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March 7, 2024

Mr. Gregory E. Morris, P.E.
Manager - Solid Waste Unit
Bureau of Land, Division of Land Pollution Control, Permit Section
Illinois Environmental Protection Agency
1021 North Grand Avenue East
Springfield, IL 62702

Subject: **Zion Landfill Site 2 North Expansion Permit Application**
Partial Response to Draft Denial letter Received January 5, 2024
Permit No. 1995-343-LFM, Log No. 2022-254

Dear Mr. Morris:

On behalf of Zion Landfill, Inc., Aptim Environmental & Infrastructure, LLC (APTIM) is submitting this partial response to the Draft Denial letter recently provided by the Illinois Environmental Protection Agency (IEPA) regarding the permit application to expand Zion Landfill. These include responses to all of the comments in the draft denial letter received on January 5, 2024 with the exception of Comment 2. Responses to Comment 2 will be provided upon receipt of further guidance from the IEPA related to our inquiries regarding temporary monitoring well locations.

Responses to Comments

1. IEPA Comment: *The application does not meet the requirements of 35 IAC 812.317(a). A site map showing the entire zone of attenuation is not provided.*

   - *The operator shall provide a site map (similar to Figure 2.8-2, but without the topographic contours) depicting the entire groundwater monitoring network, existing wells, new wells, wells to be phased in, wells to be phased out, temporary wells, clear cell phasing order, waste boundary, and the zone of attenuation.*

   Applicant Response: Per discussion with the IEPA on January 23, 2024, and in lieu of a map showing the entire facility groundwater monitoring map due to scaling issues, it was agreed to instead modify Figure 2.8-2 to include the zone of attenuation and to separately depict those existing wells that will be abandoned. A revised Figure 2.8-2 is provided in Attachment 1. It should be noted that Figure 2.8-2 can be further updated with the addition of any temporary monitoring wells that may be added subsequent to ongoing discussions with the IEPA regarding such wells.

2. IEPA Comment: *The application does not meet the requirements of 35 IAC 811.321(a)(1) & (a)(2)(C). Waste disposal operations must move from the downgradient portions first with groundwater monitoring wells placed 50 feet or less downgradient from the filled portions of the unit. Groundwater monitoring wells shall be placed fifty feet from the zone of attenuation at all times pursuant to 35 IAC 811.318(b)(3) & (5). If cell phasing order is to be from upgradient starting with Cell 11, then the interim zone of attenuation will be required on the downgradient edge of Cell 11. Then, as cell phasing progresses, interim well locations will be on the downgradient edge of the respective cells. If cell phasing is to be from the most downgradient portion first (Cell 17),*

then two zone of attenuation networks will be in place (downgradient of Cell 17 and downgradient of the northeastern boundary of the existing landfill).

- *A revised Figure 2.8-2 should be provided detailing the well phasing, installation, and abandonment schedule in relation to cell construction.*

Applicant Response: To be provided under separate cover upon receipt of further guidance by the IEPA regarding the proposed locations of temporary monitoring wells.

3. IEPA Comment: *The application does not meet the requirements of 35 IAC 811.319(a)(3)(C), which requires the "operator of a Municipal Solid Waste Landfill (MSWLF) unit must monitor each well in accordance with subsection (a)(3)(A) on a semi-annual basis". The proposal of monitoring organic constituents "at least once every two years" is inappropriate for a MSWLF.*

   - *Clarification of the proposed monitoring schedule and frequency must be provided.*

   Applicant Response: All references to sampling at least once every two years have been replaced in Section 2.8 of the permit application. Section 2.8 now states that sampling will occur on a semi-annual basis. The updated Section 2.8 is included as Attachment 2. As previously indicated, Figure 2.8-2 can be further updated with the addition of any temporary monitoring wells that may be added subsequent to ongoing discussions with the IEPA regarding such wells.

4. IEPA Comment: *The application does not meet the requirements of 35 IAC 811.319(a)(2) by not having AGQS/MAPC values for dissolved chromium and dissolved magnesium for the Shallow Drift Aquifer.*

   - *Provide AGQS/MAPC values for dissolved chromium and dissolved magnesium for the Shallow Drift Aquifer.*

   Applicant Response: These values were not provided in the permit application as they are not included on the currently permitted list of AGQS/MAPC values for the existing landfill. However, in response to this comment, AGQS/MAPC values are proposed by the applicant for inclusion in the permit. These values have been determined using data from the background wells at the existing landfill (G131, G132, G185, and R133) that was collected between second quarter 2008 and first quarter 2009.

   This data included 16 data points for each parameter, and which have been evaluated using Sanitas groundwater statistical analysis software. For dissolved chromium, the proposed interwell AGQS/MAPC value is the laboratory detection limit of 10 ug/L (non-parametric statistical evaluation due to all of the data points being non-detect). For dissolved magnesium, due to the spatial variability observed across the existing facility and an observed non-normal distribution of the data, a value of 8,530 ug/L was determined to be the proposed interwell AGQS/MAPC value. This is the highest detected concentration of the 16 data points. The Sanitas output with the proposed interwell AGQS/MACP calculations for dissolved chromium and dissolved magnesium are provided in Attachment 3.

5. IEPA Comment: *The application does not meet the requirements of 35 812.317(j) and 811.318(e)(3). Detailed descriptions of the laboratory analysis, methods for each parameter, including laboratory procedures, quality control, error tolerance, calibration procedures, calibration checks and procedures, blanks, duplicate sampling, surrogate recoveries, matrix*

spikes, and control limits for calibration checks is not provided. If this is part of the current Sampling and Analysis Plan for Zion Landfill Site 2, then a copy of that Sampling and Analysis Plan must be provided with documentation of the source (Log and Modification No.).

- *Provide detailed descriptions of the laboratory analysis, methods for each parameter, including laboratory procedures, quality control, error tolerance, calibration procedures, calibration checks and procedures, blanks, duplicate sampling, surrogate recoveries, matrix spikes, and control limits for calibration checks.*

Applicant Response: Laboratory analysis is currently performed by Pace Analytical Services, LLC. Pace Analytical Services' Quality Manual has been provided in Attachment 4. The manual includes detailed descriptions of the laboratory procedures, quality control, error tolerance, calibration procedures and checks, blanks, duplicate sampling, surrogate recoveries, matrix spikes, and control limits for calibration checks.

In addition, in response to a related additional comment received by Mr. Adam Shade via email on January 24, 2024, we are providing the current Sampling and Analysis Plan for the existing facility (refer to Attachment 5). This plan was approved as Log No. 2019-323 (Modification No. 144). This plan describes the proposed preservation techniques and methods that will continue to be used for samples collected from expansion area monitoring wells (e.g. that the samples will be containerized and preserved as specified by method, maintained at 4 degrees Celsius after collection, and transported with chain-of-custody to the laboratory by field personnel or overnight courier in water-proof containers packed to prevent bottle breakage). Method preservation and holding times are provided as follows:

Parameter	Method	Required Sample Volume	Preservative	Holding Time
Mercury, Dissolved	EPA 7470A	250 mL Plastic	4^0C, HNO_3 to pH < 2	28 Days
Total Dissolved Solids	SM 2540 C	250 mL Plastic	4^0C	28 Days
Semi-Volatiles	EPA 8270C	2 x 1L Glass	4^0C	7 Days to Extraction, 40 Days After Extraction
Phenols, Total	EPA 9066	500 mL Plastic	4^0C, HNO_3 to pH < 4	28 Days
Metals, Dissolved	EPA 6020	500 mL Plastic	4^0C, HNO_3 to pH < 2	6 Months
Anions, Dissolved	EPA 9056	250 mL Plastic	4^0C	28 Days
Metals, Dissolved	EPA 6010B	500 mL Plastic	4^0C, HNO_3 to pH < 2	6 Months
Cyanide, Total	EPA 9012 B	250 mL Plastic	4^0C, NaOH to pH > 12	14 Days
Nitrogen-Ammonia, Dissolved	EPA 350.1	250 mL Plastic	4^0C, H_2SO_4 to pH < 2	28 Days
Oil (hexane soluble or equivalent)	EPA 1664 A	1 L Glass Bottle	4^0C, H_2SO_4 to pH < 2	28 Days
Ethylene Dibromide (EDB)	EPA 8011	2 x 40 mL vials	4^0C, HCl to pH < 2	14 days, 7 days if not Acid Preserved
1,2-Dibromo-3-Chloropropane (DBCP)				
Volatiles	EPA 8260B	2 x 40 mL vials	4^0C, HCl to pH < 2	14 days, 7 days if not Acid Preserved

6. IEPA Comment: *The references to "Remedial Action" and 35 IAC 811.319(d) must be removed and replaced with "Corrective Action" and 35 IAC 811.324, 811.325, and 811.326.*

   - *Remove and replace references to "Remedial Action" and 35 IAC 811.319(d) with "Corrective Action" and 35 IAC 811.324, 811.325, and 811.326.*

   Applicant Response: The reference to "Remedial Action" and 35 IAC 811.319(d) have been removed and replaced with "Corrective Action" and 35 IAC 811.324, 811.325, and 811.326 in Section 2.8 of the permit application. The updated Section 2.8 is included in Attachment 1.

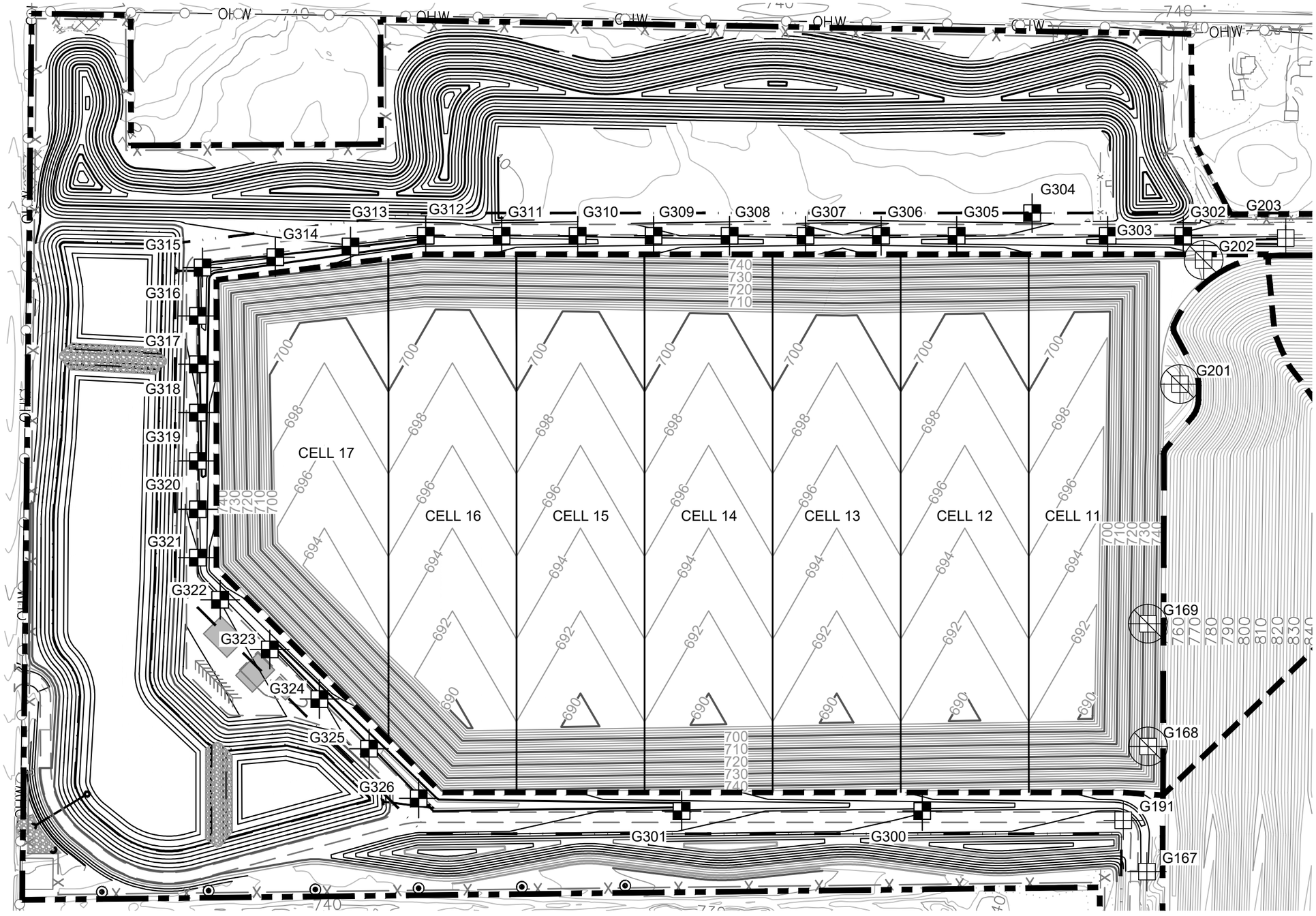
We are hopeful that the Illinois Environmental Protection Agency (IEPA) will find that this response is sufficient to address the Draft Denial Letter (except for future resolution of Comment 2), and we look forward to the IEPA's continued review of the permit application. If you have any questions, please do not hesitate to contact me at (630) 762-3322.

Sincerely,
Aptim Environmental & Infrastructure, LLC

Martin N. Fallon, P.G.
Project Manager

ATTACHMENT 1
Revised Figure 2.8-2

APTIM



LEGEND

- APPROXIMATE FACILITY BOUNDARY
- APPROXIMATE EXISTING WASTE BOUNDARY
- APPROXIMATE PROPOSED EXPANSION WASTE BOUNDARY
- APPROXIMATE ZONE OF ATTENUATION
- G302 — EXISTING MONITORING WELL - TO REMAIN
- G201 — EXISTING MONITORING WELL - TO BE REMOVED
- G301 — PROPOSED MONITORING WELL - TO BE INSTALLED

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ZION LANDFILL - SITE 2 NORTH EXPANSION
CITY OF ZION, ILLINOIS

FIGURE 2.8-2
PROPOSED MONITORING NETWORK

DRAWN BY:	KMM	APPROVED BY:	DAM	PROJ. NO.:	631020105	DATE:	JANUARY 2024

T:\Projects\2018\Advanced Zion Landfill Expansion\IEPA DOI & Draft Denial Responses\(4) Draft Denial - 01.11.24\Partial Response\Attachments\Attachment 1 Backup\ZionLF-Fig-2.8-2-MSV-Well-Loc_IEPA Application 012324.dwg, 11x17, 3/7/2024 3:06:25 PM

ATTACHMENT 2
Revised Section 2.8 (Environmental Monitoring)

2.8 ENVIRONMENTAL MONITORING PROGRAM

Introduction

The proposed Zion Landfill Site 2 North Expansion (Site 2 North Expansion) has been designed to be protective of the public, health, safety and welfare. To assure that the facility functions as designed, this Environmental Monitoring Program has been developed in accordance with applicable regulations and sound environmental practices. It includes a description of groundwater, leachate, subsurface gas, ambient air, and other environmental monitoring which will take place at the facility. The details of the Environmental Monitoring Program are described in greater detail within the following sections and within other sections of this Application.

Groundwater Monitoring

Groundwater Monitoring Overview

A groundwater monitoring program has been developed in accordance with 35 Ill. Admin. Code, Sections 811.318 and 811.319. The Groundwater Impact Assessment (GIA) has determined that groundwater quality will not be impacted at or beyond the edge of the zone of attenuation (ZOA) within 100 years after closure of the landfill, as discussed in Section 2.7 of the Application. Furthermore, the groundwater monitoring network will serve as an additional safeguard to verify that the landfill is not having any adverse impact on the groundwater quality and to provide an early warning system in the unlikely event of an impact. In other words, the groundwater monitoring network has been developed to provide assurance that the landfill will function as designed. The proposed groundwater monitoring network has been developed in accordance with current regulatory requirements based on: 1) the geology and hydrogeology, 2) the proposed landfill design features, and 3) the results of the well spacing model.

Title 35 Ill. Admin. Code Sections 811.318(b)(3) requires that monitoring wells be located as close to the potential source as practicable without interfering with operations and within one-half the distance from the edge of the potential source to the edge of the ZOA. The ZOA is located 100 feet from the waste boundary. As such, all new detection monitoring wells for the Uppermost Aquifer have been proposed to be located within 50 feet of the waste boundary.

Additionally, Title 35 Ill. Admin. Code Section 811.318(b)(2) requires that monitoring wells be located in hydrostratigraphic horizons that could serve as preferred contaminant migration pathways. Therefore, the proposed groundwater monitoring network has been designed to target the Shallow Drift Aquifer. The selection of this zone for monitoring is based on these units meeting the definition of the Uppermost Aquifer as stated in the Hydrogeologic Investigation Section (Section 2.2).

Groundwater will be routinely sampled and analyzed from the groundwater monitoring network. These monitoring results will be statistically analyzed to check that the background groundwater quality is not exceeded as defined in 35 Ill. Admin. Code Section 811.320.

Monitoring results, including the results of the data comparisons will be promptly reported in the Illinois Environmental Protection Agency (IEPA) following each sampling period.

Monitoring Well Spacing Determination

The Monitoring Analysis Package (MAP) was utilized to develop the proposed monitoring network and assure that it exceeds IEPA requirements. The Plume Generation Model (PLUME), one of three modeling packages contained within the MAP application, was utilized to determine the appropriate monitoring well spacing while taking into account current hydrogeological characteristics.

PLUME utilizes a fundamental two-dimensional analytical transport model responsible for configuring plumes. The governing equation for the transport model, originally presented in Domenico and Robbins (1985) and later modified by Domenico (1987), is:

$$C(x,y,t) = \left(\frac{C_O}{4}\right) \exp\left\{\left(\frac{xv}{2\alpha_x}\right)\left[1-\left(1+\frac{4\lambda\alpha_X}{v^2}\right)^{1/2}\right]\right\}$$

$$efrc\left\{\frac{\left[x-vt\left(1+\frac{4\lambda\alpha_X}{v^2}\right)^{1/2}\right]}{2(\alpha_X t)^{1/2}}\right\}$$

$$\left\{erf\left[\frac{\left(y+\frac{S_W}{2}\right)}{2\left(\frac{\alpha_Y x}{v}\right)^{1/2}}\right]-erf\left[\frac{\left(y-\frac{S_W}{2}\right)}{2\left(\frac{\alpha_Y x}{v}\right)^{1/2}}\right]\right\}$$

where,

C (x,y,t) = The concentration of the contaminant at location x, y from the source at time t;

C_O = Source concentration - the highest concentration of the contaminant in the groundwater at the source;

x = Distance from planar source to the location of concern along the center line of the plume;

y = Distance from planar source to the location of concern perpendicular to the centerline of the plume;

λ = 1st order decay constant;

S_W = Width of source area;

v = Average Contaminant Velocity (ki/n_e);

α_x = Dispersivity in the x direction;

α_y = Dispersivity in the y direction; and

t = Time.

