-3598 trent@marylandconcreteinc.com	ETV	Verification
Nitrex	**Manufacturer** Lombardo Associates, Inc. www.lombardoassociates.com **Local Distributor -** Lombardo Associates Pio Lombardo- (617) 964-2924 pio@lombardoassociates.com	Other 3rd Party	Under Field Verification Add-on anoxic filter with carbon source, to be coupled with a nitrification unit.
Norweco Hydro-Kinetic Model 600 FEU	**Manufacturer** Norweco, Inc. www.norweco.com **Local Distributor** **Eastern Shore -** Towers Concrete Products John Short- (443) 786-0594 btowers62@gmail.com	NSF 245 And other	Under Field Verification

The Maryland Department wants to thank you for partaking in this important program.

Contact Info

If you have additional questions or would like more information, please contact the Wastewater Permits Program, Onsite Systems Division at 410-537-3778.

Related Links

- MDE Home
- Onsite Systems Division
- Bay Restoration Fund

Acrobat® Reader is required to view and print the PDF files. If you do not have it click on the icon to the right.

BAY RESTORATION FUND RANKING DOCUMENTATION February 23, 2024

VENDOR IN ASCENDING ORDER	COST OF PURCHASE, INSTALLATION AND 2 YEAR OPERATION MAINTENANCE	VERIFIED BY
Singulair TNT	$17,182	Vendor
Singulair Green	$17,362	Vendor
AquaKlear AK6S245	$17,497	Vendor
BioMicrobics RetroFast**	$18,132	Vendor
Fuji Clean CEN 5	$18,221	Vendor
Hydro Action AN series	$19,368	Vendor
Fuji Clean CEN 7	$20,610	Vendor
Hoot BNR	$22,295	Vendor
SeptiTech M400D	$22,717	Vendor
AdvanTex AX20	$23,687	Vendor
Advantex AX20RT	$26,925	Vendor

All prices are Estimate Averages across Maryland and subject to change per county, contact Manufacturer.
The BRF Program no longer funds the non field verified systems for installation.
Price does not include electrical costs per year.
** RetroFast unit limited to households of 1-4 occupants with 3 bedrooms or less. Price includes use of new tank. For use of existing tank, manufacturer must certify tank suitable and watertight.

VENDOR IN DESCENDING ORDER	MEAN % REDUCTION TN (Using 60mg/L influent)	MEAN EFFLUENT CONCENTRATION	VERIFIED BY
Fuji Clean CEN 5	77%	14.1 mg/L	MDE
Fuji Clean CEN 7	77%	14.1 mg/L	MDE
Advantex AX20RT	76%	14.5 mg/L	MDE
AdvanTex AX20	71%	17 mg/L	MDE
SeptiTech M400D	67%	20 mg/L	MDE
Hydro Action AN series	66%	20.3 mg/L	MDE
Hoot BNR	64%	21 mg/L	MDE
BioMicrobics RetroFast**	58%	25.4 mg/L	MDE
Singulair Green	55%	27 mg/L	MDE
Singulair TNT	55%	27 mg/L	MDE
AquaKlear AK6S245	54%	27.5 mg/L	MDE

As the data for non-field verified systems is incomplete, MDE has classified the % reduction of TN and the Price per Pound of N Reduced for non-field verified systems as Deliberative Data.

** RetroFast unit limited to households of 1-4 occupants with 3 bedrooms or less.

VENDOR IN ASCENDING ORDER	PRICE PER POUND OF N REDUCED	VERIFIED BY
Fuji Clean CEN 5	$101.12	MDE
Fuji Clean CEN 7	$115.60	MDE
Hydro Action AN series	$127.98	MDE
AquaKlear AK6S245	$136.87	MDE
Singulair TNT	$140.17	MDE
AdvanTex AX20	$139.13	MDE
Singulair Green	$141.52	MDE
BioMicrobics RetroFast**	$144.44	MDE
Advantex AX20RT	$147.49	MDE
Hoot BNR	$151.11	MDE
SeptiTech M400D	$156.51	MDE

Price per pound of N reduced equals [((Price of technology plus (increased electrical costs multiplied by Ten))divided by Ten] divided by (24.32 lbs of N per year multiplied by percent reduction of N by system)

As the data for non field verified systems is incomplete, MDE has classified the % reduction of TN and the Price per Pound of N Reduced fornon field verified systems as Deliberative Data.
** RetroFast unit limited to households of 1-4 occupants with 3 bedrooms or less.

VENDOR IN ASCENDING ORDER	OPERATION AND MAINTENANCE PER YEAR AFTER THE 2 YEAR CONTRACT	MINIMUM NUMBER OF SITE VISITS PER YEAR*	VERIFIED BY
AdvanTex AX20	$250.00	1	Vendor
Advantex AX20RT	$250.00	1	Vendor
Fuji Clean CEN 5	$350.00	2	Vendor
Fuji Clean CEN 7	$350.00	2	Vendor
AquaKlear AK6S245	$275.00	1	Vendor
BioMicrobics RetroFast**	$275.00	1	Vendor
SeptiTech M400D	$275.00	1	Vendor
Hoot BNR	$250.00	1	Vendor
Singulair TNT	$350.00	2	Vendor
Singulair Green	$350.00	2	Vendor
Hydro Action AN series	$250.00	1	Vendor

All prices are estimates and based on the 2-yr O&M BAT bid submitted to the State. Some prices have been rounded.
Prices are subject to change and may vary based on location. Contact manufacturer for O&M price details.
* Based off manufacturer-required service visits per year
Additional Charges may apply with certain manufacturers. It is the responsibility of the homeowner to contact the manufacturer for precise details of contract.

VENDOR IN ASCENDING ORDER	1 YEAR ELECTRICAL CONSUMPTION (represented as kW h/year)	INCREASED ELECTRICAL COSTS PER YEAR ASSUMING $0.16 PER kW h	VERIFIED BY
Advantex AX20RT	210.2 kWh/year	$33.63	OSET NTP
Advantex AX20	210.2 kWh/year	$33.63	OSET NTP
AquaKlear AK6S245	298.7 kWh/ year	$47.79	Vendor
Fuji Clean CEN 5	446.7 kWh/year	$71.47	Manufacturer
Fuji Clean CEN 7	648.2 kWh/year	$103.71	Manufacturer
Hydro Action AN series	734.26 kWh/year	$117.48	Pump Manufacturer
Hoot BNR	765.77 kWh/ year	$122.52	NSF International
Singulair TNT	979.66 kWh/ year	$156.75	NAT Testing Lab
Singulair Green	979.66 kWh/year	$156.75	NAT Testing Lab
BioMicrobics RetroFast**	1401.6 kWh/year	$224.26	Pump Manufacturer
SeptiTech M400D	1741.05 kWh/year	$278.57	Vendor

$0.16 is an assumed average kW h rate for Maryland 2024.
** RetroFast unit limited to households of 1-4 occupants with 3 bedrooms or less.
HydroAction utilizes a mixer pump during start up. Pump use is discontinued after start up. Usage data will vary after start-up period.

For a list of vendors visit:
https://mde.maryland.gov/programs/Water/BayRestorationFund/OnsiteDisposalSystems/Documents/BAT_CLASS_I.pdf

Before selecting a technology for use on the property in question, please contact each vendor to verify the information is current and accurate. MDE is only a facilitator in presenting this information in accordance with HB347. MDE strongly advises that the applicant contact the vendor directly for more information.

Please contact the county Environmental Health Division for specific process on submitting an application
For a list of county contact information, 410-537-3599

Please contact the Maryland Department of the Environment for specific questions regarding becoming a Best Available Technology in Maryland.

For MDE contact information, 410-537-3599

RED Font = Technologies that have successfully completed Maryland's Bay Restoration Fund Field Verification process.