To determine an appropriate down-gradient well spacing, hypothetical plumes were generated with PLUME using site specific input parameters presented in the Hydrogeologic Investigation Report (Section 2.2) and as described in greater detail within the following section. Source leaks at the landfill base were assumed and average advection times of 33,950 days on the northwest side, 23,900 days on the north side, 181,000 days on the northeast side, and 180,500 days on the southeast side of the landfill were found to maximize the extent of the PLUMES while assuring that they do not extend past the zone of attenuation on the northwest, northeast, and east (down-gradient) sides of the landfill. The modeled plumes were then able to be used to determine what minimum well spacing will be necessary to assure that any leak would be detected.

PLUME Input Data

Units. Consistent units of meters and days were used within the PLUME model.

Advection Time. As previously indicated, advection times of 33,950 days on the northwest side, 23,900 days on the north side, 180,500 days on the northeast side, and 165,000 days on the southeast side of the landfill were used in order to maximize the extent of the plumes while keeping them within the zone of attenuation along the northwest, northeast, and east (down-gradient) sides of the landfill.

Dilution Contours. Dilution contours are utilized by PLUME as criterion by which to illustrate the shape of the hypothetical plume at a percentage of the source concentration. The MAP User's Manual defines a dilution contour as the ratio of the concentration of the contaminant at the detected point in the plume to the concentration of the source. MAP documentation suggests that the concentration of the contaminant at the outermost perimeter of the plume (detection point) is equal to the laboratory's detection limit. The concentration at the source is the concentration of the constituent as it occurs in leachate. Chloride is chosen to represent the constituent released in a hypothetical plume from the landfill, because it is transported conservatively due to its resistance to degradation and non-sorbing properties. The laboratory detection limit of chloride is 1.0 mg/L. The IEPA recommends utilizing 2,000 mg/L as the concentration of chloride in leachate for the modeling purposes, however the model used a slightly more conservative site specific concentration of 1,945 mg/L, which is the average concentration of chloride in leachate at the existing landfill from 2010 through 2019. The resultant outermost dilution contour of 5.14×10^{-4} was used for the model to define the shape of the plume.

Longitudinal Dispersivity. Longitudinal dispersivity is derived from the following empirical equation developed by Schulze-Makuch (2005):

$$\alpha_L = 0.085(L)^{0.81}$$

where,

α_L = longitudinal dispersivity; and
L = flow path length.

It is conservatively assumed that a failure occurs at the downward gradient edge of the proposed landfill at the base of the landfill sideslope. Therefore, the flowpath length for the northwestern portion of the downgradient edge of the proposed expansion is determined as follows:

$$\begin{aligned} L &= D1 + D2 \\ &= 221.18ft + 50ft \\ &= 271.18ft = 82.66m \end{aligned}$$

where,

L = Flow Path Length for the northwestern portion of the downgradient edge of the proposed expansion,
D1 = Average Distance from the base of the leachate collection system to the waste boundary across the northwestern edge of the proposed landfill; and
D2 = Average Distance from Waste Boundary to Compliance Point.

The flowpath length for the northern portion of the downgradient edge of the proposed expansion is determined as follows:

$$\begin{aligned} L &= D1 + D2 \\ &= 136.13ft + 50ft \\ &= 186.13ft = 56.73m \end{aligned}$$

where,

L = Flow Path Length for the northern portion of the downgradient edge of the proposed expansion,
D1 = Average Distance from the base of the leachate collection system to the waste boundary across the northern edge of the proposed landfill; and
D2 = Average Distance from Waste Boundary to Compliance Point.

The flowpath length for the northeastern portion of the downgradient edge of the proposed expansion is determined as follows:

$$\begin{aligned} L &= D1 + D2 \\ &= 181.90ft + 50ft \\ &= 231.90ft = 70.68m \end{aligned}$$

where,

L = Flow Path Length for the northeastern portion of the downgradient edge of the proposed expansion,
D1 = Average Distance from the base of the leachate collection system to the waste boundary across the northeastern edge of the proposed expansion; and
D2 = Average Distance from Waste Boundary to Compliance Point.

The flowpath length for the southeastern portion of the downgradient edge of the proposed expansion is determined as follows:

$$L = D1 + D2$$
$$= 203.92ft + 50ft$$
$$= 253.92ft = 77.39m$$

where,

L = Flow Path Length for the southeastern portion of the downgradient edge of the proposed expansion,
D1 = Average Distance from the base of the leachate collection system to the waste boundary across the southeastern edge of the proposed expansion; and
D2 = Average Distance from Waste Boundary to Compliance Point.

Longitudinal dispersivity for the northwestern edge of the proposed landfill is calculated as follows:

$$\alpha_L = 0.085(82.66)^{0.81} = 3.04m$$

Longitudinal dispersivity for the northern edge of the proposed landfill is calculated as follows:

$$\alpha_L = 0.085(56.73)^{0.81} = 2.24m$$

Longitudinal dispersivity for the northeastern edge of the proposed expansion is calculated as follows:

$$\alpha_L = 0.085(70.68)^{0.81} = 2.68m$$

Longitudinal dispersivity for the southeastern edge of the proposed expansion is calculated as follows:

$$\alpha_L = 0.085(77.39)^{0.81} = 2.88m$$

Transverse Dispersivity. In accordance with IEPA LPC-PA2, the transverse dispersivity is determined as 20% of the longitudinal dispersivity.

Diffusion Coefficient. The diffusion coefficient of the Uppermost Aquifer was assumed to be 0.064 m^2/y (1.75 x 10^{-4} m^2/d) which is the "free solution" diffusion coefficient for chloride at infinite dilution in water at 25^0 C[1]. This value is conservative when evaluating the movement of a contaminant through a porous media such as the Uppermost Aquifer.

Average Contaminant Velocity. The average contaminant velocity is defined as follows[2]:

$$V = \frac{ki}{n_e}$$

where,

v = Average Contaminant Velocity;
k = Geometric Mean Horizontal Hydraulic Conductivity;
i = Average Gradient (February 2019 through February 2021)[3]; and
n_e = Average Effective Porosity.

$$V(north) = \frac{112.58(0.002030)}{0.367} = 0.62\ m/yr$$

$$V\ (east) = \frac{112.58(0.000359)}{0.367} = 0.107\ m/yr$$

The Average Contaminant Velocity used for the north side is the highest calculated seepage velocity of 0.62 m/yr for the Uppermost Aquifer (0.0017 m/d).

The Average Contaminant Velocity used for the east side is the highest calculated seepage velocity of 0.107 m/yr for the Uppermost Aquifer (0.0003 m/d).

Width of Line Source. As suggested in IEPA LPC-PA2, the width of line source is 1.00 m. This value was used in the model.

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[1] R. Kerry Rowe, Robert M. Quigley, Richard W.I. Brachman & John R. Booker (2004). Barrier Systems for Waste Disposal Facilities. CRC Press, London.

[2] Walton, William C. (1991). Principals of Groundwater Engineering. Lewis Publishers, Inc., Chelsea, Michigan.

[3] The gradients used for calculation of the average contaminant velocity are the average of measurements taken from potentiometric data collected in February 2019 through February 2021 (data available at time of publication of the Application for Local Siting Approval for this proposed expansion).

Results of PLUME Model

The results of the PLUME evaluation indicate that well spacings of approximately 169.90 feet on the northwest, 117.48 feet on the north, 183.90 feet on the northeast, and 182.80 feet on the southeast (down-gradient) sides of the landfill will be adequate to detect any potential leak (refer to **Figures 2.8-1 and 2.8-2**). The output files from the PLUME models are included in **Appendix Q**.

It should be noted that the PLUME modeling is overly conservative and has resulted in a proposed well spacing that is much tighter than the minimum 200 foot spacing typically allowed by the IEPA. The modeling did not consider the significant environmental safeguards that are inherent in the landfill design or the conservative assumptions that have been used in the Groundwater Impact Assessment models.

The proposed landfill design includes a composite liner system consisting of a 60-mil HDPE geomembrane liner and a 4-foot compacted cohesive soil liner (1 x 10-7 cm/sec), leachate and landfill gas collection and removal systems, and a composite final cover. In addition, the base of the landfill will be below the potentiometric surface, creating an inward gradient landfill. The inward gradient will limit the potential outward migration of any contaminant to diffusion. Groundwater will flow into the landfill during the active life of the landfill and the post closure care period rather than leachate attempting to exit the landfill. The monitoring network serves as an additional safeguard to monitor the groundwater sources at the facility, verify that the landfill design is functioning as intended, and provide an early warning system in the unlikely event of a release.

Furthermore, in the PLUME models, liner failure was assumed to occur on the down gradient edge of the proposed landfill at the base of the landfill sideslope, therefore reducing the flow path length of the hypothetical plume. This reduced flow path length was used in the determination of the longitudinal dispersivity. It would be more realistic for a release to occur in areas other than the leachate sump and trench areas which will be lined with two 60-mil HDPE liners and a geosynthetic clay liner (sandwiched between the two 60 mil HDPE liners). It would seem reasonable to increase the flow path length and calculate it from the interior of the landfill. Calculating the flow path length from the interior of the landfill would increase the longitudinal dispersivity and widen the hypothetical plume. It would also increase the transverse dispersivity. As a result, an increased flow path length would result in a wider hypothetical plume that could be detected and, therefore, a wider well spacing.

In addition, the MEMO models assumed a line source of one (1) meter. However, a diffusion driven release from this inward gradient landfill will result in a wider source area, creating a wider hypothetical plume that could be detected.

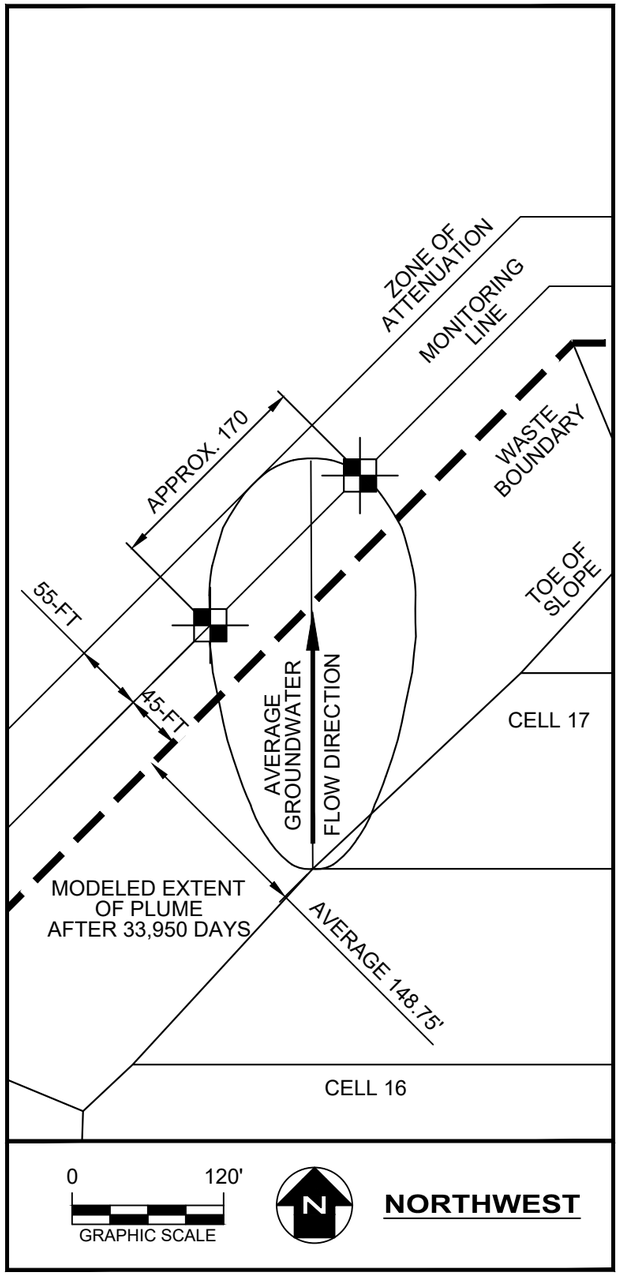
Moreover, the results of the permitted Groundwater Impact Assessment have demonstrated that the facility will not have an adverse impact on the groundwater quality. This assessment included the use of conservative model assumptions including a constant concentration, outward gradient, poor liner contact used to determine the seepage rate, and did not include the application of adsorption of degradation. The GIA determined that the proposed landfill will not adversely impact the groundwater quality at or beyond the edge of the ZOA within 100 years of landfill closure.

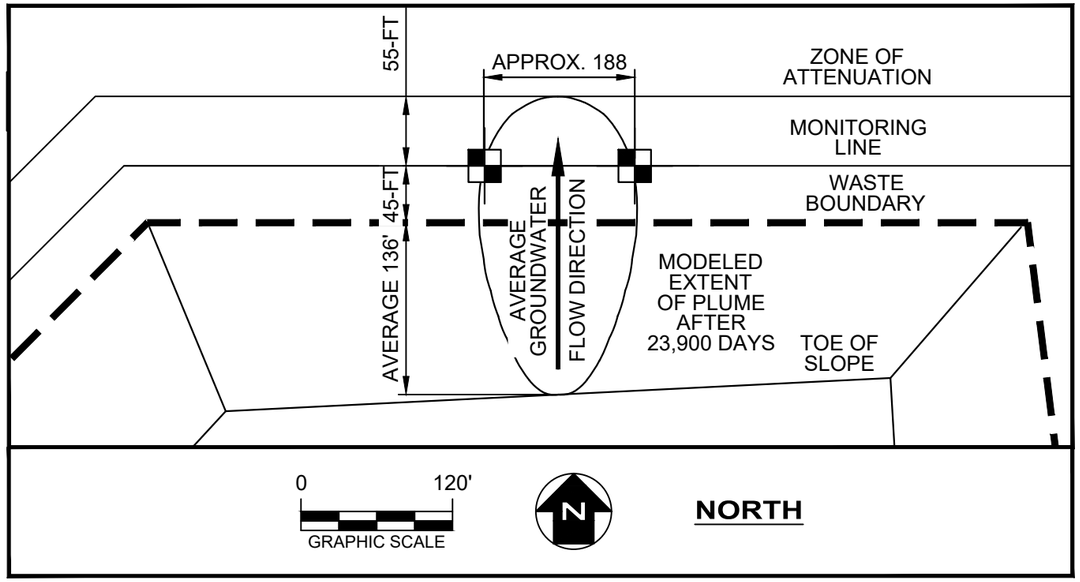
Description of the Proposed Monitoring Network

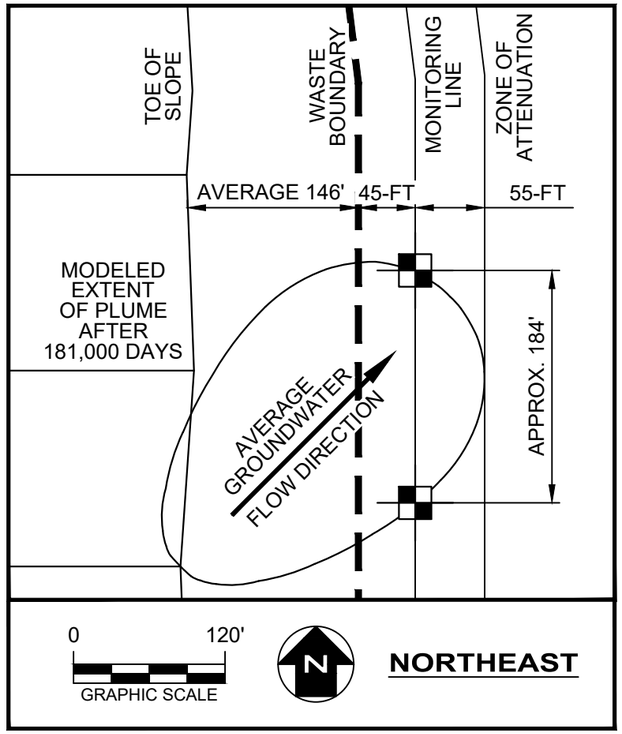
The proposed monitoring network for the landfill will include a total of 27 detection monitoring wells within the Uppermost Aquifer (G300 through G326). Down-gradient monitoring wells G302 through G306 have been spaced approximately 183 feet apart. Down-gradient monitoring wells G307 through G314 have been spaced approximately 184 feet apart. Down-gradient monitoring wells G315 through G321 have been spaced approximately 117 feet apart. Down-gradient monitoring wells G322 through G326 have been spaced approximately 170 feet apart. Additionally, two up-gradient monitoring wells (G300 and G301) have been added in order to provide continuous background groundwater quality data. The monitoring wells will be installed prior to waste placement in the cells to be monitored as cell development progresses. Proposed monitoring well G304 will be located down-gradient of the first cells to be constructed (Cell 11 and Cell 12) and will be installed at the compliance boundary (i.e. edge of the ZOA) in accordance with 35 Ill. Admin. Code Section 811.318(b)(5). This compliance boundary well is proposed to remain in operation during the life of the landfill and throughout the post-closure period.

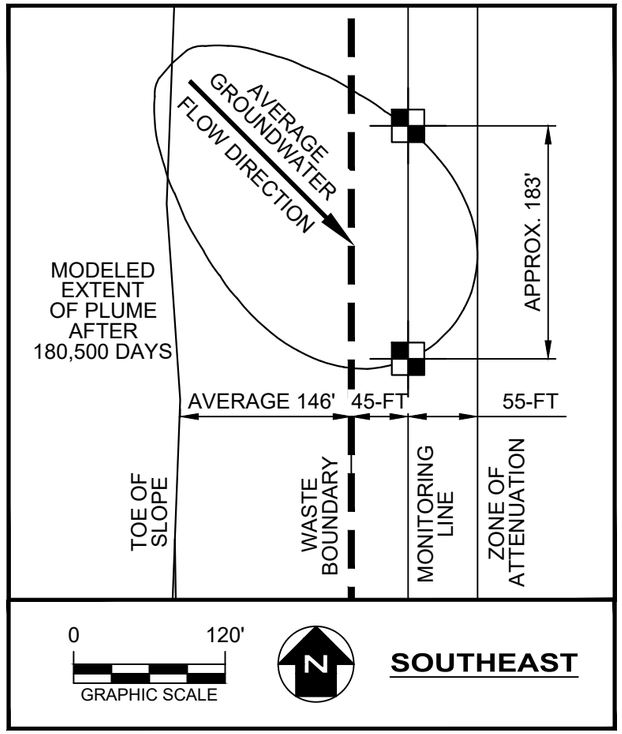
The proposed monitoring network for the landfill is depicted on **Figure 2.8-2** and on **Drawing No. D12**. A typical monitoring well is shown in **Photograph 2.8-1**.

Photograph 2.8-1 Typical Monitoring Well









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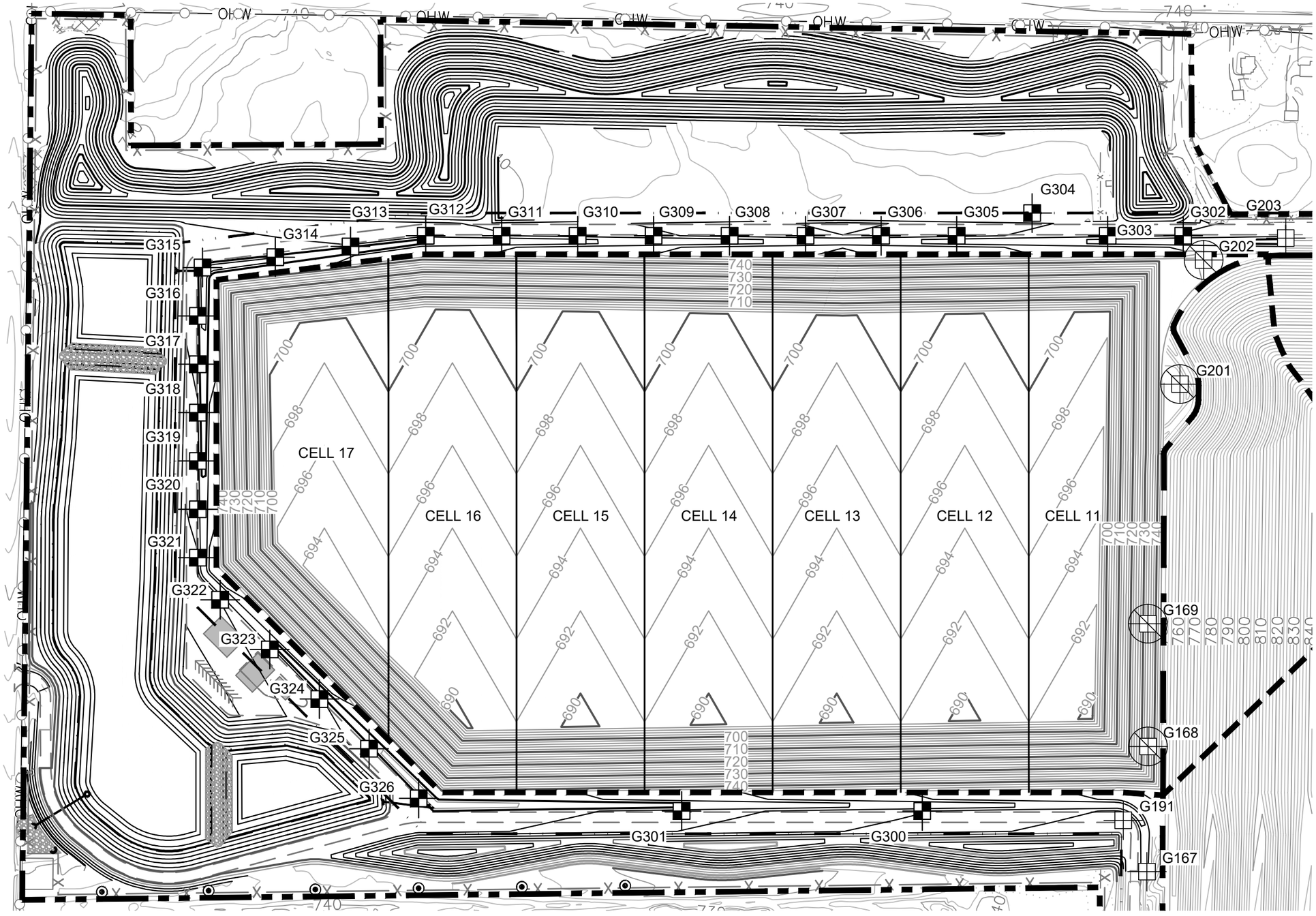
ZION LANDFILL - SITE 2 NORTH EXPANSION
CITY OF ZION, ILLINOIS

FIGURE 2.8-1
WELL SPACING DETERMINATION DIAGRAM

DRAWN BY:	MRL	APPROVED BY:	DAM	PROJ. NO.:	631020105	DATE:	MAY 2022



LEGEND

- APPROXIMATE FACILITY BOUNDARY
- APPROXIMATE EXISTING WASTE BOUNDARY
- APPROXIMATE PROPOSED EXPANSION WASTE BOUNDARY
- APPROXIMATE ZONE OF ATTENUATION
- G302 — EXISTING MONITORING WELL - TO REMAIN
- G201 — EXISTING MONITORING WELL - TO BE REMOVED
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ZION LANDFILL - SITE 2 NORTH EXPANSION
CITY OF ZION, ILLINOIS

FIGURE 2.8-2
PROPOSED MONITORING NETWORK

DRAWN BY:	KMM	APPROVED BY:	DAM	PROJ. NO.:	631020105	DATE:	JANUARY 2024

T:\Projects\2018\Advanced Zion Landfill Expansion\IEPA DOI & Draft Denial Responses\(4) Draft Denial - 01.11.24\Partial Response\Attachments\Attachment 1 Backup\ZionLF-Fig-2.8-2-MSV-Well-Loc_IEPA Application 012324.dwg, 11x17, 3/7/2024 3:06:25 PM

It should be noted that during the installation of the 27 new detection monitoring wells proposed withing this application, a nested well may also be installed within any saturated intra-till sediments that may be encountered above the Uppermost Aquifer. Should nested wells be necessary, the final monitoring network will consist of more than the 27 permanent monitoring wells indicated above.

Monitoring Well Phasing

The groundwater monitoring network will be developed in phases so that each well will be installed prior to accepting waste in the cell(s) that the wells are intended to monitor. **Table 2.8-1** provides a summary of the groundwater monitoring wells and the phasing status of each monitoring point.

Establishment of Applicable Groundwater Quality Standards

Applicable Groundwater Quality Standard (AGQS) values have been established for the Uppermost Aquifer (Shallow Drift Aquifer) and the Intratill Sediments at the existing Zion Landfill. These permitted AGQS values were used in the GIA model. Applicable pages of the permit which indicate permitted AGQS values for the existing Landfill have been provided in **Appendix Q**.

The AGQS values may be revised to incorporate new standards, additional wells, or intra-well evaluations as approved by the IEPA using Sanitas Groundwater Monitoring statistical software (Sanitas). Prior to calculation of the AGQS values, groundwater monitoring data will be evaluated for potential outliers and spatial variance using Sanitas.

Upon completion of the outlier and spatial variance evaluations, statistical analyses will then be performed in accordance with the USEPA 1992 Standards. Ultimately, the AGQS values will be determined using appropriate procedures specific to each constituent due to the characteristics of its data set (i.e. number of non-detects, normality, etc.).

The Sanitas software allows for the development of AGQSs through the use of a built-in decision logic framework that assures consistency with the USEPA's statistical requirements. The decision logic framework allows the software to move through the series of statistical step flow charts and testing algorithms, ultimately choosing the most appropriate statistical method and making any necessary adjustments or transformations.

For these analyses, normality will first be evaluated using Shapiro-Wilk Test with a specified alpha of 99 percent. Sanitas then utilizes a variety of power transformations in an attempt to normalize the distribution for use in the parametric tests (ladder of powers). The software then chooses the data transformation that normalizes the data with the least powerful transformation. When necessary, the software automatically substitutes a value of one half of the method detection limit for non-detects.

Parametric tests will be performed on normal and log normal datasets when the number of non-detects for a sample set is found to be less than 50 percent. Cohen's Adjustment will be used on the sample mean when the number of non-detects is found to be between 15 and 50 percent.

TABLE 2.8-1
PROPOSED GROUNDWATER MONITORING WELL NETWORK PHASING

Well Name	Location (Site-Specific Coordinate System)		Location (NAD83 Illinois State Planes, East Zone, US Foot)		Ground Surface Elevation	[1,2]Bottom of Screen Elevation	Depth to Bottom of Screen	Installation / Phasing
	Northing	Easting	Northing	Easting	ft MSL	ft MSL	ft bgs	
G300	13044.49	11685.73	2120548.40	1109231.59	745.55	640.55	105.00	Up-gradient well to be installed within 50 feet of the waste boundary prior to Cell 11 operations.
G301	13626.9	11685.73	2121130.81	1109234.64	742.17	645.82	96.35	Up-gradient well to be installed within 50 feet of the waste boundary prior to Cell 11 operations.
G302	12412.86	13077.70	2119909.49	1110620.22	743.06	639.89	103.17	Up-gradient well to be installed within 50 feet of the waste boundary prior to Cell 11 operations.
G303	12595.66	13077.70	2120092.29	1110621.18	744.02	640.31	103.71	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 11 Operations.
G304	12778.46	13132.70	2120274.80	1110677.14	745.57	640.76	104.81	Down-gradient well to be installed at the Zone of Attenuation prior to Cell 11 operations.
G168	12497.75	11841.91	2120000.85	1109384.90	746.00	-	-	Existing well to be abandoned during Cell 11 construction.
G169	12498.20	12138.81	2119999.75	1109681.80	745.01	-	-	Existing well to be abandoned during Cell 11 construction.
G201	12420.64	12718.73	2119919.15	1110261.30	745.21	-	-	Existing well to be abandoned during Cell 11 construction.
G202	12363.21	13019.03	2119860.15	1110561.30	742.71	-	-	Existing well to be abandoned during Cell 11 construction.

TABLE 2.8-1
PROPOSED GROUNDWATER MONITORING WELL NETWORK PHASING

Well Name	Location (Site-Specific Coordinate System)		Location (NAD83 Illinois State Planes, East Zone, US Foot)		Ground Surface Elevation	[1,2]Bottom of Screen Elevation	Depth to Bottom of Screen	Installation / Phasing
	Northing	Easting	Northing	Easting	ft MSL	ft MSL	ft bgs	
G305	12961.26	13077.70	2120457.88	1110623.10	746.02	641.27	104.75	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 12 operations.
G306	13144.06	13077.70	2120640.68	1110624.05	746.26	642.18	104.08	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 13 operations.
G307	13326.86	13077.70	2120823.48	1110625.01	746.41	643.09	103.33	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 13 operations.
G308	13510.76	13077.70	2121007.38	1110625.98	746.00	643.80	102.20	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 14 operations.
G309	13694.66	13077.70	2121191.27	1110626.94	744.48	643.99	100.48	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 14 operations.
G310	13878.56	13077.70	2121375.17	1110627.90	744.01	644.12	99.89	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 15 operations.

TABLE 2.8-1
PROPOSED GROUNDWATER MONITORING WELL NETWORK PHASING

Well Name	Location (Site-Specific Coordinate System)		Location (NAD83 Illinois State Planes, East Zone, US Foot)		Ground Surface Elevation	[1,2]Bottom of Screen Elevation	Depth to Bottom of Screen	Installation / Phasing
	Northing	Easting	Northing	Easting	ft MSL	ft MSL	ft bgs	
G311	14062.46	13077.70	2121559.07	1110628.87	743.19	644.18	99.01	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 16 operations.
G312	14246.36	13077.70	2121742.97	1110629.83	742.16	643.18	98.98	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 16 operations.
G326	14263.32	11716.31	2121767.05	1109268.55	740.00	646.90	93.11	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 16 operations.
G313	14428.42	13051.76	2121925.16	1110604.85	740.48	641.22	99.26	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G314	14610.49	13025.83	2122107.36	1110579.87	738.59	639.26	99.33	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G315	14786.52	13000.82	2122283.52	1110555.78	740.00	638.34	101.66	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G316	14797.81	12883.82	2122295.42	1110438.84	740.15	638.54	101.61	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.

TABLE 2.8-1
PROPOSED GROUNDWATER MONITORING WELL NETWORK PHASING

Well Name	Location (Site-Specific Coordinate System)		Location (NAD83 Illinois State Planes, East Zone, US Foot)		Ground Surface Elevation	[1,2]Bottom of Screen Elevation	Depth to Bottom of Screen	Installation / Phasing
	Northing	Easting	Northing	Easting	ft MSL	ft MSL	ft bgs	
G317	14797.81	12766.82	2122296.03	1110321.84	740.46	639.00	101.46	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G318	14797.81	12649.82	2122296.64	1110204.84	742.01	639.45	102.56	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G319	14797.81	12532.82	2122297.26	1110087.84	742.04	639.90	102.14	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G320	14797.81	12415.82	2122297.87	1109970.84	742.34	640.35	101.99	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G321	14797.81	12298.82	2122298.48	1109853.85	744.00	641.08	102.92	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G322	14743.87	12196.86	2122245.08	1109751.61	743.78	642.15	101.62	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.

TABLE 2.8-1
PROPOSED GROUNDWATER MONITORING WELL NETWORK PHASING

Well Name	Location (Site-Specific Coordinate System)		Location (NAD83 Illinois State Planes, East Zone, US Foot)		Ground Surface Elevation	[1,2]Bottom of Screen Elevation	Depth to Bottom of Screen	Installation / Phasing
	Northing	Easting	Northing	Easting	ft MSL	ft MSL	ft bgs	
G323	14623.73	12076.73	2122125.57	1109630.85	742.22	643.78	98.44	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G324	14503.59	11956.59	2122006.07	1109510.08	742.08	644.96	97.12	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.
G325	14383.46	11836.45	2121886.56	1109389.32	740.40	645.93	94.47	Down-gradient well to be installed within 50 feet of the waste boundary prior to Cell 17 operations.

Notes:
1. The screened interval will be approximately 5-10 feet.
2. The proposed groundwater monitoring network has been designed to target the Uppermost Aquifer (Shallow Drift Aquifer).

Additionally, if all the background values are less than the MDL for a given parameter, the Practical Quantitation Limit (PQL) will be used to evaluate data from the monitoring wells. Therefore, the AGQSs for the parameters which are non-detections will be set at their respective PQLs.

It should be noted that following the USEPA statistical requirements, as well as the use of Sanitas software, has traditionally been accepted by the IEPA.

Maximum Allowable Predicted Concentrations (MAPCs)

The GIA in Section 2.7 demonstrates that the proposed expansion will not cause an exceedence of any of the constituent concentrations over the AGQS values at or beyond the edge of the ZOA within 100 years of landfill closure for the Uppermost Aquifer. MAPC values were conservatively set equal to the AGQS values.

Design and Construction of Monitoring Wells

All monitoring wells for the Site 2 North Expansion will be designed and constructed in accordance with the following procedures:

1. Standards established in 35 Ill. Admin. Code, Section 811.318(d);

2. IEPA guidance;

3. Standard Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers, ASTM D 5092-90; and

4. Monitoring Well Design and Construction, Chapter 3, RCRA Groundwater Monitoring Technical Enforcement Guidance Document, U.S. EPA, September 1986.

A typical as-built diagram for groundwater monitoring well construction is provided in **Appendix Q** and on **Drawing No. D20**. The monitoring wells will be constructed to yield groundwater samples that represent the quality of groundwater at the landfill site.
The procedure for constructing the monitoring wells at the landfill will typically consist of the following steps:

1. Prior to well construction, all monitoring well locations will be staked in the field by a survey crew under the supervision of a Professional Land Surveyor licensed in the State of Illinois;

2. Borings will be drilled and continuously sampled to the target depth at each monitoring well location. Drilling fluids will be avoided to the extent practible. Soil samples will typically be obtained by either advancing a 5-foot continuous split core barrel (or similar), driving a 2-inch outside diameter split-spoon sampler (ASTM D 1586) or pushing a thin-walled 3-inch diameter Shelby tube sampler (ASTM D 1587). A geologist or geotechnical engineer will direct the field exploration operations, log the

soil samples, and document the well construction. Boreholes within 10 feet of an existing continuously sampled boring need not be continuously sampled through the depth intervals that were previously sampled;

3. Each monitoring well will be constructed using a 2-inch inside diameter, flush joint, well screen and riser pipes. The screen length for the proposed monitoring wells will be approximately 5 or 10 feet. An end plug will be placed at the bottom of the screen and a vented cap will be placed on the top. Monitoring wells may be constructed of PVC, stainless steel, Teflon, or other materials approved by the IEPA. All threaded joints will be sealed using either manufacturer supplied O-rings or Teflon tape;

4. A filter pack will be constructed in each well by filling the annular space with silica sand (approximately 2-1/2 to 3 times larger than the 50% grain size of the zone being monitored) to a depth of approximately 2 feet above the top of the screen. If the in-situ material is appropriate (i.e. sand and gravel), then the formation may be allowed to collapse around the well screen to the desired elevation;

5. A minimum 2-foot-thick bentonite chip or pellet seal may be placed above the top of the filter pack if the seal can be placed without bridging the chips or pellets. Otherwise, an approximate 3-foot thick bentonite slurry seal may be placed above the sandpack using a tremie pipe method;

6. The annular space above the bentonite seal and/or sand pack will be grouted to within 2 to 4 feet of the ground surface with a bentonite Volclay® grout, or equivalent, using the tremie method;

7. Concrete will be used to top off the annular space at the ground surface;

8. A well protector with a locking lid will then be installed in the concrete to protect and secure the monitoring well;

9. The well protector will be clearly labeled with the monitoring well number;

10. A concrete pad will be constructed around the well protector. The pad will be sloped to divert surface water away from the well;

11. The drill tooling, sampling equipment, and well screen/riser pipe that contact the in-situ geologic materials will be decontaminated using a hot water pressure washer prior to drilling each borehole. Field decontamination of certified pre-cleaned well screen/riser pipe materials will not be required. The sampling equipment will be washed in a solution of Alconox™ (or equivalent) and potable water and then rinsed in potable water prior to each use; and

12. The monitoring wells will be developed to ensure that the well screens are unobstructed and that representative groundwater is flowing into the wells.

The construction of each monitoring well will be documented by completing and submitting the IEPA Well Completion Report, the Illinois Department of Public Health (IDPH) Well Construction Report form, and an as-built diagram as provided in **Appendix Q**.

Monitoring Well and Boring, Plugging, and Abandonment

Test borings, damaged wells or piezometers and wells or piezometers no longer used for long-term monitoring at the landfill will be abandoned in accordance with 35 Ill. Admin. Code, Section 811.315 and 811.316 Plugging and Sealing of Drill Holes, and in accordance with 77 Ill. Admin. Code, Section 920.120. Abandonment procedures as described below will be followed in the event a monitoring well becomes unserviceable and must be replaced. Abandonment procedures will also be used if any unknown wells are encountered during site development. The grout used to abandon the wells will typically be a pure bentonite grout. The specific abandonment procedures are provided in the following sections.

Test Boring Abandonment

Any test borings to be drilled at the landfill for site development will be surveyed and properly abandoned as described in this section. Abandoment will be documented by a geologist or engineer.

Test borings temporarily left unattended (e.g., to obtain water elevation readings) will be temporarily covered and marked (e.g., using flagged lath). The temporary cover will minimize the flow of stormwater runoff into the boring and prevent accidental entry by animals. If an uncased boring partially or completely collapses, resulting in a potential contaminant migration pathway, the borehole will be redrilled prior to abandonment. Immediately after the required data has been collected or the boring has been redrilled, the boring will be abandoned in accordance with the following procedure.

A tremie pipe will be inserted to the bottom of each boring to be advanced. If the boring collapses, the tremie pipe will be inserted through the hollow stem augers or casing. The slurry will be tremied under pressure. As the formation water is displaced, the tremie pipe will be withdrawn. The bottom of the augers and the tremie pipe will remain just below the top of the slurry until the grout reaches the ground surface.

The surveyed ground elevation and the location of the abandoned borehole will be recorded by the supervising engineer, geologist. An abandoned boring certification form will be completed and submitted to the IEPA in accordance with permit conditions and the IDPH requirements. A copy of this form is included in **Appendix Q.**

Monitoring Well or Piezometer Abandonment

A groundwater monitoring well or piezometer required to be removed from service will be abandoned in accordance with the following procedure.