Nitrogen reduction trials of advanced on-site effluent treatment systems

Prepared by Paul Scholes, Environmental Scientist

Environment Bay of Plenty
Environmental Publication 2006/12
July 2006

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ISSN 1175 - 9372

Working with our communities for a better environment

Acknowledgements

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The combined effort and cooperation of many parties have contributed to this project:

Environment Bay of Plenty: Janine Barber, Paul Futter, Paul Scholes
Rotorua District Council: Paul Cooper, Andy Bainbridge, Alison Lowe, Sean Barnes, Dave Anderson
Environment Waikato: Urlwyn Trebilco, Brent Fletcher
Hynds Environmental: Niki Johnstone
Devan Blue: Karl Geiseler
Innoflow: Jim Buchan, Keith Martin
Smith & Loveless: Dan Sharkey
Oasis Clearwater: Rob White, Lewis Austin

Executive Summary

Regional Plans from Environment Bay of Plenty and Environment Waikato have recognised the contribution of significant amounts of nutrients (primarily nitrogen) to sensitive receiving environments from communities, served by on-site effluent treatment systems. Nutrient contributions help to cause the eutrophication of water bodies, especially lakes.

Wastewater treatment technology has progressed in the past few decades. Advanced on-site effluent treatment (OSET) systems are now capable of achieving greater treatment of wastewaters, which in turn results in reduced impacts on the environment. In recognition of this, regional authorities are implementing policies that will utilise commercially available nitrogen reducing on-site wastewater treatment technology, to avoid adverse effects of nutrient discharges to land degrading waterways.

A trial of five commercially available advanced on-site effluent treatment (OSET) systems, has been undertaken to evaluate their potential, particularly with respect to nitrogen reduction. One system, from Devan Blue, was a test system (not commercially available) and this was replaced part way through the trial with a second system. Untreated sewage from Rotorua City's Eastside sewer was fed to the advanced OSET systems over 11 months, with the feed rate simulating typical domestic use.

Once the systems had stabilised (14 to 16 weeks) all showed the capability to reach Environment Bay of Plenty's On-Site Effluent Treatment Regional Plan 2006 Rule 11 and 13 limit of 15 g/m^3 total nitrogen (TN). Only Innoflow's Orenco AdvanTex® AX20 system could remain under the 15 g/m^3 TN for a consistent period as well as complying with Environment Waikato's Proposed Waikato Regional Plan Variation 5 (Lake Taupo Catchment) permitted activity discharge limit of 25 g/m^3 TN. The Orenco AdvanTex® AX20 system achieved an 82% TN removal from the influent. Other systems removed on average 63 to 73% of TN.

Table 1 Statistics for Total Nitrogen in effluent and influent for weeks 16 to 55

Advanced OSET System	Median (g/m^3)	Minimum (g/m^3)	Maximum (g/m^3)
MicroFAST 0.5	23	14	42
Hynds Lifestyle	20	10	27
Oasis 2000	25	10	45
Orenco AdvanTex® AX20	13	7	23
Devan Blue Test System	33	10	53
Devan Blue *DB9000 NRS*	-	14	38
Influent	*71*	*31*	*135*

Note: Devan Blue Test system data is for weeks 16 to 34, and the DB9000 NRS is from week 50 to 55. No median result is presented for the DB9000 NRS as the system was not trialled for a sufficient time to accurately assess its nitrogen reduction performance.

Monitoring results showed that all systems were able to achieve the biochemical oxygen demand (BOD_5) and suspended solids (SS) discharge limits, set in both Environment Bay of Plenty's and Environment Waikato's regional plans. Systems were shown to remove 27-30% of total phosphorus, 92-99% of $CBOD_5$, 96-99% SS, and all systems achieved a better than 10^2 order faecal coliform reduction (Oasis 2000 > 10^5 order).

Installation problems and mechanical failure were some of the reasons attributed to low nitrogen reduction of influent in some systems. External environmental factors were explored as potentially impacting some systems. It was concluded that the as at least two systems achieved excellent TN reduction of the influent that environmental factors had not greatly influenced the trial and were the same for all systems. The functioning of the systems aeration, solids retention times and other system functions are not discussed as these parameters were not measured.

Contents

Chapter 1: Introduction

The contribution of nutrients from on-site effluent treatment (OSET) systems has been implicated as a contributing factor to the eutrophication of New Zealand lakes (NIWA, 2000). Due to the location and density of some lake-side communities served by on-site effluent treatment systems, contributions of up to 25% of the total nitrogen (TN) input to the lake may be coming from OSET systems (NIWA, 2000). To address the continued flow of nutrients into the environment, particularly TN, Environment Bay of Plenty has put in place policies, methods and rules under its On-site Effluent Treatment Regional Plan 2006 (Plan) to limit TN discharges from septic tanks. One method to meet reduction targets set in the Plan, is to replace or modify conventional on-site wastewater treatment systems with advanced OSET systems capable of greatly improved TN reduction.

Nitrogen in influent is primarily composed of organic matter and ammonium-nitrogen, with effluent from conventional OSET systems having greater than 85% ammonium-nitrogen (Bioresearches, 2003). As such, conventional OSET systems have offered little nitrogen treatment. Advanced OSET systems seek to more effectively reduce suspended solids and organic loads, as well as reduce nitrogen. Knowledge of the quantity of nitrogen reduction by advanced OSET systems has for the most part, relied on information supplied by the manufacturers or suppliers of advanced OSET systems. Bioresearches (2003) documented many of the systems available in New Zealand, finding that the TN concentration in the effluent ranged from 0.5 - 45 grams per cubic metre (g/m^3) (i.e. 50 - 80% TN removal)). However, as most of these advanced OSET systems are biological treatment systems employing nitrification-denitrification biological reactions, they are sensitive to a variety of parameters that can affect nitrogen removal efficiencies. For rules for TN discharge limits to be effective, reliable information on the nitrogen reduction from commercially available systems is required.

To gain improved knowledge of the potential for advanced OSET systems, to remove nitrogen from domestic influent, Rotorua District Council, Environment Bay of Plenty and Environment Waikato commissioned a trial of commercially available advanced OSET systems. A number of manufactures and/or suppliers of OSET systems were approached and as a result, five systems were installed for trial (one system, Devan Blue, was changed part way through the trial). All systems were installed without any irrigation treatment connected.

This report details the results of the 55 week trial. The primary objective of the trial is to see if TN output from the advanced OSET systems of 15 g/m^3 is achievable and to discuss factors inhibiting nitrogen reduction. An opportunity is also provided in the trial to observe how well the advanced OSET systems meet suspended solids (SS) and biochemical oxygen demand (BOD_5) levels, as set in the On-Site Effluent Treatment Regional Plan 2006.

Chapter 2: Trial regime

Five advanced OSET systems (Table 2) were trialled to determine outputs over the period of eleven months (May 2005 to April 2006), with the exception of two systems: Oasis supplied system was monitored for nine months and the original Devan Blue test system was replaced after seven months by the DN9000 NRS (the Devan Blue test system initially installed will not be available on the commercial market).

Untreated wastewater from Rotorua City's Eastside sewer is screened, before passing into a header tank from which influent is delivered to the systems in equal quantities. Influent was pumped to each system twice daily by positive displacement pumps operating from a single variable drive. Loading regime was 1.0 m^3/day/system with 66.7% of the load delivered between 6 am and 11 am every morning and the balance between 6 pm and 9 pm at night. This pumping regime is designed to simulate average household usage. Harrison Grierson Consultants and AWT New Zealand Limited provided technical assistance for the trial setup.

Table 2 System specifications from supplier

Supplier	System	Treatment		Process	Effluent Quality		
		Flow (L/day)	Tank Capacity (L)		BOD_5 (g/m^3)	SS (g/m^3)	TN (g/m^3)
Innoflow Technologies Limited	Orenco AdvanTex® (AX20)	1,900	7200	Recirculating textile packed bed filter.	≤ 15	≤ 15	<25#
Hynds Environmental Systems Limited	Hynds Lifestyle	1,800	8,500 (1,850)^	Submerged Aeration Filtration (SAF) technology.	≤ 20	≤ 20	≤ 25-30
Oasis Clearwater Environmental Systems Limited	Oasis 2000 (TEXASS)	2,500	9,400	Submerged membrane reactor, aerated waste water system.	≤ 30	≤45	≤10
Smith & Loveless new Zealand Limited (FAST)	MicroFAST 0.5	1,800	5,400	Fixed activated sludge treatment, aerated with suspended growth media (with SFR Biomicrobics).	≤ 10	≤ 10	≤ 10*
Devan Blue$^{\Delta}$	DB 9000 NRS	1,500	6,400	Advanced multi stage fixed growth aerated system.	≤ 20	≤ 30	-

*Based on total kjeldahl nitrogen (TKN) figures supplied (TKN + Nitrate ≤10).
^ Emergency storage capacity.
# Based on results from Orenco AdvanTex® (AX100) systems (or larger).
$^{\Delta}$ Systems specification for new installed system (First system will not be commercially available).

Photo 1 Advanced OSET trial site, Rotorua

Effluent from each system was collected in a 200 litre drum from which grab samples were taken between 7 am and 11 am. Sampling occurred every six days, ensuring sampling occurred on a different day of the week. Over the fifty-five weeks of sampling, samples were also taken every day for five to six days, every seven to ten weeks. The effluent distribution and sampling programme is based on information from Ewert, Couper and Maginness (2005).

Samples were analysed for pH, alkalinity (Alk), total nitrogen (TN), ammonium-nitrogen (NH_4-N), nitrate-nitrogen (NO_3-N), nitrite-nitrogen (NO_2-N), total phosphorus (TP), dissolved reactive phosphorus (DRP). Additional analyses of carbonaceous oxygen demand ($CBOD_5$), total suspended solids (SS) and faecal coliforms (FC) were done on the consecutive daily sampling events. Analysis was performed by the Rotorua District Council Environmental Laboratory (IANZ accredited) in accordance with "Standard Methods for the Examination of Waste Water", APHA, AWWA, WPCF. Temperature of effluent was measured in the outflow collection drums. The drums are filled intermittently depending upon the individual system characteristics. As 1,000 litre of influent is introduced to each system over the course of a day, the 200 litre effluent drums are periodically flushed as influent is introduced.

Chapter 3: Results

The results of analysis are presented in two forms. The first is based on grab samples taken daily over six to seven days, which occurred at six to ten week intervals (see Table 3 and Figure 1). The second is based on grab sample data taken every week, where six days equals one week (see Figure 1, Figure 2, and Table 4).

Effluent characteristics of the five systems are variable for most parameters partly due to problems experienced by some systems, changes in influent quality and environmental factors. All systems do achieve high percentage reductions in SS, $CBOD_5$, FC and TN, once the systems stabilised. After the initial stabilisation period (16 weeks) all systems averaged a better than 90% reduction in $CBOD_5$, SS and FC (Table 4). Reduction in TN varied from 63% to 82% and all systems achieved a very similar reduction in TP, varying from 27% to 30% (Table 3).

The systems generally maintained a pH of greater than pH 7, with the average influent pH at around pH 8. All systems were net users of alkalinity using on average 43% to 81% of alkalinity.

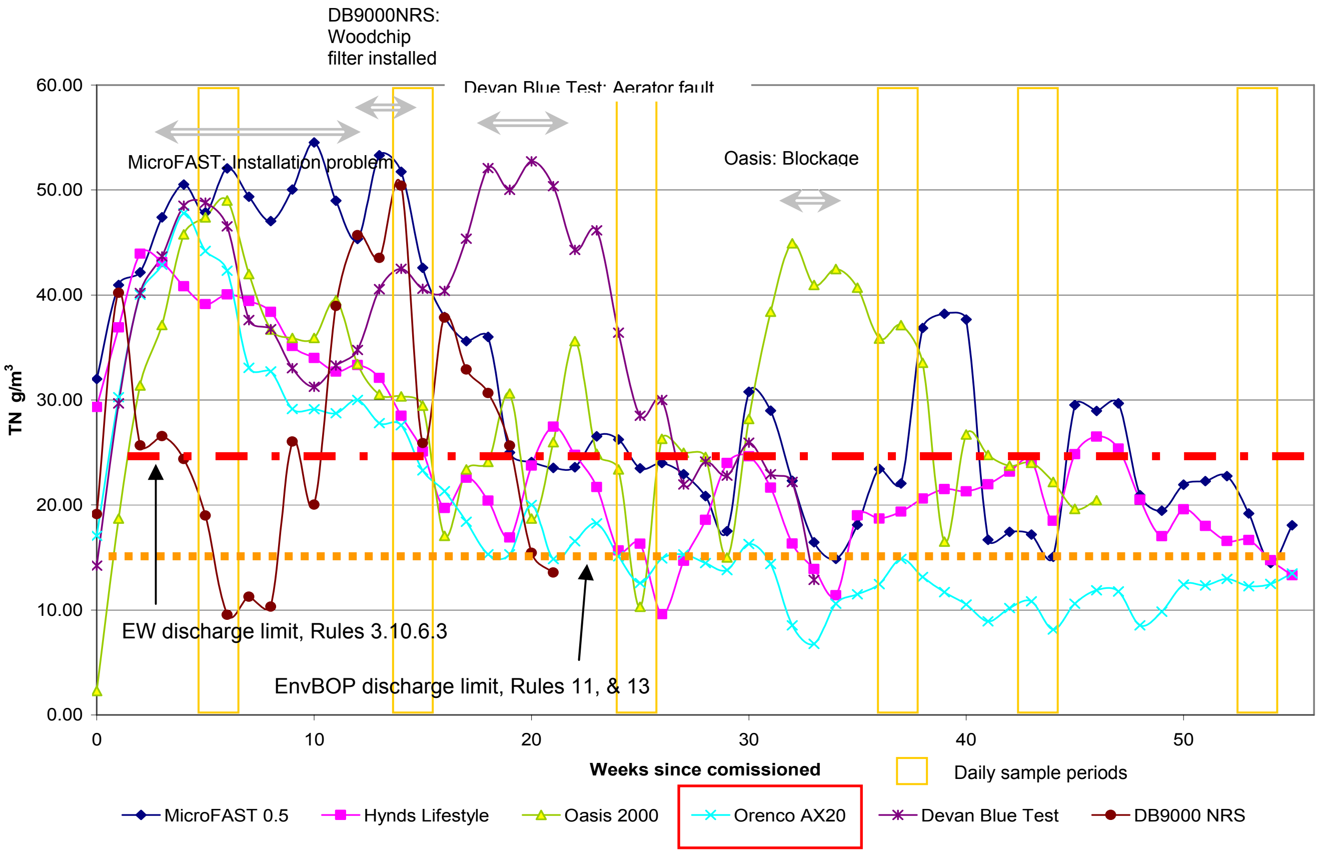

Figure 1 Total Nitrogen for five advanced on-site effluent treatment systems. (Note: the Oasis 2000 was installed 10 weeks after other systems, and the DB9000NRS 35 weeks after).