For monitoring wells or piezometers in which the well is screened in bedrock, the following plugging procedure should typically be used (it is assumed that any obstruction in the well casing will be removed prior to this procedure; if an obstruction is not able to be removed, the second procedure described below should be followed):

1. Cut casing off at desired depth;
2. Mix grout;
3. Insert tremie pipe into well and extend to bottom;
4. Slowly pump slurry under low pressure through tremie pipe;
5. Slowly withdraw tremie pipe making sure bottom of pipe remains below the grout slurry mix; and
6. Continue slow pumping until all formation water and the grout is displaced from top of casing.

For monitoring wells or piezometers which were screened in unconsolidated sediments, the following procedure should typically be used:

1. Knock out and remove thin surface concrete plug, if present;
2. Re-auger entire length of well;
3. Remove well casing from re-augered borehole;
4. Mix grout;
5. Insert tremie pipe into augers and extend to bottom;
6. Slowly pump grout under low pressure through tremie pipe;
7. Continue slow pumping until all formation water and the watery slurry mix is displaced from top of casing;
8. Slowly withdraw tremie pipe making sure bottom of pipe remains below the grout;
9. Pull a flight of augers; and
10. Top off grout after each flight is removed.

The ground elevation and the location of the abandoned monitoring well or piezometer will be recorded by the supervising engineer or geologist. An abandoned monitoring well certification form will be completed and will be submitted to the IDPH and the IEPA in accordance with permit conditions and IDPH requirements.

Groundwater and Leachate Sampling Procedures

Upon approval of the IEPA, dedicated submersible pumps will be utilized to sample each monitoring well using low flow purging techniques. The detailed sampling procedure (including procedures for sample preservation and chain of custody) that will be followed to collect leachate or groundwater samples from the monitoring wells where a dedicated submersible pump is utilized is provided in **Appendix Q**. Care will be taken to decontaminate all equipment to prevent possible cross contamination of wells. Depth to water from top of riser and elevation of the groundwater surface in reference to Mean Sea Level (MSL) datum will also be provided.

Traditional Groundwater Sampling for a Well Without a Dedicated Pump

In the case that traditional groundwater sampling is required, the following procedures will be followed:

After unlocking the monitoring well protector and removing the vented cap, the water level will generally be obtained utilizing an electronic water level indicator. After the water level is recorded, a minimum of three (3) well volumes of water will be evacuated from the monitoring well if possible. Field measurements of water level, water temperature, pH, conductivity and well depth will be recorded after each well volume is removed.

The groundwater sample will be marked appropriately and logged on the water sample chain of custody records. Water samples will be stored on ice and transported or shipped to the laboratory in a cooler or other suitable container. The laboratory will be capable of performing all analytical analysis in accordance with standard testing methods as approved by the state. Upon arrival at the laboratory, water samples and the chain of custody records will be surrendered to the laboratory. By following these quality assurance procedures, the potential for false positives should be minimized. **Photograph 2.8-2** depicts a sample being pulled from a typical monitoring well.

Sampling and testing will be governed by the approved IEPA permit and applicable State regulations.

Detection Monitoring Parameters, Frequency and Data Analyses

Groundwater monitoring at the landfill can be divided into the following three stages:

1. Monitoring prior to accepting waste;

2. Monitoring during the landfill operations; and

3. Monitoring during post-closure.

The specific monitoring program for each stage is detailed in the following sections.

Photograph 2.8-2 Sampling of a typical monitoring well

Monitoring Prior to Accepting Waste

As cell development progresses, all groundwater monitoring wells designated for each cell will be installed prior to accepting waste in that cell. Documentation of well construction will generally be provided with the application for a significant permit modification for operating authorization for each landfill cell.

Detection Monitoring During Landfill Operation

Groundwater monitoring will be performed quarterly in accordance with 35 Ill. Admin. Code, Section 811.319 for the indicator parameters required within 35 Ill. Adm. Code, Section (a)(2). Organic constituents will be monitored within each new well within three months of installation and will be added to the monitoring list on a semi-annual basis in accordance with 35 Ill. Admin. Code, Section 811.319(a)(3). The detection monitoring analytical results for the permitted monitoring wells will be evaluated in accordance with 35 Ill. Admin. Code, Section 811.319(a)(4).

Monitoring During Post-Closure

Monitoring during post-closure will remain unchanged from that performed during landfill operations, unless a change to the monitoring program is approved by the IEPA as provided for in 35 Ill. Admin. Code, Section 811.319.

Statistical Analysis of Groundwater Quality Data

As required by 35 Ill. Admin. Code, Section 811.320, routine groundwater quality monitoring data will be analyzed by comparing the results of the groundwater sampling to AGQS and MAPC values which have been established at the site using the applicable statistical procedure specific to each particular constituent and its background data set.

The routine groundwater quality monitoring data will be compared to the AGQS and MAPC values. The applicable water quality standards may be revised to incorporate new standards, additional wells, or intra-well evaluations as approved by the IEPA. The AGQS values that will be used for groundwater quality evaluation are summarized in the GIA in Section 2.7 of the Application. Additionally, applicable pages of the permit which indicate permitted AGQS values for the existing landfill have been provided in **Appendix Q**.

Evaluation of Groundwater Quality Data

The groundwater quality data for the routine monitoring parameters will be evaluated in accordance with Title 35 Ill. Admin. Code, Section 811.319(a)(4). The current required evaluations include the comparison of the concentration of constituents in wells:

1. Over the last eight consecutive monitoring periods;

2. To the applicable MAPC values (if established);

3. To the preceding measured concentration (for the organic constituents); and

4. To the applicable AGQS values.

As the AGQS and MAPC values have been established pursuant to statistical procedures, the comparison in item numbers 2 and/or 4 above will satisfy the requirement of Title 35 Ill. Admin. Code, Section 811.320(e) for statistical analysis of groundwater monitoring data. According to current regulations, a monitored (observed) increase occurs when:

1. The concentration of any constituent monitored in a particular monitoring well shows a progressive increase over eight consecutive monitoring periods;

2. The concentration of any constituent in a particular monitoring well exceeds the MAPC values at an established monitoring point within the zone of attenuation;

3. The concentration of any organic constituent monitored annually in a particular monitoring well exceeds the preceding measured concentration; and

4. The concentration of any constituent monitored in a particular monitoring well at or beyond the zone of attenuation exceeds its AGQS value.

In the event a monitored (observed) increase occurs, Zion Landfill, Inc. will, within 48 hours of the observed increase, obtain a representative sample of the source water in each well

which is located within 200 feet of the affected well and whose owners have agreed to participate in the monitoring program per the terms of the host agreements in Appendix C.

Confirmation of Observed Increase

The observed increase will be confirmed in accordance with 35 Ill. Admin. Code, Section 811.319(a)(4)(B). Current confirmation procedures generally includes taking additional samples within 90 days of the initial observation to confirm the validity of the initial sample. In the event an observed increase is confirmed, the following procedures are generally followed:

1. Determine the source of any confirmed increase, which may include, but not be limited to, natural phenomena, sampling or analytical errors, or an off-site source;

2. The IEPA will be notified in writing no later than 180 days after the original sampling event of any confirmed increase. Within this notification, a demonstration will be made, if possible, that the increase is a result of a source other than the Facility, providing rationale used in such a determination; and

3. If an alternate source demonstration cannot be made or is denied by the IEPA, assessment monitoring will be proposed.

In the event that there is a confirmed increase in the concentration of any constituent in any monitoring well, and a demonstration that the confirmed increase is not caused by the landfill is not made, the necessary steps will be implemented immediately. These steps may include the following:

1. Assessment monitoring as outlined in 35 Ill. Admin. Code, Section 811.319(b);

2. Assessment of potential groundwater impact as outlined in 35 Ill. Admin. Code, Section 811.319(c); and

3. Corrective action as outlined in 35 Ill. Admin. Code, Section 811.324, 811.325, and 811.326.

A remedy that will protect human health and the environment will be selected in accordance with 35 Ill. Admin. Code, Section 811.325. The corrective action, if appropriate, will be implemented and completed in accordance with the requirements of 35 Ill. Admin. Code, Section 811.326.

Leachate Monitoring

The existing facility has a leachate monitoring network as illustrated on Drawing No. D5. There will ultimately be a total of 7 new leachate monitoring points for the expansion area; one corresponding to each sump location as illustrated in Drawing No. 10. Leachate will be sampled on a semi-annual basis in accordance with 35 Ill. Admin. Code 811.309(g) and 35 IAC 811.319(a)(3)(C). Sampling will be conducted as long as the leachate collection system is in operation (a minimum of 30 years after closure of the facility), unless

a reduced post closure sampling period is found to sufficiently protect the public health and the environment. All test results will be submitted to the IEPA. At a minimum, leachate will be analyzed for the same list of parameters as the groundwater monitoring wells. The sampling procedure that will be followed to collect leachate samples is provided in **Appendix Q**.

Landfill Gas Monitoring

Subsurface Monitoring

Subsurface landfill gas monitoring at the Site 2 North Expansion is proposed to be conducted in accordance with the requirements of 35 Ill. Admin. Code Section 811.310. The proposed landfill gas probe network will be utilized to verify that the landfill gas collection and containment systems are functioning as designed. The proposed landfill gas monitoring network is illustrated on **Drawing No. D14**. A schematic of a typical landfill gas probe is illustrated in **Diagram 2.8-1**. Landfill gas probes will be inspected at the time of monitoring events for structural integrity and proper operations.

Perimeter landfill gas monitoring probes are proposed to be constructed (see **Drawing No. D20**) of 1-inch diameter Schedule 40, or equivalent material which will not react with or be corroded by landfill gas. The probes will be equipped with valve/hose pressure

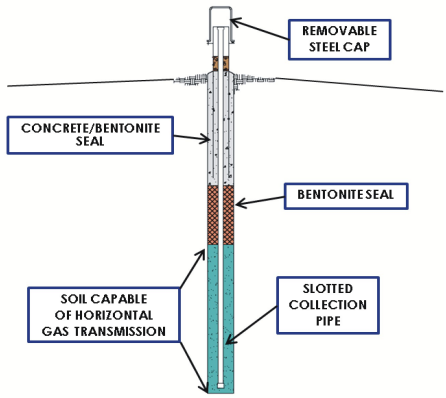


Diagram 2.8-1 Schematic of a typical gas monitoring probe

fitting(s), etc. as necessary to measure pressure and allow collection of a representative sample of gas within the probes.

The monitoring zone for these probes will be in accordance with 811.310. Pipe joints and fittings will be maintained in air-tight condition, and the probe will be installed with a bentonite seal at the surface to minimize leakage. The design and construction of the landfill gas monitoring system will not interfere with the operations of the liner or leachate collection system, or delay the construction of the final cover system.

Subsurface landfill gas monitoring devices will be sampled on a periodic basis in accordance with 811.310(c). At a minimum, below ground monitoring points will be screened for methane, pressure, nitrogen, oxygen, and carbon dioxide as required by the

IEPA. Monitoring will be adjusted as necessary to comply with the federal, state, and local regulations to ensure proper operation procedures.

Surface Emission Monitoring (SEM) and Ambient Air Monitoring

As discussed within Section 2.3 of this Application, in addition to subsurface landfill gas monitoring, ambient air monitoring will be conducted around the perimeter of the unit and in on-site buildings to verify that the landfill gas collection and containment systems are functioning as designed. At least three ambient air monitoring locations will be chosen, and samples must be taken no higher than 1 inch above the ground and 100 feet downwind from the edge of the waste boundary or at the property boundary, whichever is closer to the waste boundary. All buildings within the facility will be monitored for methane by utilizing continuous detection devices located at likely points where methane might enter each building. Ambient air monitoring locations at the site will be monitored in conformance with the requirements of the prevailing regulations which require sampling on a monthly basis for the entire operating period and for a minimum of five years after closure. The sampling frequency may be reduced to a quarterly frequency after five years of closure upon approval by the IEPA.

Surface emissions monitoring (SEM) will be performed in accordance with 40 CFR 60.755 (c) and (d); 40 CFR 60, Appendix A, Method 21; and Title 35 IAC 220.240(c). A flame ionization detector will be used to monitor the landfill surface along a site-specific traverse pattern, and at areas suspected of exceeding 500 ppm methane, including signs of gas bubbles, odors, stressed piping, etc. SEM events will be performed on a quarterly basis for the entire landfill. Prior to each monitoring event, background will be established as outlined in 40 CFR 60.755. The existing SEM Plan has been updated to include the Site 2 North Expansion Area within **Appendix L**.

In the event of a methane exceedance of 500 ppm above background, the following actions will be taken in accordance with 35 IAC 220.240(c)(4).

1. The location of each monitored exceedance will be marked and the location recorded.

2. Cover maintenance or adjustments to the vacuum of the adjacent wells to increase the gas collection in the vicinity of each exceedance shall be made and the location will be re-monitored within 10 calendar days after detecting the exceedance.

3. If the re-monitoring of the location shows a second exceedance, additional corrective action will be taken, and the location will be monitored again within 10 days after the second exceedance. If the re-monitoring shows a third exceedance for the same location, the action specified in number 5 below will be taken.

4. If re-monitoring of the location does not show an exceedance, as specified in numbers 2 or 3 above, the location shall be re-monitored 1 month from the initial exceedance. If the 1-month re-monitoring shows a concentration less than 500 ppm above background, no further monitoring of that location is required until the next quarterly monitoring period. If the 1-month re-

monitoring shows an exceedance, the actions specified in numbers 3 above or 5 below, as appropriate, will be taken.

5. For any location where there are three monitored exceedances within a quarterly period, a new well or other collection device will be installed within 120 calendar days after the initial exceedance. An alternate remedy to the exceedance, such as upgrading the blower, header pipes, or control device, and a corresponding timeline for installation may be submitted to the IEPA for approval.

Surface Water Monitoring

A Stormwater Management Plan for the Site 2 North Expansion has been designed to efficiently collect, route, and detain stormwater runoff from the Facility in an environmentally sound manner as described in greater detail within Section 2.4 of this Application. Environmental monitoring of surface water will occur in accordance with NPDES permits which will be modified for the proposed expansion as development progresses. Surface water monitoring and analysis will be performed per the site-specific Stormwater Pollution Prevention Plan and NPDES Permits.

Conclusions

The potential for the Site 2 North Expansion to impact the environment has been evaluated. In addition to the results of the GIA which demonstrate that the facility will not have an adverse impact on the groundwater quality, a comprehensive groundwater monitoring program has been designed for the Site 2 North Expansion. Additionally, Facility operations will include leachate monitoring, subsurface landfill gas monitoring, ambient air monitoring, and surface water monitoring. The Environmental Monitoring Plan at the Facility will serve as an additional safeguard to:

- Monitor potential sources of environmental impact at the facility;
- Verify that the facility design and construction are properly functioning to protect the public health, safety and welfare; and
- Provide an early warning system in the unlikely event of a leachate or landfill gas release.

Monitoring will follow strict quality control, quality assurance, and chain of custody procedures.

ATTACHMENT 3
Interwell AGQS Determination for Dissolved Chromium and Dissolved Magnesium

APTIM

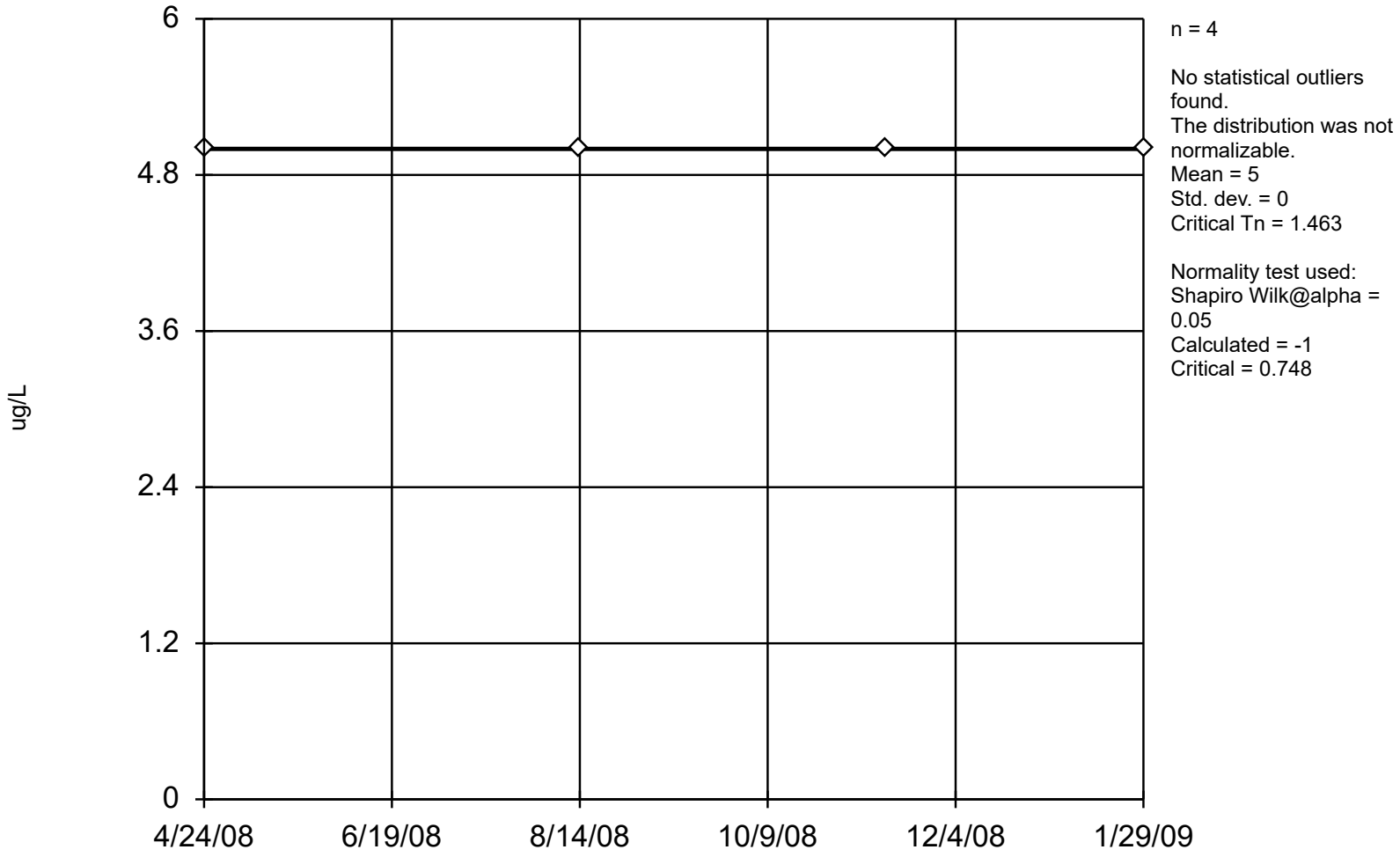
Outlier Analysis - Advanced Zion LF Expansion

Facility: Advanced Zion LF Expansion Client: Aptim Data File: 4Qs data upgradient wells ZION Printed 1/24/2024, 9:58 AM