Table 3 Average characteristics of influent and effluent over time

Influent	Alk (g/m3)	pH	$CBOD_5$ (g/m3)	FC cfu/100mls	SS (g/m3)	Temp °C	NH_4-N (g/m3)	TKN (g/m3)	TO_XN (g/m3)	TN (g/m3)	TP (g/m3)
Wk 6/7	273.6	8.4	245	10914286	275	15.8	51.8	72.8	0.2	73.0	12.0
Wk 15/16	224.9	7.7	217	4300000	497	14.7	36.1	53.4	0.0	53.4	9.0
Wk 25/26	210.7	7.7	138	4557143	152	17.9	35.2	50.7	0.0	50.7	7.9
Wk 37/38	279.9	8.2	165	10200000	193	19.5	50.8	67.8	0.3	68.1	10.4
Wk 44/45	322.2	8.3	310	14757143	399	19.8	62.6	91.5	0.0	91.5	13.8
Wk 54/55	286.6	8.3	236	8248333	269	17.8	56.4	75.8	0.0	75.8	11.6
FAST – MicroFAST 0.5											
Wk 6/7	243.1	7.4	52	1765714	27	13.2	42.3	52.4	0.0	52.5	7.8
Wk 15/16	203.9	7.9	7	26617	6	14.5	32.1	35.7	2.0	37.7	8.7
Wk 25/26	161.4	7.6	12	85714	15	18.0	17.8	22.2	2.8	24.9	9.1
Wk 37/38	161.0	7.7	7	70833	6	20.8	19.1	23.8	2.2	26.0	9.0
Wk 44/45	176.0	7.8	9	134000	9	19.0	22.7	26.9	1.9	28.8	8.9
Wk 54/55	91.0	7.3	5	57083	6	16.2	5.9	8.4	5.9	14.2	8.0
Hynds Lifestyle											
Wk 6/7	14.4	6.4	7	279143	13	12.5	1.2	4.7	35.9	40.6	6.9
Wk 15/16	51.3	7.2	2	20367	3	12.8	0.2	2.5	19.2	21.7	8.2
Wk 25/26	69.0	7.2	5	42429	5	17.2	0.2	3.2	12.5	15.7	8.7
Wk 37/38	52.6	7.2	4	26000	7	19.9	0.5	3.5	17.8	21.3	8.7
Wk 44/45	32.0	7.0	4	9461	9	18.3	0.3	2.6	22.2	24.8	8.2
Wk 54/55	62.1	7.4	1	15683	2	16.3	0.1	1.6	9.9	11.5	8.1
Oasis – Oasis 2000											
Wk 6/7	-	-	-	-	-	-	-	-	-	-	-
Wk 15/16	78.1	7.4	8	83133	6	13.1	10.9	15.4	29.1	44.4	7.5
Wk 25/26	33.3	7.2	1	7	1	18.1	0.1	1.4	24.0	25.4	8.2
Wk 37/38	67.7	7.3	5	148	10	20.0	0.6	2.6	18.2	20.9	9.1
Wk 44/45	294.1	8.3	2	12	3	16.7	32.6	34.7	0.6	35.3	5.7
Wk 54/55	59.6	7.4	1	3	0	15.9	0.0	0.4	14.8	15.2	7.3
Innoflow - Orenco AX20®											
Wk 6/7	152.6	7.2	5	12729	8	11.8	21.5	23.8	11.0	34.8	7.3
Wk 15/16	61.1	6.6	3	53967	5	12.4	0.4	3.2	19.4	22.6	7.8
Wk 25/26	71.3	6.9	2	37314	2	17.1	0.1	1.9	12.5	14.4	8.6
Wk 37/38	70.5	6.7	1	44286	2	19.6	0.2	1.5	13.3	14.8	8.3
Wk 44/45	82.8	7.1	1	51857	2	17.6	0.2	1.4	9.3	10.8	8.1
Wk 54/55	72.0	6.8	1	24467	1	15.7	0.1	0.8	9.7	10.5	7.5
Devan Blue – DB9000 Test System											
Wk 6/7	184.8	7.7	20	1228000	16	12.9	31.2	35.1	2.6	37.7	7.7
Wk 15/16	206.4	7.6	10	62167	8	14.6	33.7	37.7	1.7	39.5	8.5
Wk 25/26	120.7	7.4	6	16629	5	18.3	16.2	18.9	6.9	25.8	8.6
Devan Blue – DB9000 NRS											
Wk 37/38	49.9	7.1	8	16229	10	19.7	6.4	10.4	17.1	27.5	8.7
Wk 44/45	206.9	7.2	84	422857	11	17.6	32.0	38.1	0.0	38.1	8.4
Wk 54/55	89.9	7.3	5	20167	6	16.3	9.6	8.6	3.5	12.1	8.3

Temperatures increased with the warmer summer months then began to cool again, with the trial ending in autumn. Under normal installation conditions, these systems would be inserted in the ground and thus moderated by the insulating effect of the ground. As the systems are above ground, it is possible that temperature variations have affected trial results. In winter, it is likely that the advanced OSET systems would go through a greater temperature change over the course of a 24 hour day. The effect of temperature on the systems is further discussed below.

Table 4 Percentage removal of influent constituents by OSET systems

System	TN	TP	$CBOD_5$	SS
MicroFAST 0.5	67%	30%	96%	96%
Hynds Lifestyle	73%	31%	98%	98%
Oasis 2000	63%	27%	99%	98%
Orenco AX20®	82%	30%	99%	99%
Devan Blue DB9000 NRS	67%	30%	89%*	97%

*BOD reduction was negatively influenced by installation of a bark filter. It is likely to be similar to the other systems trialled.

Figure 1 shows a plot of TN over the 55 week trial. In Figure 1 and Figure 2, it can be seen that Orenco AdvanTex® (AX20) and Hynds Lifestyle systems have achieved the best nitrogen reduction, followed by the MicroFAST 0.5. The range of TN found in the effluent and influent as well as medium and inter-quartile data is displayed in Figure 2. Data used to derive Table 4 and Figure 2 is from week 16 onwards, after which time the systems had stabilised and good TN removal rates were occurring for most systems.

Table 5 Statistics for Total Nitrogen for weeks 16 to 55

System	n	Mean (g/m^3)	Median (g/m^3)	Minimum (g/m^3)	Maximum (g/m^3)	Std.Dev. (g/m^3)
MicroFAST 0.5	41	25	23	14	42	7
Hynds Lifestyle	41	20	20	10	27	4
Oasis 2000	32	27	25	10	45	9
Orenco AX20®	41	13	13	7	23	4
Devan Blue Test*	20	34	33	13	53	13
Devan Blue DB9000 NRS*	6	-	-	14	38	-
Influent	*41*	*72*	*71*	*31*	*135*	*28*

* Statistics representing the new Devan Blue test are from week 16 to 34, DB9000 NRS from week 50 to 55.

All systems did achieve less than 15 g/m^3 TN in effluent at some stage in the trial. However, only one system did this with any consistency. Other systems dipped below the 15 g/m^3 TN target for only a short period.

Systems have taken around 14 to 16 weeks to settle in as nitrifying bacteria numbers build up and the nitrification-denitrification process starts to function effectively (Figure 1). After this time all systems (apart from the MicroFAST 0.5 system) start markedly reducing the total nitrogen in their outflow. The Devan Blue supplied test system seems to be on par with the Innoflow and Hynds supplied systems until week 10 when the TN content of the raw sewage increased. After this point, the Devan Blue supplied test system has an increased TN concentration in its output and shows some recovery when the TN concentration of the raw sewage drops.

An incorrect installation has been found to be the reason for the MicroFAST 0.5 systems lack of performance in nitrogen reduction over the first 14 weeks of the trial. This problem was rectified on 22 July (week 14) and adjustments made through to 29 July.

A blockage and consequent overflow from the Oasis 2000 system has also affected nitrogen renovation over weeks 30 to 34. It would also appear that further problems have occurred with the MicroFAST 0.5 and Devan Blue systems at various times from week 34 onwards (Figure 1).

A new Devan Blue system was replaced the test system at week 35. The DB9000 NRS system stabilised relatively quickly under summer conditions, compared to the other systems installed in winter, achieving less than 15 g N/m^3 TN within five weeks. However, it would seem installation of a wood chip filter detrimentally impacted on the system impeding nitrification. Unfortunately, this phase of the trial ended without accurate determination of the systems nitrogen reducing capability. However, from week 53 onwards, with removal of the filter, the system was achieving excellent TN reduction.