Constituent	Well	Outlier	Value(s)	Date(s)	Method	Alpha	N	Mean	Std. Dev.	Distribution
Chromium, Dissolved (ug/L)	G131 (bg)	No	n/a	n/a	EPA 1989	0.05	4	5	0	unknown
Chromium, Dissolved (ug/L)	G132 (bg)	No	n/a	n/a	EPA 1989	0.05	4	5	0	unknown
Chromium, Dissolved (ug/L)	G185 (bg)	No	n/a	n/a	EPA 1989	0.05	4	5	0	unknown
Chromium, Dissolved (ug/L)	R133 (bg)	No	n/a	n/a	EPA 1989	0.05	4	5	0	unknown

EPA 1989 Outlier Test

G131 (bg)



n = 4

No statistical outliers found.
The distribution was not normalizable.
Mean = 5
Std. dev. = 0
Critical Tn = 1.463

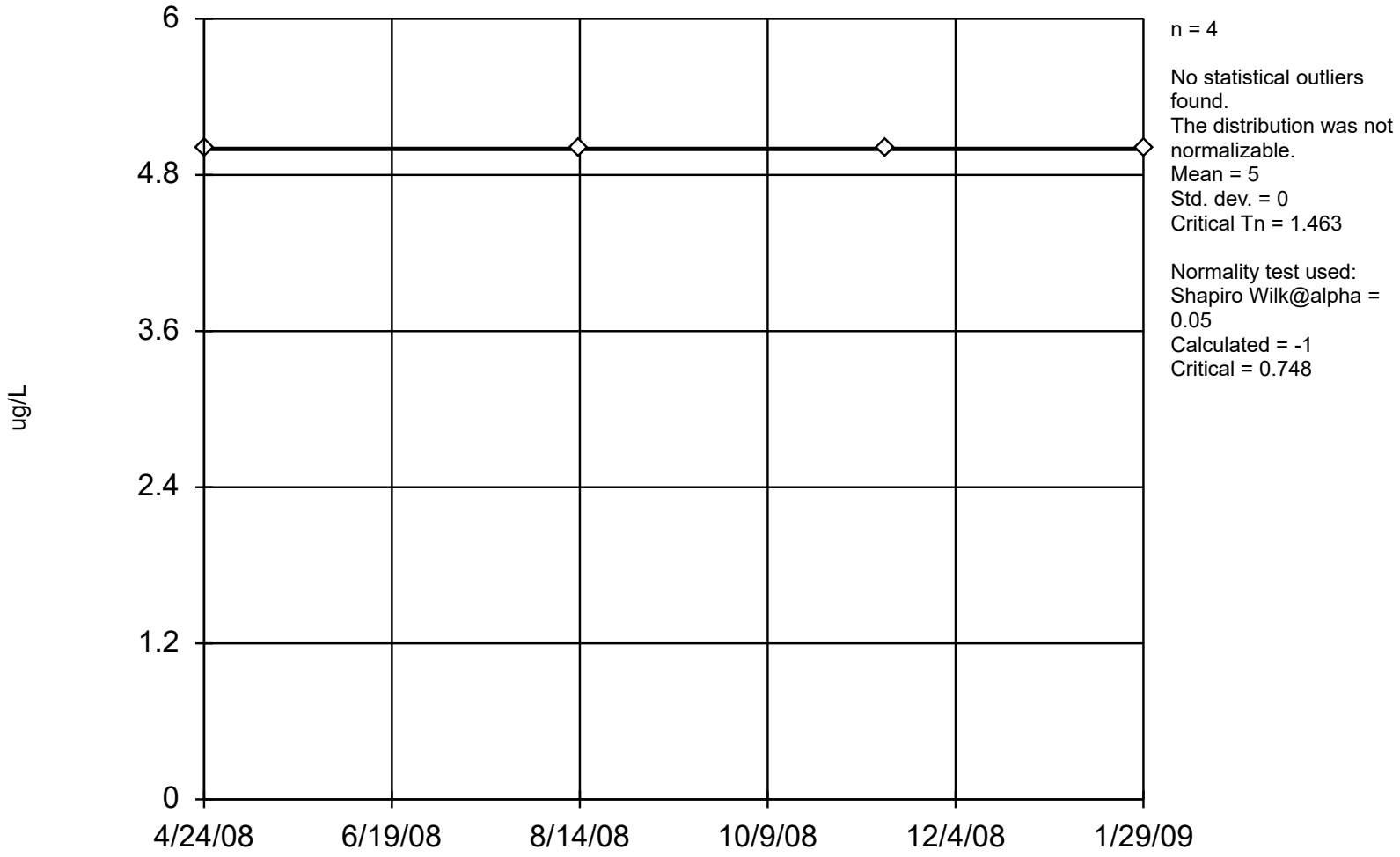
Normality test used:
Shapiro Wilk@alpha = 0.05
Calculated = -1
Critical = 0.748

Constituent: Chromium, Dissolved Analysis Run 1/24/2024 9:46 AM

Facility: Advanced Zion LF Expansion Client: Aptim Data File: 4Qs data upgradient wells ZION

EPA 1989 Outlier Test

G132 (bg)



n = 4

No statistical outliers found.
The distribution was not normalizable.
Mean = 5
Std. dev. = 0
Critical Tn = 1.463

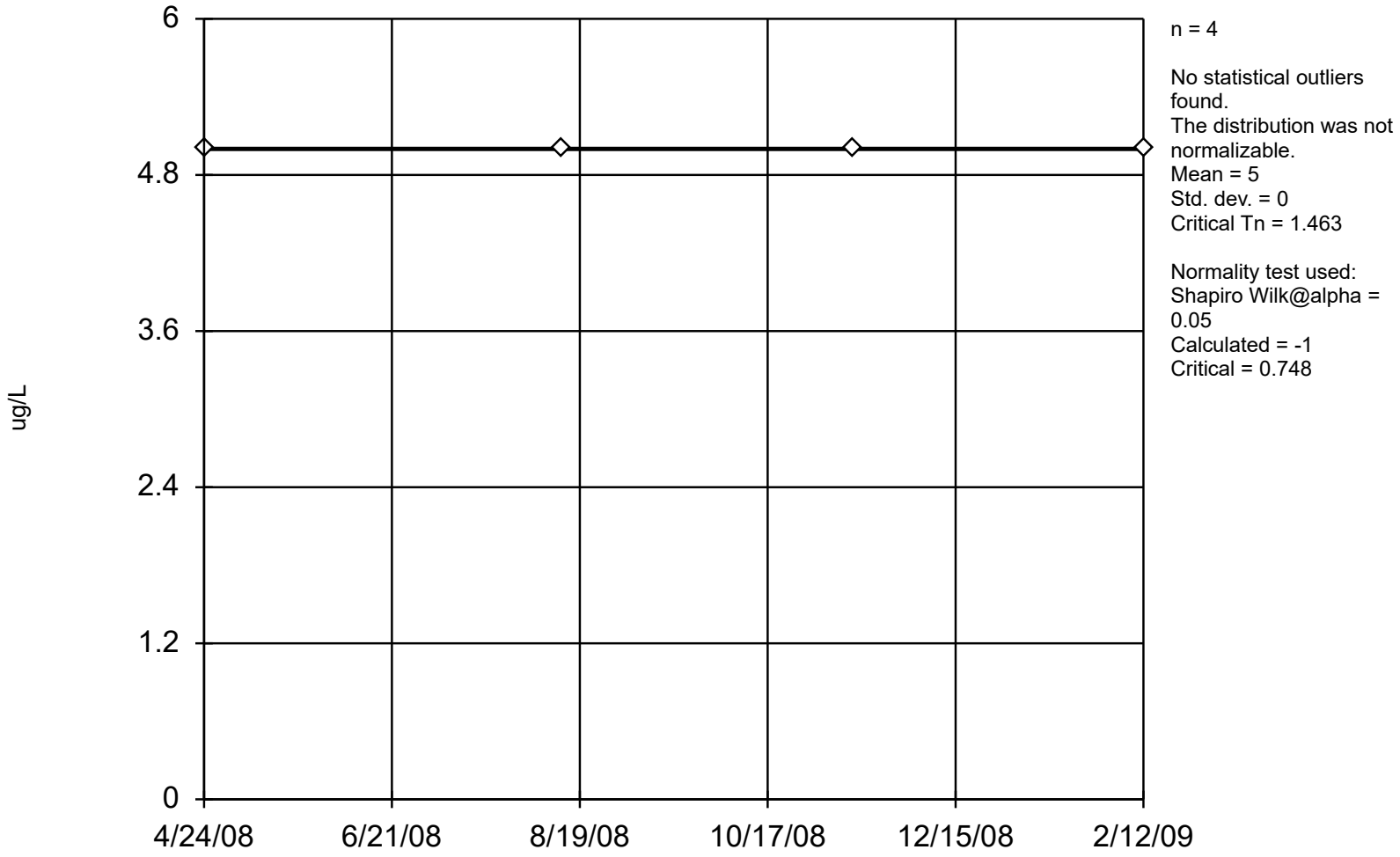
Normality test used:
Shapiro Wilk@alpha = 0.05
Calculated = -1
Critical = 0.748

Constituent: Chromium, Dissolved Analysis Run 1/24/2024 9:49 AM

Facility: Advanced Zion LF Expansion Client: Aptim Data File: 4Qs data upgradient wells ZION

EPA 1989 Outlier Test

G185 (bg)



n = 4

No statistical outliers found.
The distribution was not normalizable.
Mean = 5
Std. dev. = 0
Critical Tn = 1.463

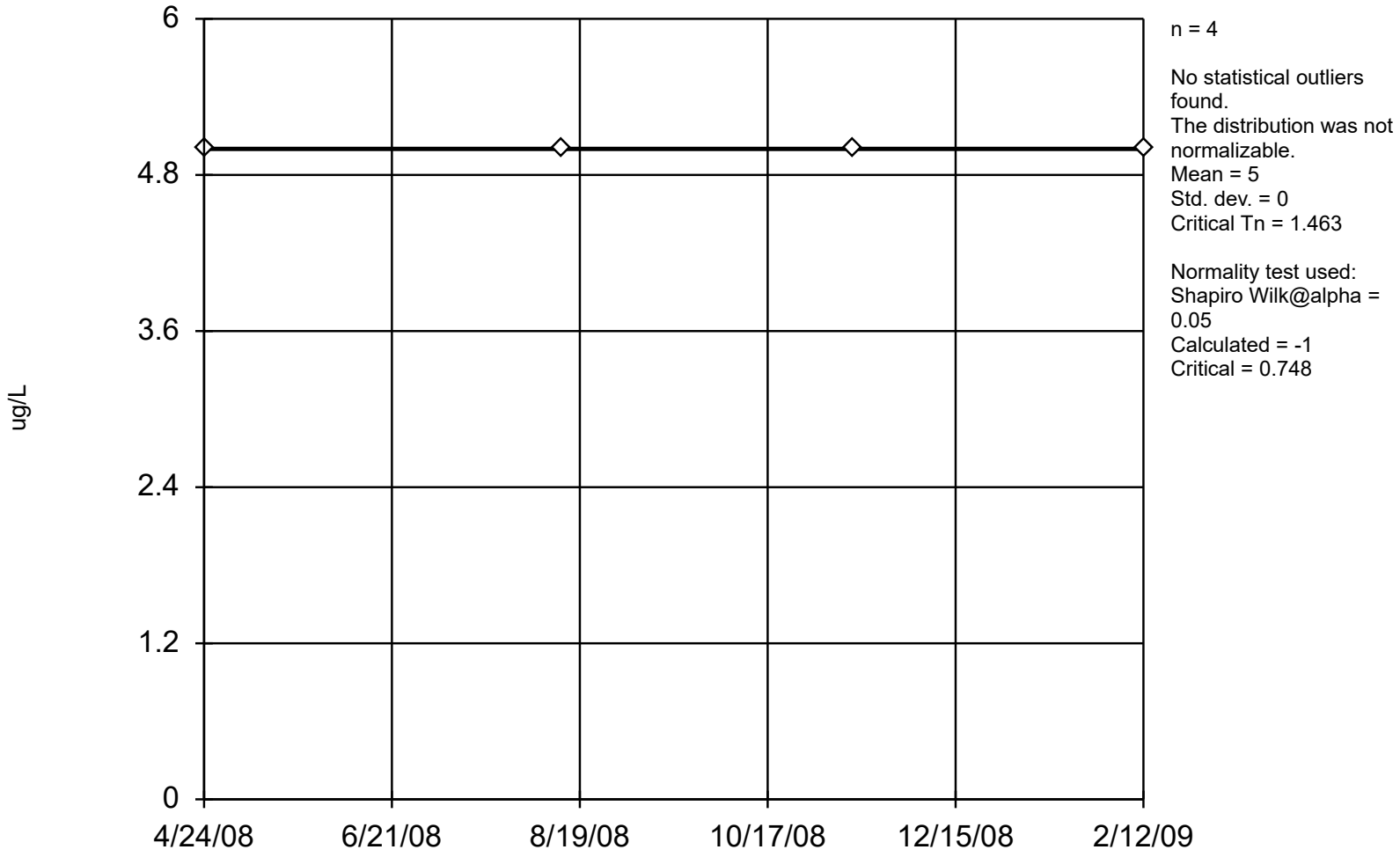
Normality test used:
Shapiro Wilk@alpha = 0.05
Calculated = -1
Critical = 0.748

Constituent: Chromium, Dissolved Analysis Run 1/24/2024 9:55 AM

Facility: Advanced Zion LF Expansion Client: Aptim Data File: 4Qs data upgradient wells ZION

EPA 1989 Outlier Test

R133 (bg)



n = 4

No statistical outliers found.
The distribution was not normalizable.
Mean = 5
Std. dev. = 0
Critical Tn = 1.463

Normality test used:
Shapiro Wilk@alpha = 0.05
Calculated = -1
Critical = 0.748

Constituent: Chromium, Dissolved Analysis Run 1/24/2024 9:56 AM

Facility: Advanced Zion LF Expansion Client: Aptim Data File: 4Qs data upgradient wells ZION

Shapiro-Wilk Normality Test

Constituent: Chromium, Dissolved Analysis Run 1/24/2024 9:58 AM

Facility: Advanced Zion LF Expansion Client: Aptim Data File: 4Qs data upgradient wells ZION

Well	Transformation	Calculated	Critical	Normal
G131 (bg) (n = 4, alpha = 0.01)				
	no	-1	0.687	No
	square root	-1	0.687	No
	square	-1	0.687	No
	cube root	-1	0.687	No
	cube	-1	0.687	No
	natural log	-1	0.687	No
	x^4	-1	0.687	No
	x^5	-1	0.687	No
	x^6	-1	0.687	No
G132 (bg) (n = 4, alpha = 0.01)				
	no	-1	0.687	No
	square root	-1	0.687	No
	square	-1	0.687	No
	cube root	-1	0.687	No
	cube	-1	0.687	No
	natural log	-1	0.687	No
	x^4	-1	0.687	No
	x^5	-1	0.687	No
	x^6	-1	0.687	No
G185 (bg) (n = 4, alpha = 0.01)				
	no	-1	0.687	No
	square root	-1	0.687	No
	square	-1	0.687	No
	cube root	-1	0.687	No
	cube	-1	0.687	No
	natural log	-1	0.687	No
	x^4	-1	0.687	No
	x^5	-1	0.687	No
	x^6	-1	0.687	No
R133 (bg) (n = 4, alpha = 0.01)				
	no	-1	0.687	No
	square root	-1	0.687	No
	square	-1	0.687	No
	cube root	-1	0.687	No
	cube	-1	0.687	No
	natural log	-1	0.687	No
	x^4	-1	0.687	No
	x^5	-1	0.687	No
	x^6	-1	0.687	No
Pooled Background (bg) (n = 16, alpha = 0.01)				
	no	-1	0.844	No
	square root	-1	0.844	No
	square	-1	0.844	No
	cube root	0	0.844	No
	cube	-1	0.844	No
	natural log	0	0.844	No
	x^4	-1	0.844	No
	x^5	-1	0.844	No
	x^6	-1	0.844	No

Prediction Limit

Interwell Non-parametric

Non-parametric test used in lieu of parametric prediction limit because censored data exceeded 50%. All background values were censored; limit is most recent reporting limit. Report alpha = 0.05882. Assumes 1 future value. Insufficient data to test for seasonality; data will not be deseasonalized.

Constituent: Chromium, Dissolved Analysis Run 1/24/2024 10:01 AM

Facility: Advanced Zion LF Expansion Client: Aptim Data File: 4Qs data upgradient wells ZION

Advanced Zion LF Expansion - Chromium, Diss. Interwell Perdiction Limit

Facility: Advanced Zion LF Expansion Client: Aptim Data File: 4Qs data upgradient wells ZION Printed 1/24/2024, 10:04 AM

Constituent	Well	Upper Lim.	Date	Observ.	Sig.	Bg N	%NDs	Transform	Alpha	Method
Chromium, Dissolved (ug/L)	n/a	10	n/a	1 future	n/a	16	100	n/a	0.05882	NP Inter (NDs)

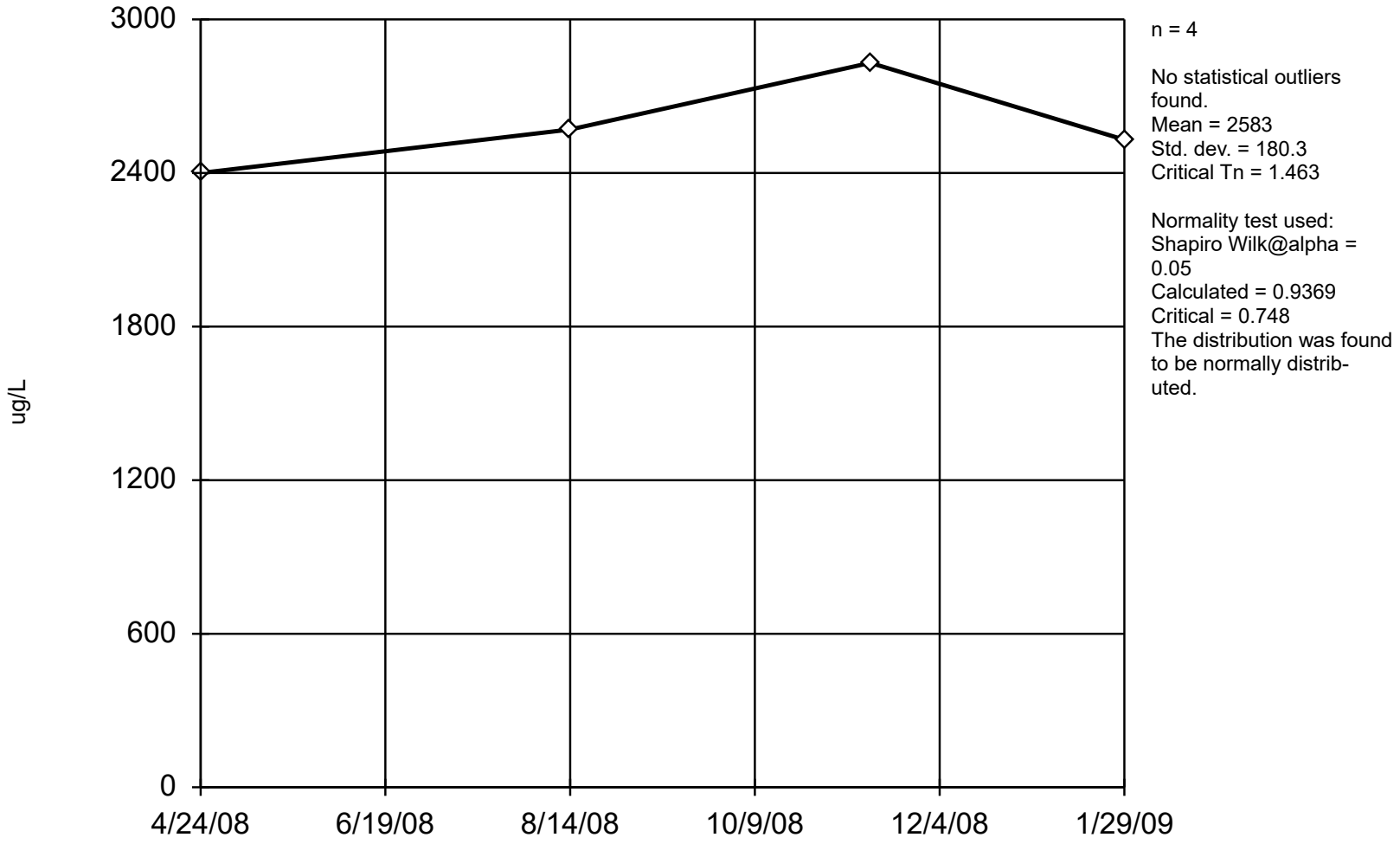
Outlier Analysis - Advanced Zion LF Expansion

Facility: Advanced Zion LF Expansion Client: Aptim Data File: 4Qs data upgradient wells ZION Printed 1/24/2024, 10:13 AM

Constituent	Well	Outlier	Value(s)	Date(s)	Method	Alpha	N	Mean	Std. Dev.	Distribution
Magnesium, Dissolved (ug/L)	G131 (bg)	No	n/a	n/a	EPA 1989	0.05	4	2583	180.3	normal
Magnesium, Dissolved (ug/L)	G132 (bg)	No	n/a	n/a	EPA 1989	0.05	4	2935	104.7	normal
Magnesium, Dissolved (ug/L)	G185 (bg)	No	n/a	n/a	EPA 1989	0.05	4	7895	764.8	normal
Magnesium, Dissolved (ug/L)	R133 (bg)	No	n/a	n/a	EPA 1989	0.05	4	3245	137.7	normal

EPA 1989 Outlier Test

G131 (bg)



n = 4

No statistical outliers found.
Mean = 2583
Std. dev. = 180.3
Critical Tn = 1.463

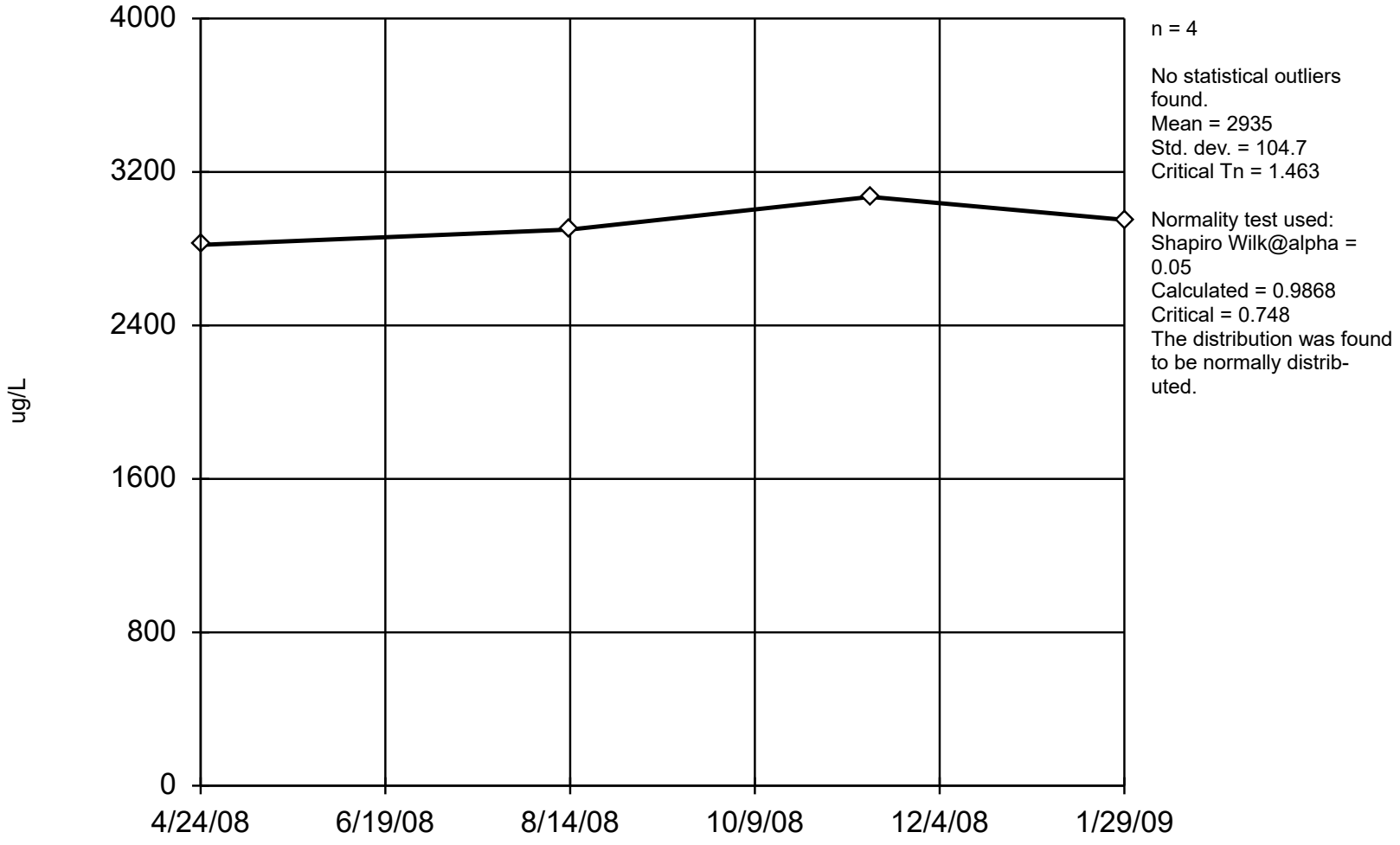
Normality test used:
Shapiro Wilk@alpha = 0.05
Calculated = 0.9369
Critical = 0.748
The distribution was found to be normally distrib-uted.

Constituent: Magnesium, Dissolved Analysis Run 1/24/2024 10:09 AM

Facility: Advanced Zion LF Expansion Client: Aptim Data File: 4Qs data upgradient wells ZION

EPA 1989 Outlier Test

G132 (bg)



n = 4

No statistical outliers found.
Mean = 2935
Std. dev. = 104.7
Critical Tn = 1.463

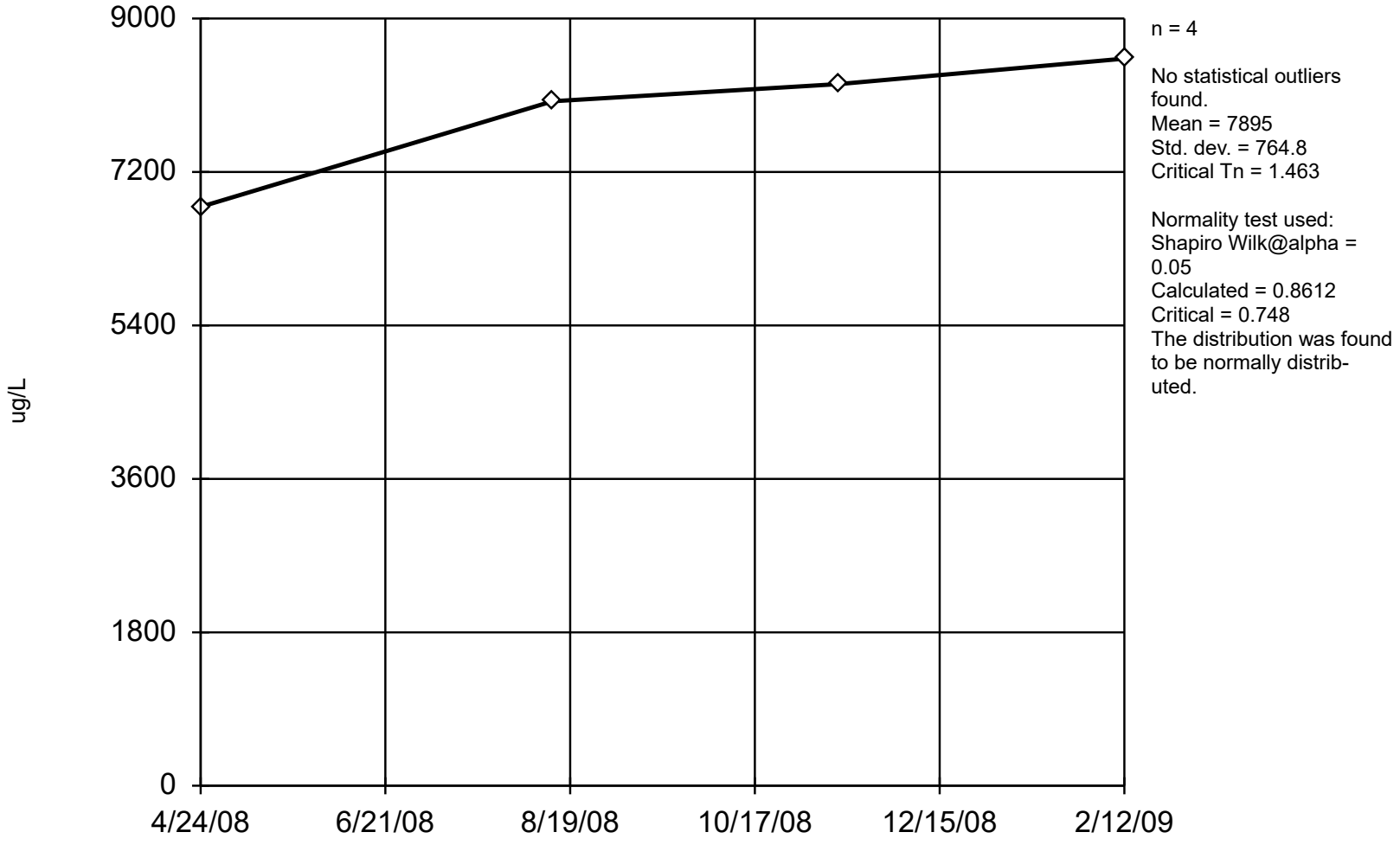
Normality test used:
Shapiro Wilk@alpha = 0.05
Calculated = 0.9868
Critical = 0.748
The distribution was found to be normally distrib-uted.

Constituent: Magnesium, Dissolved Analysis Run 1/24/2024 10:10 AM

Facility: Advanced Zion LF Expansion Client: Aptim Data File: 4Qs data upgradient wells ZION

EPA 1989 Outlier Test

G185 (bg)



n = 4

No statistical outliers found.
Mean = 7895
Std. dev. = 764.8
Critical Tn = 1.463

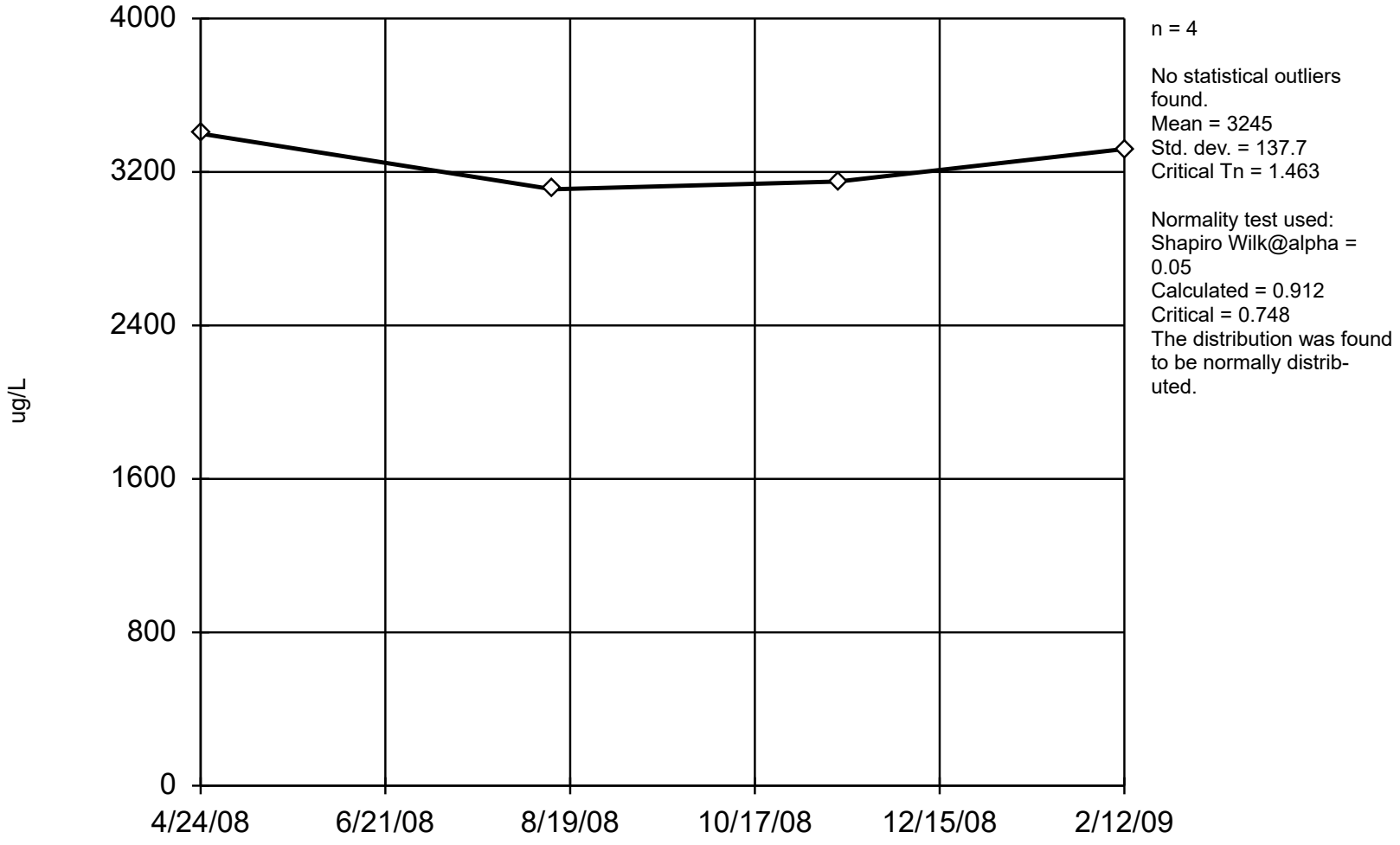
Normality test used:
Shapiro Wilk@alpha = 0.05
Calculated = 0.8612
Critical = 0.748
The distribution was found to be normally distrib-uted.

Constituent: Magnesium, Dissolved Analysis Run 1/24/2024 10:11 AM

Facility: Advanced Zion LF Expansion Client: Aptim Data File: 4Qs data upgradient wells ZION

EPA 1989 Outlier Test

R133 (bg)



n = 4

No statistical outliers found.
Mean = 3245
Std. dev. = 137.7
Critical Tn = 1.463

Normality test used:
Shapiro Wilk@alpha = 0.05
Calculated = 0.912
Critical = 0.748
The distribution was found to be normally distrib-uted.

Constituent: Magnesium, Dissolved Analysis Run 1/24/2024 10:12 AM

Facility: Advanced Zion LF Expansion Client: Aptim Data File: 4Qs data upgradient wells ZION

Shapiro-Wilk Normality Test

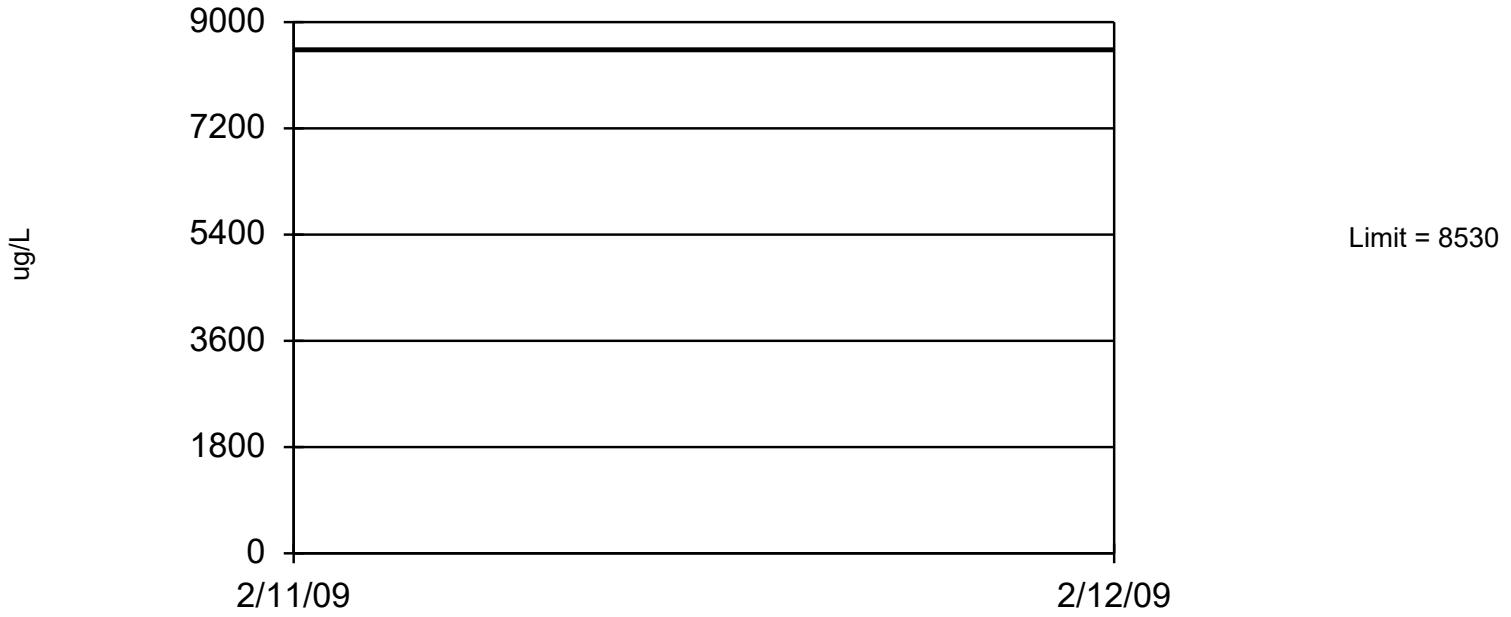
Constituent: Magnesium, Dissolved Analysis Run 1/24/2024 10:15 AM

Facility: Advanced Zion LF Expansion Client: Aptim Data File: 4Qs data upgradient wells ZION

Well	Transformation	Calculated	Critical	Normal
G131 (bg) (n = 4, alpha = 0.01)				
	no	0.9369	0.687	Yes
	square root	0.9421	0.687	Yes
	square	0.9258	0.687	Yes
	cube root	0.9438	0.687	Yes
	cube	0.914	0.687	Yes
	natural log	0.9471	0.687	Yes
	x^4	0.9017	0.687	Yes
	x^5	0.8889	0.687	Yes
	x^6	0.8759	0.687	Yes
G132 (bg) (n = 4, alpha = 0.01)				
	no	0.9868	0.687	Yes
	square root	0.9883	0.687	Yes
	square	0.9836	0.687	Yes
	cube root	0.9888	0.687	Yes
	cube	0.98	0.687	Yes
	natural log	0.9897	0.687	Yes
	x^4	0.976	0.687	Yes
	x^5	0.9718	0.687	Yes
	x^6	0.9673	0.687	Yes
G185 (bg) (n = 4, alpha = 0.01)				
	no	0.8612	0.687	Yes
	square root	0.8525	0.687	Yes
	square	0.8784	0.687	Yes
	cube root	0.8497	0.687	Yes
	cube	0.8952	0.687	Yes
	natural log	0.8439	0.687	Yes
	x^4	0.9115	0.687	Yes
	x^5	0.9269	0.687	Yes
	x^6	0.9412	0.687	Yes
R133 (bg) (n = 4, alpha = 0.01)				
	no	0.912	0.687	Yes
	square root	0.9119	0.687	Yes
	square	0.912	0.687	Yes
	cube root	0.9119	0.687	Yes
	cube	0.912	0.687	Yes
	natural log	0.9119	0.687	Yes
	x^4	0.9119	0.687	Yes
	x^5	0.9118	0.687	Yes
	x^6	0.9116	0.687	Yes
Pooled Background (bg) (n = 16, alpha = 0.01)				
	no	0.6838	0.844	No
	square root	0.7133	0.844	No
	square	0.6401	0.844	No
	cube root	0.7243	0.844	No
	cube	0.6134	0.844	No
	natural log	0.7476	0.844	No
	x^4	0.5971	0.844	No
	x^5	0.5859	0.844	No
	x^6	0.5772	0.844	No

Prediction Limit

Interwell Non-parametric



Non-parametric test used in lieu of parametric prediction limit because the Shapiro Wilk normality test showed the data to be non-normal at the 0.05 alpha level. Limit is highest of 16 background values. Report alpha = 0.05882. Assumes 1 future value. Insufficient data to test for seasonality; data will not be deseasonalized.