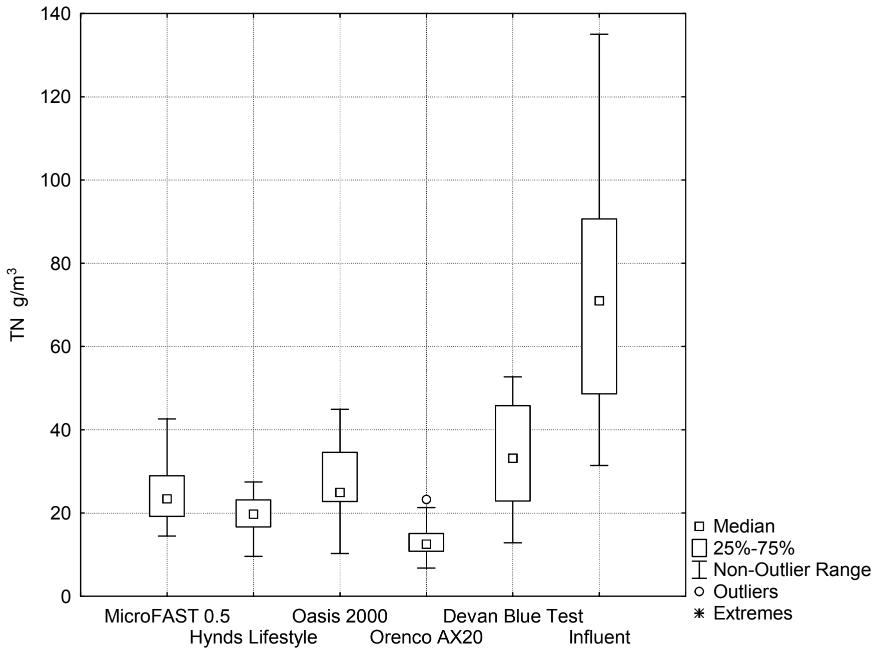

Figure 2 *Total nitrogen box-whisker plots for advanced on-site effluent treatment system (effluent and influent), from week 16 (Oasis 2000 from week 26).*

Faecal coliform levels were generally reduced by an order of greater than 10^2 (Figure 3). The Oasis 2000's membrane filtration system achieved the best faecal coliform reduction being greater on average than 10^5 reduced.

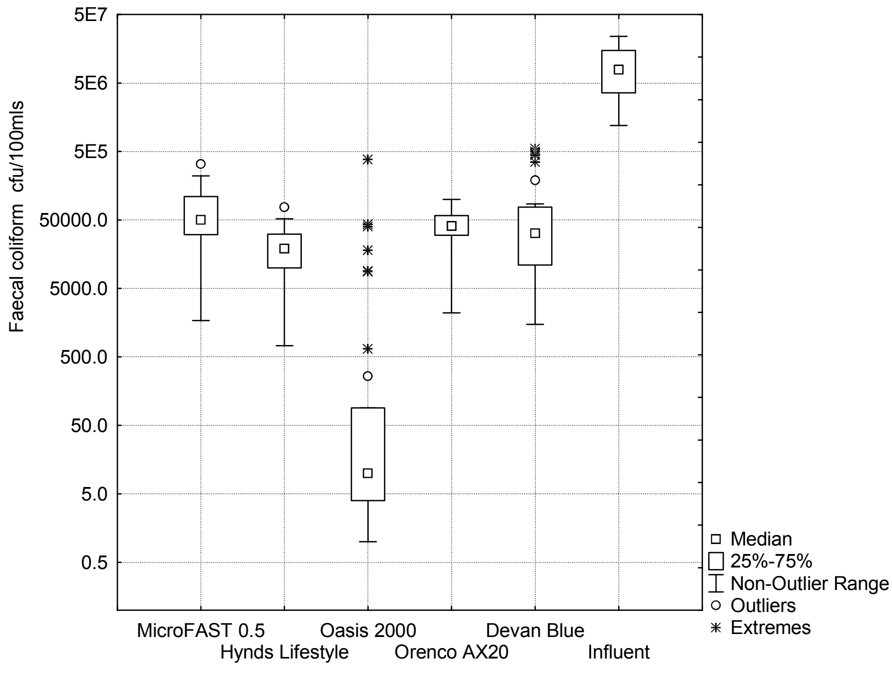

Figure 3 *Faecal coliform box-whisker plots for advanced on-site effluent treatment system effluent and influent, from week 15*

Chapter 4: Discussion

The Innoflow supplied system (Orenco AdvanTex® AX20) achieved a median TN of 13 g/m^3 for the period week 16 to 55, with TN removal efficiency better than 88% at its peak performance (Figure 4). This was the only system to consistently remain under the 15 g N/m^3 target. Next best was the Hynds system, with a median of 20 g/m^3 TN and a peak removal of over 84% TN. Median values for MicroFAST 0.5 and Oasis 2000 systems were 23 and 25 g N/m^3 respectively. The Devan Blue test systems median TN value over the 16 to 34 week period was 33 g N/m^3, however with replacement of the test system with the DB9000 NRS system this figure looks to have the potential to improve.

Once systems had established nitrifying-denitrifying bacteria, only the Orenco AdvanTex® AX20 systems managed to meet Environment Waikato's permitted activity rule discharge limit of 25 g N/m^3 in the effluent.

Both the Innoflow and Hynds supplied systems have been effective in nitrification and nitrate dissimilation. The other systems have at time had problems with nitrification. This can be partly explained by mechanical faults and installation problems, but there are other factors that have been raised as potential reasons for less than ideal total nitrogen reduction.

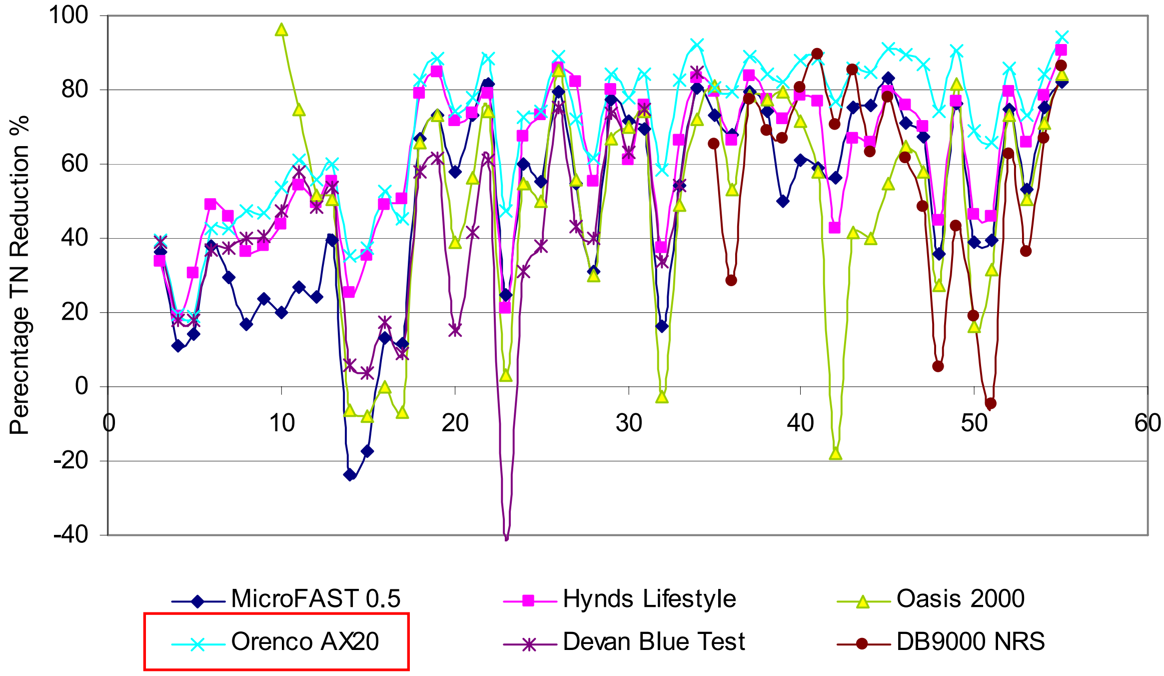

Figure 4 *Percentage TN removal or influent by advanced on-site effluent treatment systems, based on weekly data*

Reduction of TN through nitrification-denitrification and nitrate dissimilation in septic systems can be affected by a variety of factors. These include:

- Features of the systems (e.g. capacity, surface area, circulation, etc.)
- Dissolved oxygen content
- Organic loading rate and solids retention time
- Inhibiting substances
- Alkalinity and pH
- Available carbonaceous material
- Temperature

4.1 System features and function

Each system has different features and this analysis will not dwell on any specific system feature(s) or function(s), accept to report electricity consumption (measured during the trial).

Two systems had consistent electricity consumption over the trial period (Figure 5), Orenco AdvanTex® AX20 and Hynds Lifestyle. Other systems had variable consumption due to a variety of factors: mechanical failure; incorrect installation; and blockages.

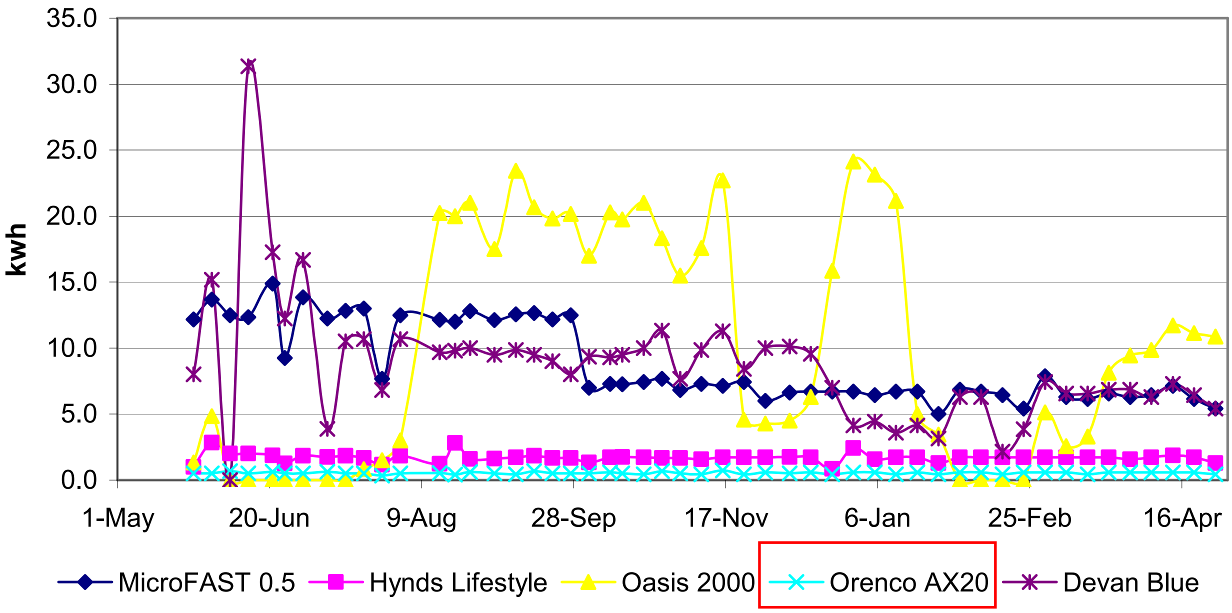

Figure 5 Electricity consumption by advanced OSET systems over trial

4.2 Dissolved oxygen

Specific system aeration characteristic and dissolved oxygen (DO) content are not being measured in this study and so cannot be considered in this analysis. It is just worth mentioning that decreased DO can become a growth limiting factor in the nitrification process and this is likely to have played a part in the increase in TN in the Devan Blue test system when the aerator malfunctioned.

4.3 Organic loading rate and solids retention times

Organic loading rate and solids retention times can affect both nitrification and denitrification. The loading rate (influent) is fixed for all systems and is designed to be representative of the loading rate for an average household, within the design specification of the systems. However, depending upon how an effluent treatment system is designed, the ratio of BOD_5 to total kjeldahl nitrogen (TKN) can affect the nitrification process.

Figure 6 shows the correlation between $CBOD_5$ and TKN in the influent over the trial. This correlation plot shows that over the trial the ratio between $CBOD_5$ and TKN has been reasonably consistent. Using a conversion factor for changing $CBOD_5$ to BOD_5 of 0.68 the median ratio of BOD_5:TKN is 2.0 (sd = 0.7). Such a ratio suits systems with a separate stage nitrification chamber (Water Pollution Control Federation, 1983). Most systems have such a chamber and this helps increase the BOD_5:TKN for nitrification in the next stage. Thus the organic content of the influent should be suitable for most advanced on-site effluent treatment systems trialled, with the influent being delivered at a fairly consistent BOD_5:TKN ratio.

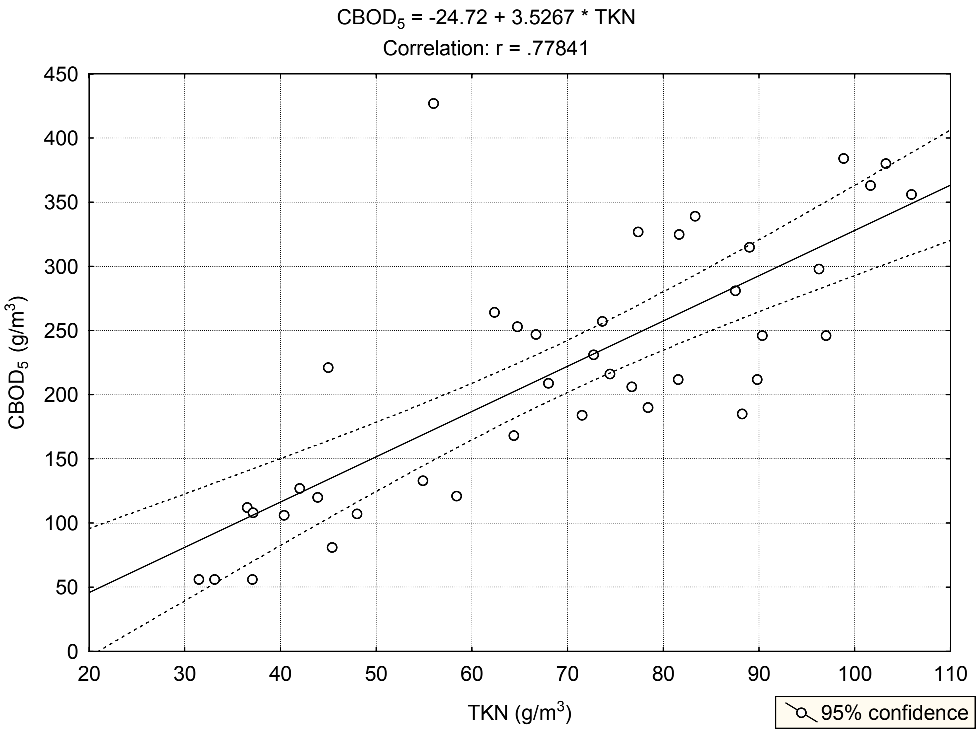

Figure 6 Correlation of $CBOD_5$ and TKN in influent

4.4 Inhibiting substances

The influent comes from a predominantly urban source, with minimal contributions from industrial and commercial premises. It is likely that a variety of substances could be present in the sewage that may affect the growth of bacterial species and enzymes in the advanced OSET systems. However, inhibition of nitrification does not seem to have occurred in the Orenco AdvanTex® and Hynds Lifestyle systems, with both systems achieving high ammonium-nitrogen conversion to nitrate and nitrite. Thus it is likely that the influent has not contained inhibiting substances in high enough concentrations to greatly impact on the nitrification process in the advanced OSET systems.