Constituent: Magnesium, Dissolved Analysis Run 1/24/2024 10:16 AM

Facility: Advanced Zion LF Expansion Client: Aptim Data File: 4Qs data upgradient wells ZION

Advanced Zion LF Expansion - Magnesium, Diss. Interwell Perdiction Limit

Facility: Advanced Zion LF Expansion Client: Aptim Data File: 4Qs data upgradient wells ZION Printed 1/24/2024, 10:18 AM

Constituent	Well	Upper Lim.	Date	Observ.	Sig.	Bg N	%NDs	Transform	Alpha	Method
Magnesium, Dissolved (ug/L)	n/a	8530	n/a	1 future	n/a	16	0	n/a	0.05882	NP Inter (normality)

ATTACHMENT 4
Laboratory Quality Control Manual

APTIM

Brian Basten Approved on 8/4/2022 10:49:59 AM
Christopher Haase Approved on 8/4/2022 10:56:49 AM
Donavon Sieloff Approved on 8/8/2022 9:53:58 AM
Ryan Grubofski Approved on 8/5/2022 10:48:39 AM
Scott Turner Approved on 8/12/2022 10:20:52 AM
Anthony Haag Approved on 8/12/2022 3:35:16 PM
Paul Junio Approved on 8/15/2022 12:20:07 PM
Chad Rusch Approved on 8/16/2022 1:48:44 PM
Luke Falken Approved on 8/25/2022 1:35:41 PM

Title Page

Quality Manual
Pace Analytical Services, LLC

Prepared for:

Pace® Analytical Services, LLC
1241 Bellevue Street, Suite 9
Green Bay, WI 54302
Phone: 920-469-2436

Pace® Analytical Services, LLC
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Parent Company: Pace® Analytical Services, LLC

Pace® Analytical Services, LLC
6409 Odana Road, Suite 3-E
Madison, WI 53719
Phone: 608-232-3300
Owner: Specified Testing Laboratories, LLC
Parent Company: Pace® Analytical Services, LLC

Signatory Attestation: I attest the application of my electronic signature on this title page affirms my management commitment and responsibility to uphold the requirements of the PAS Quality Management System (QMS) described in this Quality Manual (manual) at each location for which this manual is prepared.

Refer to the Quality Manual Signatory Page to view the job title and physical address for each signatory.

Quality Manual Approval Signatories

The following individuals represent the PAS corporate and local management team responsible for implementing the PAS Quality Management System (QMS) and upholding the requirements of this manual at the location(s) for which this manual was prepared, at the time this version of the manual was made effective, and that correlate with the electronic signatures shown on the title page of this manual.

If these persons(s) change positions, leave the company, or are on extended leave of absence, the approval of this manual automatically transfers to the person replacing the signatory or to the signatory's primary or alternate deputy until the manager is replaced and/or the manager returns to work. The individual replacing the signatory automatically accepts the responsibilities associated with the original signatory's attestation. Refer to Section 4.1.5.1.1 of this manual for the deputies assigned to key personnel job titles.

The manual is not revised and released under an updated version for the sole purpose of updating personnel change(s). Personnel information is updated when the next revision of the manual is released. See manual Sections 1.2.1 and 1.2.2 for more information about how this manual is maintained.

Name	Job Title	Address, City, State, ZIP	Phone
Luke Falken	Vice President of Operations	1800 Elm Street SE Minneapolis, MN 55414	218-213-8642
Chad Rusch	General Manager	1241 Bellevue Street, Suite 9 Green Bay, WI 54302	920-321-9438
Paul Junio	Quality Program Manager	1241 Bellevue Street, Suite 9 Green Bay, WI 54302	262-433-0572
Anthony Haag	Quality Manager	1241 Bellevue Street, Suite 9 Green Bay, WI 54302	920-321-9426
Jill Duranceau	Safety Officer	1241 Bellevue Street, Suite 9 Green Bay, WI 54302	920-321-9441
Brian Basten	Manager – Client Services	1241 Bellevue Street, Suite 9 Green Bay, WI 54302	920-321-9411
Christopher Haase	Manager – Semi-Volatiles	1241 Bellevue Street, Suite 9 Green Bay, WI 54302	920-321-9453
Donavon Sieloff	Manager – Inorganics	1241 Bellevue Street, Suite 9 Green Bay, WI 54302	920-321-9459
Scott Turner	Manager – Volatiles	1241 Bellevue Street, Suite 9 Green Bay, WI 54302	920-321-9425

TABLE OF CONTENTS

1.0 PURPOSE AND SCOPE

1.1 Purpose

This quality manual (manual) outlines the quality management system (QMS) and management structure of Pace® Analytical Services, LLC. Pace® Analytical Services, LLC is referred to by brand name Pace® Analytical Services and by the acronyms PAS or ENV. The acronyms PAS and ENV are interchangeable.

The PAS QMS is also referred to as the quality program throughout this manual and other PAS documents. The phrases "quality management system" and "quality program" are synonymous and are referred to by the acronym QMS.

The QMS is the collection of policies and processes established by the senior leaders of PAS (top management) to ensure the service and products provided by PAS consistently meet relevant requirements and achieves the goal of Pace® to provide customers with high quality, cost-effective, analytical measurements, and services.

The QMS is also planned to establish conformance[1] and compliance with the current published versions of the following international and national quality system standards:

- ISO/IEC 17025: *General requirements for the competence of testing and calibration laboratories*
- NELAC/TNI Standard Volume 1: *Management and Technical Requirements for Laboratories Performing Environmental Analysis*

[1]The statement of conformity to these Standards pertains only to testing and sampling activities carried out by the laboratory at its physical address, in temporary or mobile facilities, in-network, or by laboratory personnel at a customer's facility.

In addition to the international and national standards, the QMS is planned to achieve regulatory compliance with the various federal and state programs for which PAS locations provide compliance testing and/or holds certification or accreditation. Federal or state requirements that do not apply to all PAS locations, are provided in addendum to this manual or in other documents that supplement the manual. Customer-specific project and program requirements are not included in the manual in order to maintain client confidentiality.

- A list of accreditation and certifications held by each location associated with this manual is provided in Appendix A.
- A list of analytical testing capabilities offered by each location associated with this manual is provided in Appendix B.

1.2 Scope and Application

This manual applies to each location listed on the Title Page of this manual, including PAS laboratories, satellite laboratories, service centers, and supporting business functions.

For purposes of the PAS QMS:

- The term "location" used in this manual refers to laboratories and/or service centers.
- The term "laboratory" refers to any PAS location, however named by Pace® that provides testing, collects samples (sampling), or conducts field measurement services in a fixed building, mobile unit, or in-situ (field).

- The phrase "service center" refers to any PAS location, however named by Pace® that does not perform any testing, sampling, or field measurements.
- The phrase "satellite laboratory" refers to a limited-service laboratory affiliated to a larger business unit or location. Some PAS business groups, such as accounting, may refer to a satellite laboratory as a "service center." Irrespective of internal jargon or reference by any group, any PAS location that generates a test result for external use is a "laboratory" and must comply with the requirements specified in this manual for all analytical testing services.

PAS locations are defined by physical address. Laboratories are defined by physical address and certification/accreditation ID except mobile units which may be defined by the address of the location to which they are assigned, by VIN (vehicle identification number), or by certification/accreditation ID. Laboratories that provide sampling and field testing are defined by the physical address of the PAS location to which they are affiliated and that manages these activities.

1.2.1 Quality Manual Template

This manual was prepared using the PAS Quality Manual Template (template) created by the PAS Corporate Quality Director (CQD).

The template, known as document ID ENV-TMP-CORQ-0007, specifies the minimum requirements that every PAS location must abide by, regardless of scope of services or number of personnel, to maintain a quality program that achieves the objectives of the PAS Quality Policy (See Section 4.2.2).

The template is the mechanism used by top management to communicate to PAS personnel their commitment to continuously develop and improve the QMS for effectiveness, to meet customer expectations, and to comply with any statutory and regulatory requirements. Their signature of approval on this template is the mechanism used to document this responsibility.

"Top Management" is the phrase used by the TNI Standard to refer to the leaders of an organization that develop and/or release the PAS Quality Policy Statement and QMS under their authority

For PAS, these managers include the Chief Executive Officer (CEO) and Chief Compliance Officer (CCO) of Pace® and the President, CQD, Senior Vice President of Operations (Sr. VPO), and the Chief Technical Officer (CTO) of PAS.

The template and instructions for use of the template are released by corporate quality personnel to local quality managers responsible for each location (Local QM). The local QM uses the template to prepare the location manual by following the instructions provided to them. The local QM may not alter the font, structure, or content of the template, except where specified by instruction to do so. As previously stated, program specific requirements unique to each location are provided in addendum or in documents that supplement the manual.

The template is reviewed by corporate quality personnel annually and updated, if needed. More frequent review and revision may occur to manage change, to maintain conformance and compliance to relevant standards or to improve the QMS.

See standard operating procedure (SOP) ENV-SOP-CORQ-00015 *Document Management and Control* for more information

1.2.2 Quality Manual

The quality manual is created from template ENV-TMP-CORQ-0007 by local quality personnel, who are also responsible for maintenance and management of the document.

- PAS locations are not permitted to alter content of the template when preparing their manual, except where specified in the template. Control of content in the manual is necessary to ensure consistency of implementation of the PAS quality program across the network.
- If additions or changes to the manual are needed to maintain regulatory compliance or conformance to relevant standards and these changes cannot be covered by addendum to the manual, the need for change must be raised to the PAS Corporate Quality Director, who will decide how to resolve the need.

The manual is approved for release by the management team listed on the Quality Manual Approval Signatory Page. The manager's electronic signature on the Title Page of the manual affirms their commitment to implement and uphold the requirements, processes, and procedures of the PAS QMS at each location for which the manual was prepared.

The manual is reviewed annually and updated with each release of a new version of the template, and as needed to update appendices and addendum. More frequent review and revision may be necessary when there are significant changes to the capabilities, and resources of the laboratory during the calendar year

See SOP ENV-SOP-CORQ-00015 *Document Management and Control* for more information.

1.2.3 References to Supporting Documents

The template and the manual include references to other organization documents that support the QMS such as policies and standard operating procedures (SOPs).

These references may include the document's document control number (DC#) and the document title. This information is subject to change at the discretion of PAS. The manual and/or template are updated to reflect the editorial change during the manual's next scheduled review/revision cycle or the next time a version of the manual is released, whichever is sooner.

Each location maintains a current list of documents used by the location to support the QMS. This list, known as the "Master List", is readily available to personnel for their use and it provides a cross reference to the legacy document ID, where applicable. Parties external to PAS may contact the location of interest to obtain the most current version of the Master List for their use as needed.

2.0 REFERENCES

References used to prepare this manual include:

- "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act." Federal Register, 40 CFR Part 136, most current version.
- "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods." SW-846.
- "Methods for Chemical Analysis of Water and Wastes," EPA 600-4-79-020, 1979 Revised 1983, U.S. EPA.

- U.S. EPA Contract Laboratory Program Statement of Work for Organic Analysis, current version.
- U.S. EPA Contract Laboratory Program Statement of Work for Inorganic Analysis, current version.
- "Standard Methods for the Examination of Water and Wastewater." Current Edition APHA-AWWA-WPCF.
- "Annual Book of ASTM Standards," Section 4: Construction, Volume 04.04: Soil and Rock; Building Stones, American Society of Testing and Materials.
- "Annual Book of ASTM Standards," Section 11: Water and Environmental Technology, American Society of Testing and Materials.
- "NIOSH Manual of Analytical Methods," U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health, most current version.
- "Methods for the Determination of Organic Compounds in Finished Drinking Water and Raw Source Water," U.S. EPA, Environmental Monitoring and Support Laboratory – Cincinnati (Sep 1986).
- Quality Assurance of Chemical Measurements, Taylor, John K.; Lewis Publishers, Inc. 1987.
- Methods for Non-conventional Pesticides Chemicals Analysis of Industrial and Municipal Wastewater, Test Methods, EPA-440/1-83/079C.
- Environmental Measurements Laboratory (EML) Procedures Manual, HASL-300, US DOE, February 1992.
- Requirements for Quality Control of Analytical Data, HAZWRAP, DOE/HWP-65/R1, July 1990.
- Quality Assurance Manual for Industrial Hygiene Chemistry, AIHA, most current version.
- National Environmental Laboratory Accreditation Conference (NELAC) Standard- most current version.
- ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories, 2nd Edition 2005-05-15; 3rd Edition 2017-11

  The following are implemented by normative reference to ISO/IEC 17025:

  - ISO/IEC Guide 99, *International vocabulary of metrology –Basic and general concepts and associated terms*
  - ISO/IEC 17000, *Conformity assessment – Vocabulary and general principles*
- Department of Defense Quality Systems Manual (QSM), most current version.
- TNI (The NELAC Institute) Standard, 2009 and 2016 versions.
- UCMR Laboratory Approval Requirements and Information Document, most current version.
- US EPA Drinking Water Manual, most current version.

3.0 TERMS AND DEFINITIONS

Refer to Appendix C for terms, acronyms, and definitions used in this manual and in other documents used by PAS to support the QMS.

4.0 MANAGEMENT REQUIREMENTS

4.1 Organization

4.1.1 Legal Identity

Pace® Analytical Services, LLC (Pace® Analytical Services) is the responsible entity authorized by the State of Minnesota to do business as a limited liability company, under the parent company, PAS Parent, Inc.

4.1.1.1 Change of Ownership

If there is a change of ownership, if a location goes out of business, or if the entire organization ceases to exist, PAS management is responsible to notify regulatory authorities of the change within the timeframe required by each state agency for which the location is certified or accredited.

Requirements for records and other business information are addressed in the ownership transfer agreement or in accordance with appropriate regulatory requirements, whichever takes precedence.

4.1.2 Compliance Responsibility

PAS management has the responsibility and authority to establish and implement procedures and to maintain resources necessary to assure its activities are carried out in such a way to meet the federal and statutory requirements in addition to the requirements of the PAS QMS. Also See Section 1.1.

4.1.3 Scope of the Quality Management System

The QMS applies to work carried out at each location covered by this manual including permanent facilities, at sites away from its permanent facilities, or in associated temporary or mobile facilities.

The permanent and mobile facilities to which this manual applies are listed on the Title Page of this manual.

4.1.4 Organization History and Information

Founded in 1978, Pace® Analytical Services, LLC (PAS) is a privately held scientific services firm operating one of the largest full-service contract laboratory and service center networks in the United States.

The business purpose of PAS is to deliver the highest standard of testing and scientific services in the market. We offer the most advanced solutions in the industry, backed by transparent data, a highly trained team, and the service and support that comes from over four decades of experience.

4.1.4.1 Organization Structure

Each PAS location is led by a management team referred to as local management[1]. Local management is responsible for making day-to-day decisions regarding the operations of the facility and implementing, and sustaining the requirements, policies, and procedures of the PAS quality program.

The roles that make up the local management team include a Vice President of Operations (VPO), a General Manager (GM) or Director of Laboratory Operations (DLO), a Quality Program Manager (QPM), and the Quality Manager (QM).

[1] The term "local management" does not mean "on-site" management. Some of the roles that make up the local management team, work off site or from a different PAS location. Refer to the Quality Manual Approval page at the beginning of this manual for the physical address of each manager that comprises the local management team.

The local management team is supported by department specific supervisors and in some PAS locations, a site supervisor or operations manager.

Local management and supervisors are supported by personnel from functional groups that support the division, such as HR, IT, Sales & Marketing, Finance, and EHS (Environmental Health & Safety).

Technical oversight for each location is provided by local personnel with support and guidance from the PAS Chief Technical Officer (CTO), PAS corporate quality personnel, and the Pace® compliance team. Locations that hold TNI accreditation, also have personnel appointed to serve as the "acting technical manager for TNI, however named" to perform the duties and responsibilities of this designation per the TNI Standard. See Section 4.1.5.2.1 for more information on this TNI requirement.

The reporting relationships and responsibilities of quality personnel are independent of operations in order to safeguard impartiality. See Section 4.1.5.2 for more information.

Refer to the organization charts provided in Appendix D to view the organization structure, reporting relationships, and the interrelationships between positions.

4.1.5 Management Requirements

4.1.5.1 Personnel

Each PAS location is staffed with administrative and/or technical personnel who perform and verify work under the supervision of their direct line supervisor.