4.5 Alkalinity and pH

A low pH will inhibit nitrification/denitrification and this is controlled by the available alkalinity. The pH in all systems remains fairly stable (Table 2). Generally an alkalinity of greater than 50 g/m^3 is recommended to deal with fluctuations in influent ammonium-nitrogen concentrations. For pH, the recommended optimum level for nitrification is a pH of 7.5 to 8.6, while maintaining a pH of greater than 7.2 and between 7 and 8 for denitrification (Water Pollution Control Federation, 1983).

Alkalinity and pH are not measured within the systems, so no assessment of their controlling influence is made here. One observation worth noting is that the Orenco AdvanTex® AX20 outflow pH reaches as low as 6.2 (Alk < 50 g/m^3). However, a low pH in the outflow does seem to have affected nitrogen reduction with excellent results still being achieved.

4.6 Carbon content

Removal of available carbon in the advanced on-site effluent treatment systems occurs in settling, nitrification and dissimilation of nitrate. An excess of available carbon in the nitrification process can limit nitrifying bacterial growth. The microorganisms responsible for completing the dissimilation of nitrate are facultative heterotrophic aerobes contained in the wastewater that are also responsible for $CBOD_5$ oxidation. Again, carbon is not measured within the systems so no assessment of carbon limiting nitrification-denitrification reactions is made here.

4.7 Temperature

Temperature affects the biochemical reactions within the advanced on-site effluent treatment system. Changes in the influent can also be brought about by seasonal temperature differences. Temperature changes (diurnal or otherwise) within the systems are difficult to establish without 24 hour monitoring, but is likely to vary within in each chamber. Figure 7 shows that the effluent temperatures have their greatest difference between readings in winter, lying somewhere between influent and ambient air temperatures. Effluent temperatures reach just under 10ºC in winter and over 20ºC in summer.

Comparison of ambient air temperatures (measured at Pererika, Rotorua) with effluent temperatures indicate that effluent temperature in the systems drops with air temperature changes. It is unlikely that the extent of diurnal temperature variation that occurs in ambient air is repeated in the systems, as the lowest temperature recorded in the 200 litre drums was 8.5ºC compared to an 8 am low of 4.0ºC. This would suggest that heat loss occurs, but may not be significant in the systems over a 24 hour period.

As temperature effects nitrification it also has a direct relationship with the growth of microorganisms. The rate of ammonium-nitrogen oxidation is directly proportional to growth of nitrifying organisms and it can be seen that in both the Innoflow and Hynds systems ammonium- nitrogen oxidation has been achieved, almost completely regardless of temperature variation. Effluent from the Orenco AdvanTex® AX20 has recorded the lowest temperatures (Figure 7) and yet has one of the best nitrification rates, also suggesting temperature has not had much of an impact on the TN reduction.

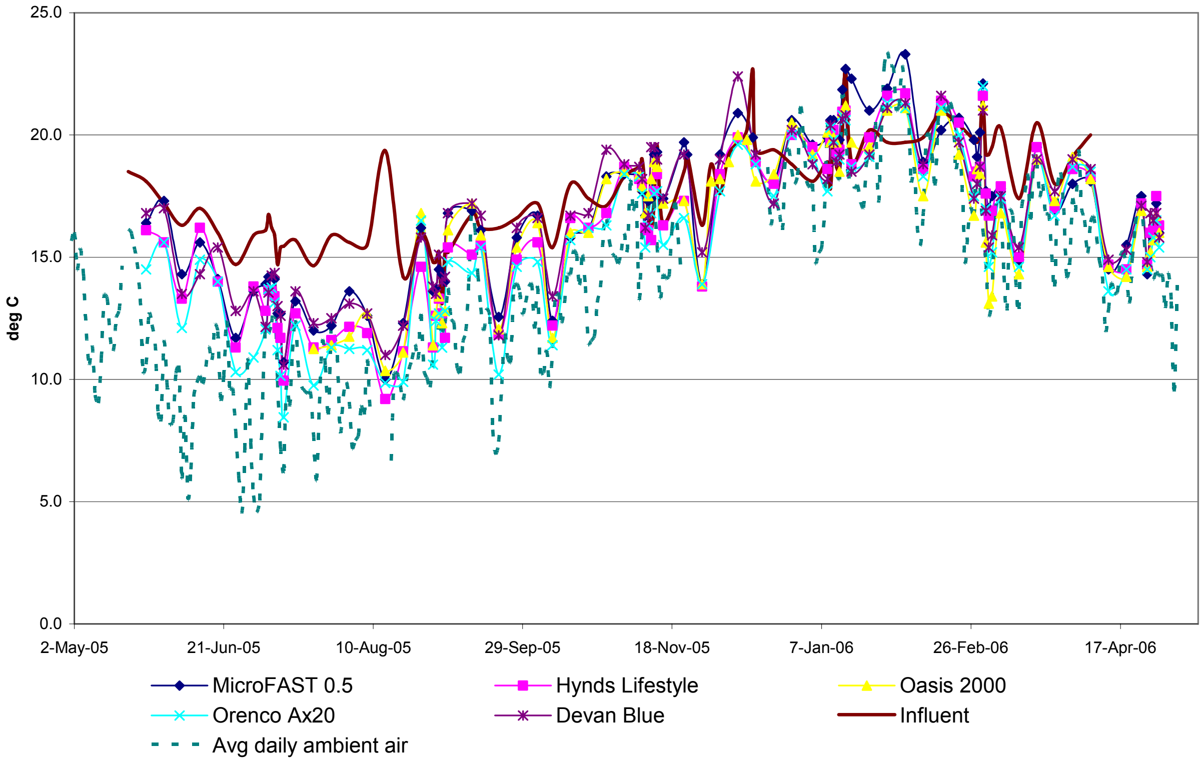

Figure 7 Ambient air, influent and effluent temperatures

Given the current data set, it is difficult to tell if temperature is a major limiting factor in the dissimilation process. However, denitrification has been reported to occur as low as 0ºC (Water Pollution Control Federation, 1983).

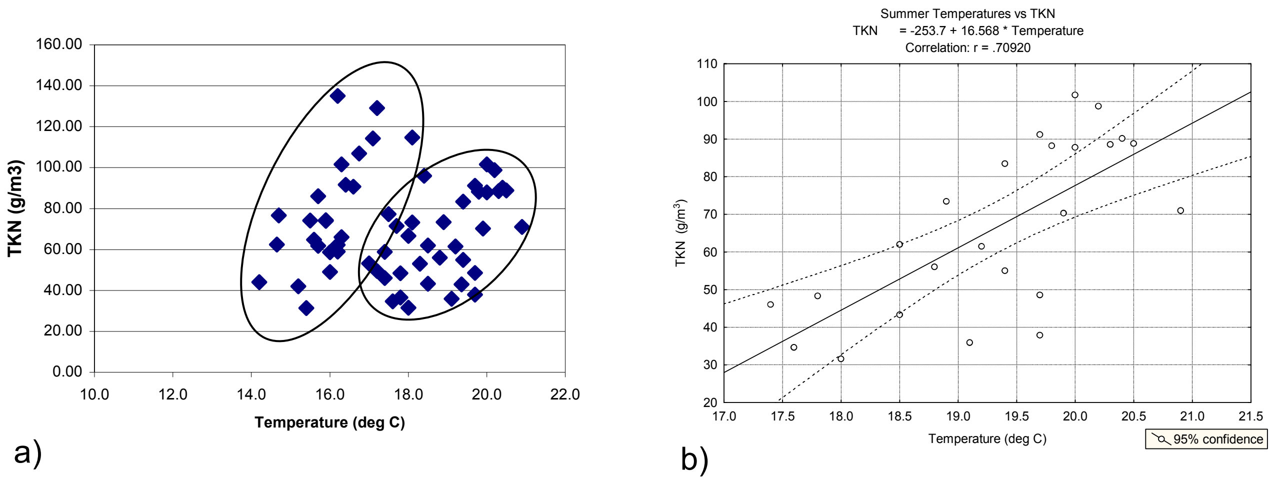

Figure 8 Influent temperature versus TKN for a) over the trial period and b) summer.

The TKN concentration is important as it dictates available carbon in the system to the quality of NH_4-N to be converted. It is possible for hydrolysis/acidogenisis of the influent to be influenced by temperature. Analysis of influent data indicates that the influent make-up has changed with a change in temperature (Figure 8). In Figure 8 (a) when influent temperature is plotted against influent TKN, two distinct groups of data are apparent. Inspection of the groups (minus outliers) shows that there was a distinct summer grouping (late November to mid April) and a winter grouping. Correlation of the summer grouping indicates that TKN is temperature related, however no correlation is found for the winter grouping. This would suggest that influent organic loading is more variable over the winter months, potentially impacting on the nitrification process.

Chapter 5: Conclusion

A trial of five different advanced on-site effluent treatment systems has successfully provided information on the ability of these systems to reduce nitrogen, BOD and SS in domestic sewage. The focus of the trial was on the reduction of total nitrogen to meet the limits as stated in Environment Bay of Plenty and Environment Waikato regional plans.

The limit of 15 g/m^3 from rules 11 and 13 of Environment Bay of Plenty's On-Site Effluent Treatment Regional Plan 2006 was achieved by all systems in this trial (after settling). However only one system, Innoflow's Orenco AdvanTex® AX20, could sustain this target. It was also the only system to meet the Environment Waikato regional plan maximum permitted discharge limit of 25 g N/m^3.

Several systems had problems over the trial period. The MicroFAST 0.5 had an initial installation problem, Devan Blue's installation of a woodchip based filter in their DB9000 NRS system resulted in elevated $CBOD_5$ and TN concentrations. Likewise the Oasis 2000 systems results were affected by a blockage during the trial.

All systems successfully achieved the limits for BOD_5 and SS as set by Environment Bay of Plenty's and Environment Waikato's regional plans.

Systems took around 16 weeks for nitrogen reduction to stabilise to around target levels. When this wasn't achieved it became apparent that incorrect installation or system malfunctions had caused nitrogen reduction to fluctuate.

Environmental factors influencing the trial with the potential to compromise the efficiency of the advanced OSET systems to reduce nitrogen were explored. These potential problems included micro-organism inhibition due to toxicants in the influent, temperature extremes, variation in alkalinity and influent concentrations and loading. It is concluded that environmental factors did not have much bearing on trial results as they were the same for all systems and some systems achieved excellent nitrogen reduction.

Influent quality does not seem to have been a factor affecting the nitrification-denitrification process. However, influent is more variable over the winter months than summer. This difference is temperature driven and may affect the functioning of some systems. While temperature may affect nitrification/denitrification, the major limiting factors are alkalinity, pH and possibly the carbon content of the influent.

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Appendices

Appendix I Log book – record of visits to and work done on systems

Appendix I – Log book – record of visits to and work done on systems

OSET log book					
Ref No.	**Date**	**Time**	**Person/Company**	**Nature of Visit**	**Comment**
1	20/05/05	7:00	Andy B	Vf drive tripped	Reset drive and PLC. Pump unblocked system back on line by 10:00am
2	23/05/05	9:30	Jack LeComte	Unblock pump 5	Blocked with rags
3	26/05/05	9:00	Jack LeComte	Unblock pump 4	Line from pump blocked, cut line fit mac union.
4	31/05/05	11:00	Devan Blue	System 5 had no power	Bplug in shed not in properly.
5	10/06/05	8:30	Mark Mohi	Vf drive fault	Fitted extension to system 5 pipe. Leak in last joint (KJ/SB informed Devan Blue. System 4 Kwh meter to be checked. (Townley Elect.
6	13/05/05	10:15	Devan Blue	Installed plate clarifier	Installed plate clarifier into irrigation pump sump. Installed pressure gauge to irrigation filter.
7	13/06/05	12:10	Devan Blue	Noted nitrate still lowish & Amm. High	Change setting X 2 Aeration.
8	21/06/05	10:30	Hynds Environmental	Check aeration and filters	Zabel blocked so cleaned and replaced
9	23/06/05	8:45	Innoflow	System check	Checked levels;POD growth. Temp monitoring to be set up by AB
10	28/06/05	3:00	Devan Blue	Check out system	Added sep-tech 500ml to aeration tank all well.
11	1/07/05	10:15	Devan Blue	Site visit with Lix Milne for sampling	Ecogent Karl & Bill visit lab for latest results.
12	6/07/05	16:00	Jack LeComte	System 5 not using Kwh	Found main switch on unit "OFF" turned on.
13	11/07/05	15:30	Andy B	Increase pump rates	Increased min speed P1 - 18 to 25: P2 - 17 to 25: Done to increase daily flow up from 930 litres per day.
14	19/07/05	14:30	Oasis	Commissioning System 3	
15	20/07/05	8:45	Tony Hamon	All pumps tripped	Reset system
16	21/07/05	15:00	Smith & Loveless	Checked system found Aeration fault.	Put up sign
17	22/07/05	10:00	Smith & Loveless	Fixing system problem	Adjusted aeration pipe by raising 100mm. Need to return later to do electrical mod.
18	22/07/05		Niki J & John B	?? Hynds	Checked aeration; changed valve for clarifier (ball to gate). Cleared zabel & irrigation filter. Zabel filter blocked.
19	23/07/05		Smith & Loveless	Checked system after pump pipe changed	
20	28/07/05		Smith & Loveless	Pump pip[e unit cut shorter	
21	29/07/05	7:00	Andy B	No flow	Fault on level probe no flow till 10:00
22	29/07/05	10:00	Andy B		Increased min speed P1 - 25 to 30: P2 - 25 to 30: max speed P1 - 79 to 85: P2 - 63 to 70.Done to increase daily flow up from 930 litres per day.
23	29/07/05	11:00	Smith & Loveless	Process Check	Checking unit after alteration made yesterday
24	29/07/05		Hynds Environmental	Visitors escorted to plant by JD.	Complaint received 1/8/05 re visit and S&L working on their unit.
25	15/08/05	9:30	Andy B	Pumps tripped	Reset back on line 9:30am

26	15/09/05		Devan Blue	Clean service system	
27	28/09/05		S&L	System tripped - entire system removed pump connection	
28	29/09/05		S&L	All working again	
29	5/10/05		Hynds Environmental	General check	All good
30	5/10/05		Townley Elect	Change date for daylight saving	
31	11/10/05		Devan Blue	Service	Clean filters
32	28/10/05		Oasis	Check System	
33	7/11/05		Devan Blue	General check	
34	16/11/05		Hynds Environmental	6 monthly service	Beauty
35	17/11/05		Oasis	F/T sludge return and clean	All good
36	22/11/05		Townley Elect	Connect up Super treat	
37	23/11/05		S&L	Sampling influent & Effluent	
38	15/12/05		S&L	General check	Grab sampling
39	21/12/05		Devan Blue	Install new replacement system	
40	23/01/06		Biolytix	System Commissioning	
41	26/01/06		Devan Blue	General check adjust recycle time	cool
42	9/02/06		Oasis	Unit overflowing	
43	16/02/06		Devan Blue	Install clarifier unit to pump out stage	even more cool
44	20/02/06		Biolytix	Paint lid white	
45	23/02/06		Devan Blue	Check clarifier seal cable junction	
46	27/02/06		Devan Blue	Sample taken	
47	1/03/06		Hynds Environmental	Service reset sludge return	
48	7/03/06		Devan Blue	Sampling influent & Effluent	
49	??		Devan Blue	Remove polishing filter	
50	5/05/06		Hynds Environmental	General check	
51	1/06/06		Devan Blue	Relocate flow meter	