All personnel are expected to perform their duties in accordance with the policies and processes outlined in this manual and in accordance with standard operating procedures (SOPs) and other quality system documents. PAS policies and procedures are designed for impartiality and integrity. When these procedures are fully implemented, personnel remain free from undue pressure and other influences that adversely impact the quality of their work or data.

4.1.5.1.1 Key Personnel

Key personnel are management positions that have the authority and responsibility to plan, direct, and control activities related to the QMS for the entire division (PAS Corporate), or for one or more PAS locations (Local).

PAS Key Personnel Positions & Deputy Assignments by Role

Job Title	Acronym	Primary / Alternate Deputy
Chief Executive Officer	CEO	President
Chief Compliance Officer	CCO	CQD
President	NA	CEO / Sr. VPO
Corporate Quality Director	CQD	CCO
Quality Program Manager	QPM	CQD / Peer QPM
Chief Technical Officer	CTO	CQD / CCO
Sr. VP of Operations	Sr. VPO	President / VPO
Vice President of Operations	VPO	Sr. VPO / Peer VPO
Director of Lab Operations[1]	DLO	VPO / Peer GM or Sr. VPO
Health and Safety Director	NA	CCO
IT Director	NA	CTO
Quality Manager	QM	Direct QPM / Peer QPM
General Manager[1]	GM	VPO / Sr. VPO or Peer GM
Operations Manager[1]	OM	GM / DL or VPO
Technical Manager[1]	TM	CTO / Peer TM
TNI Approved TM[2]	TNI TM	Another Qualified Employee

[1]: Position is not in place at all locations.
[2]: The TNI TM is not a PAS position. See Section 4.1.5.2.1 for more information.

Some certification and accreditation programs require notification when there is a change in key personnel. Notification requirements and timeframes by agency, are tracked and upheld by the local QM, when these requirements apply.

4.1.5.2 Roles and Responsibilities

The qualifications, duties, and responsibilities for each position at Pace® are detailed in job descriptions maintained by the Pace® Human Resource personnel (HR).

The following sections provide a general overview of various management and supervisory roles and are presented in no particular order.

Chief Executive Officer (CEO): Provides leadership for overall operations; oversight of regulatory and compliance standards; development of growth strategies; and long-range capital and strategic planning for Pace®.

Chief Compliance Officer (CCO): Has overall responsibility for statutory and regulatory compliance and the environmental health and safety programs (EHS) for Pace®.

President: Provides leadership for overall operations; oversight of regulatory and compliance standards; development of growth strategies; and long-range capital and strategic planning for PAS.

Chief Technical Officer (CTO): Provides technical oversight and leadership to all PAS locations. Responsible for innovation and standardization of technical activities.

Corporate Director of Quality (CQD): Responsible for developing the PAS quality program and the policies and procedures that support the QMS. The CQD leads the

quality team, establishing functions, responsibilities, duties, and organization structure for PAS.

Corporate Quality Program Manager (QPM): Responsible for helping local management implement, monitor, maintain and improve the PAS quality program for one or more locations in the network and for direct supervision of Quality Manager(s).

Director of Information Technology: Oversees and delivers the systems and processes of information technology used by PAS. These systems include Laboratory Information Management Systems (LIMS); data acquisition, reduction, and reporting software; virus-protection, communication tools, and ensuring the integrity, security of electronic data, and associated policies and procedures.

Sr. Vice President of Operations (Sr VPO): Provides leadership, direction, and insight necessary to achieve strategic initiatives. Develops and improves processes, structure, and allocation of resources for operations for all of PAS.

Vice-President of Operations (VPO): Provides leadership, guidance, and resources, including allocation of personnel, necessary to achieve the strategic goals of the organization and the PAS quality program to one or more PAS locations.

Director of Laboratory Operations (DLO): See description for General Manager.

General Manager (GM): The GM is responsible for overall administration and operation of one or more PAS locations and service centers. Although task duties associated with this responsibility may be delegated, the GM is responsible for ensuring all duties and activities of the locations they oversee comply with the PAS QMS, the PAS EHS program, and with any applicable statutory, regulatory requirements or program requirements.

Any GM of a NELAC/TNI Accredited laboratory is also responsible for the designation of technical personnel to serve as acting technical managers for TNI for the fields of accreditation held by the laboratory (See Section 4.1.5.2.1) and for notifying the accreditation body (AB) of any extended absence or reassignment of these designations.

Quality Manager (QM): The QM oversees and monitors the implementation, compliance, and improvement of the QMS and communicates gaps, deviations, and opportunities for improvement to local and corporate laboratory management. The QM is independent of the operation and analytical activities for which they provide oversight and has the authority to carry out the roles and responsibilities of their position without outside influence.

The QM:

- serves as the focal point for QA/QC protocol decisions and oversees review of QC data for trend analysis;
- evaluates data objectively and performs assessments without outside influence;

- has documented training and experience in QA/QC procedures and the PAS quality system;
- has a general knowledge of the analytical methods offered by the laboratory;
- coordinates and conducts internal systems and technical audits;
- notifies laboratory management of deficiencies in the quality system;
- monitors corrective actions;
- provides support to technical personnel and may serve as the primary deputy for the acting TNI Technical Manager(s).

Manager-Client Services (CSM): This position is responsible for the training and supervision of project manager(s) and/or shipping, receiving and courier personnel. The primary responsibility of the CSM is to ensure projects are successfully managed to meet the expectations and needs of PAS customers.

Department Managers / Supervisors / Team Lead): These positions are responsible for administrative and operations management and implementation of the QMS in the work area he/she oversees. These responsibilities include but are not limited to: training and supervision of personnel, monitoring work activity to maintain compliance with this manual, SOPs, policies and other instructional documents that support the QMS; method development, validation and the establishment and implementation of SOPs to assure regulatory compliance and suitability for the intended purpose; monitoring QA/QC performance, proper handling and reporting of nonconforming work, purchasing of supplies and equipment adequate for use, maintaining instrumentation and equipment in proper working order and calibration, and general maintenance of administrative and technical processes and procedures established by the laboratory.

Operations Manager (OM): The OM is responsible for management of production and/or other duties assigned by the GM.

4.1.5.2.1 Approved Technical Manager (TNI Accreditation Only):

The requirements in this subsection apply to only to PAS locations that are NELAC/TNI accredited.

The TNI Standard specifies requirements for the qualification and duties of technical personnel. The TNI Standard lists these duties under the reference "technical manager(s), however named."

At PAS, these duties closely correlate with the responsibilities and duties outlined in the PAS job descriptions for managers, supervisors, team leads, and/or scientist. However, these duties do not need to be associated with any specific job title and can be assigned to any one or more PAS employees that meets the qualifications specified in the TNI Standard.

Refer to the applicable version of the TNI Standard to view the required qualifications for each discipline.

PAS locations that are TNI accredited must designate one or more employees to perform these duties and submit these qualifications to the TNI accreditation body (AB) for approval.

Employees approved by the TNI AB, to perform these duties retain their Pace® assigned job title.

When TNI Accreditation Bodies (AB) refer to these employees as 'technical manager' or 'technical director' on the official certificate or the scope of accreditation, this reference is referring to their approval to perform duties of the 'technical manager, however named' as specified in the TNI Standard and not to a PAS job title.

The duties of any approved technical manager for TNI, however named, can be completed in person or remotely. If an employee that is an approved technical manager for TNI is completely absent from work or on a leave of absence for more than 15 calendar days, the duties and responsibilities specified in the TNI Standard are temporarily reassigned to another employee that meets the qualifications for the technology or field of accreditation. If the employee's absence exceeds 35 calendar days, the local QM must formally notify the TNI primary AB of the absence and the details of reassignment of duties in writing.

4.1.5.3 Conflict of Interest

A conflict of interest is a situation where a person has competing interests that may affect impartiality. It is the policy of Pace® to ensure business relationships, decisions and transactions do not place personal interest ahead of the organization, customers, colleagues, job responsibilities or the public we serve. Conflict of interest is avoided by making personnel aware of circumstances that conflict or appear to conflict with impartiality and/or designing process and procedures to include checks and balances to prevent conflict and ensure impartiality.

See the current version of policy COR-POL-0004 *Code of Ethics and Professional Conduct* for more information.

4.1.5.4 Confidentiality

PAS management is committed to preserving the confidentiality of Pace® customers and confidentiality of Pace® business information.

Client information obtained or created during work activities is considered confidential and is protected from intentional release to any person or entity other than the client or the client's authorized representative, except when Pace® is required by law to release confidential information to another party, such as a regulatory agency or for litigation purposes. In which case, Pace® will notify the client

of the release of information and the information provided, unless notification is prohibited by law.

When Pace® obtains information about the customer from a source other than the customer, Pace® will keep the source of the information confidential unless disclosure is agreed upon by the source.

The terms of client confidentiality are included in PAS Standard Terms and Conditions (T&C). With the acceptance of the T&C and/or the implicit contract for analytical services that occurs when the client sends samples to PAS for testing, the client authorizes Pace® to release confidential information when required. Other procedures used by PAS to maintain confidentiality include:

- A Code of Ethics and Professional Conduct policy that covers this topic (COR-POL-0004):
- A Confidentiality Agreement which supervisory and sales personnel and other positions are required to sign at the time of employment and abide by the conditions of throughout employment;
- Record retention and disposal procedures that assure confidentiality is maintained;
- Physical access controls and encryption of electronic data; and

See policy COR-POL-0004 *Code of Ethics and Professional Conduct* for more information.

4.1.5.5 Communication

Communication is defined as the imparting or exchanging of news and information. Effective (good) communication occurs when the people included in the communication gets the point and understands it.

4.1.5.5.1 Workplace Communication

Effective communication in the workplace is necessary to assure work is performed correctly, efficiently, and in accordance with client specifications.

Instructions for how to conduct testing and other work activities are communicated to personnel via written policies, standard operating procedures, and other work instructions.

Information about PAS performance (positive and negative) and ideas for improvement are communicated to personnel using various communication channels such as face to face meetings, video conferencing, conference calls, email, memoranda, written reports, and posters.

4.1.5.5.2 External Communication

Communication with external parties such as customers, vendors, business partners, and regulatory agencies takes place every day.

PAS management is responsible for training personnel to communicate in professional and respectful ways to build strong relationships and to avoid misunderstanding.

4.2 Quality Management System

4.2.1 Quality Management System Objectives

The objectives of the PAS QMS are to provide clients with consistent, exemplary professional service, and objective work product that is of known and documented quality that meets their requirements for data usability and regulatory compliance.

Objective work product is analytical services, data, test results, and information that is not influenced by personal feeling or opinions. The quality of being objective is also known as 'impartiality.'

4.2.1.1 Impartiality

PAS achieves and maintains impartiality by establishing an organizational structure that safeguards impartiality (See 4.1.4.1) and implementing and adhering to the policies and processes of the QMS outlined in this manual, which are based on industry accepted standards and methodologies.

PAS procedures for handling nonconforming work (See 4.9), corrective and preventive actions (See 4.11, 4.12) and management review (See 4.15) are the primary mechanisms used to identify risk to impartiality and to prompt actions necessary to eliminate or reduce the threat when risk to impartiality is suspected or confirmed.

4.2.1.2 Risk and Opportunity Assessment

Risks are variables that make achieving the goals and objectives of the QMS uncertain.

An opportunity is something that has potential positive consequences for the organization.

PAS personnel manage risks and opportunities on a daily basis by following policies, procedures and processes that support the QMS. Some ways in which the QMS is designed to identify, minimize, or eliminate risk on a daily basis include but are not limited to:

- Capability and capacity reviews of each analytical service request to assure the laboratory can meet the customer's requirements;
- Maintenance of accreditation and certification for test methods in multiple states and programs to cover a broad range of jurisdiction for regulatory compliance;
- SOPs and other controlled instructional documents are provided to personnel to eliminate variability in the process. These documents include actions to counter risk factors inherent in the process and are reviewed on a regular basis for on-going suitability and relevancy;
- Participation in proficiency testing programs and auditing activities to verify on-going competency and comparability in performance;

- Provision of on-the-job training and established protocol for quality control (QC) corrective action for nonconforming events;
- An established program for ethics, and data integrity;
- Tiered data review process;
- Culture of continuous improvement;
- Monitoring activities to assess daily and long-term performance; and
- Annual critical review of the effectiveness of the QMS.

PAS also promotes a continuous improvement culture based on the principles of lean manufacturing. These principles include 3P (Process, Productivity, Performance) and Kaizen. 3P is a platform used by PAS to share best practices and standardization across the network to achieve operational excellence. Kaizen is a team-based process used to implement tools and philosophies of lean to reduce waste and achieve flow with the purpose of improving both external and internal customer satisfaction. The PAS lean program and activities help to mitigate risk because they generate a collective understanding of vulnerabilities and utilize group-effort to develop and implement solutions at all levels.

Risk and opportunities may also be formally identified using specific risk and opportunity assessment methods such as SWOT Analysis (Strength, Weakness, Opportunity, Threats) and 3-Stage Impact/Probability Grids.

4.2.1.3 Communication of the Quality Management System

This manual is the primary mechanism used by PAS management to communicate the QMS to personnel.

To assure personnel understand and implement the quality program outlined in the manual:

- PAS personnel are required to sign a Read and Acknowledgement Statement to confirm the employee has:

  1) been informed of the manual by management,

  2) has access to the manual,

  3) has read the manual

  4) understands the content of the manual, and

  5) agrees to abide by the requirements, policies, and procedures therein.
- Personnel are informed that the manual provides the “what” of the QMS. The “how to” implementation of the QMS is provided in policy, SOPs, standard work instructions, and other instructional documents.
- This manual and supporting policies and procedures are made readily accessible to personnel in the area where the work activity is performed.

4.2.2 Quality Policy Statement

The quality policy of PAS is to provide customers with data of known and documented quality fit for their intended purpose. PAS achieves this policy by implementing the QMS defined in this manual, by following industry accepted protocol for analytical testing and quality assurance and quality control (QA/QC) activities, by conformance with published and industry accepted testing methodologies, and by compliance with international and national standards for the competency and/or accreditation of testing laboratories.

Intrinsic to this policy statement is each of the following principles:

- PAS will provide customers with reliable, consistent, and professional service. This is accomplished by making sure each PAS location has the resources necessary to maintain capability and capacity; that staff are trained and competent to perform the tasks they are assigned; that client-facing staff are trained and prepared to find solutions to problems and to assist customers with their needs for analytical services. Customer feedback, both positive and negative, is shared with personnel and used to identify opportunities for improvement.
- PAS maintains a quality program that complies with applicable state, federal, and industry standards for analytical testing and competency.
- PAS management provides training to personnel so that all personnel are familiar with the QMS outlined in this manual and that they understand that implementation of the QMS is achieved by adherence to the Pace® and PAS policies and procedures.
- PAS management continuously evaluates and improves the effectiveness of the QMS by responding to customer feedback, and other measures of performance, such as but not limited to the results of internal/external audits, proficiency testing, metrics, trend reports, and annual and periodic management reviews.

4.2.2.1 Ethics Policy / Data Integrity Program

Pace® has established a comprehensive ethics and data integrity program that is communicated to all Pace® employees so that they understand what is expected of them. The program is designed to promote a mindset of ethical behavior and professional conduct that is applied to all work activities.

The key elements of the Pace® Ethics / Data Integrity Program include:

- Ethics Policy (COR-POL-0004);
- Ethics Officer (Chief Compliance Officer);
- Standardized data integrity training course taken by all new employees on hire and a yearly refresher data integrity training course for all existing employees;
- Policy Acknowledgement Statements that all Pace® personnel, including contract and temporary, are required to sign at the time of employment and again during annual refresher training to document the employee's commitment and

obligation to abide by the company's standards for ethics, data integrity and confidentiality;

- SOPs that provide instructions for how to carry out a test method or process to assure tasks are done correctly and consistently by each employee;
- On the Job Training;
- Data integrity monitoring activities which include, but are not limited to, primary, secondary and completeness data reviews, internal technical and system audits, data audits, data surveillance, and proficiency testing; and
- Confidential reporting process for alleged ethics and data integrity issues.

All PAS managers and supervisors are expected to provide a work environment where personnel feel safe and can report unethical or improper behavior in complete confidence without fear of retaliation. Retaliation against any employee that reports a concern is not tolerated.

Pace® has engaged Lighthouse Services, Inc. to provide personnel with an anonymous reporting process available to them 24 hours a day/7 days per week. The alert line may be used by any employee to report potential violations of the company's ethics and data integrity program. Reports are forwarded to the Pace® Ethics Compliance Officer to investigate and resolve the matter. Investigations concerning data integrity are kept confidential.

See COR-POL-0001 *Compliance Alertline* for more information.

Posters and flyers with the compliance alert line information must be prominently posted in each PAS location for personnel reference.

Compliance Alert Line Information:

English Speaking US & Canada	(844) 940-0003
Spanish Speaking North America	(800) 216-1288
Internet	www/lighthouse-services.com/pacelabs
Email	reports@lighthouse-services.com

4.2.3 Management Commitment: Quality Management System

Evidence of management's commitment for the development, maintenance, and on-going improvement of the QMS is provided by the application of their signature of approval to the template and/or manual. Their signature confirms they understand their responsibility to implement the QMS outlined in this manual, to communicate the quality program to personnel, and to uphold requirements of the program during work activities.

4.2.4 Management Commitment: Customer Service

Management communicates the importance of meeting customer and regulatory requirements to personnel by training personnel on the QMS outlined in this manual, implementing the QMS outlined in this manual, and upholding these requirements for all work activities.

4.2.5 Supporting Procedures

References to processes and procedures that support the QMS are included throughout this manual. The structure of the document management system is outlined in SOP ENV-SOP-CORQ-0015 *Document Management and Control* and summarized in the following subsections.

4.2.5.1 Quality Management System Document Structure

Documents associated with the QMS are classified into document types that identify the purpose of the document and establish how the document is managed and /or controlled.

Examples: Types of PAS Internally Created Documents

Document Type	Purpose
Quality Manual	Outlines the PAS QMS and structure and how it works for a system including policy, goals, objectives and detailed explanation of the system and the requirements for implementation of system. Includes roles and responsibilities, relationships, procedures, systems, and other information necessary to meet the objectives of the system described.
Policy	Provide requirements and rules for a process and is used to set course of actions and to guide and influence decisions. Policy describes the "what," not the "how".
Standard Operating Procedure	Provide written and consistent set of instructions or steps for execution of a routine process, method, or set of tasks performed. Assures that activities are performed properly in accordance with applicable requirements.
Standard Work Instruction	Provide step by step visual and/or written instruction to perform a specific task to improve competency, minimize variability, reduce work injury and strain, or to boost efficiency and quality of work (performance). SWI are associated with an SOP unless the task described is unrelated to generation of or contribution to environmental data or analytical results.
Template	Pre-formatted document that serves as a starting point for a new document.
Guide	Assists users in using a particular product; or a technical interpretation of a method or process by which PAS locations must abide.
Form	Used for a variety of purposes such as to provide a standardized format to record observations, to provide information to supplement an SOP.
Guidance	Non-binding advice used to explain internal policies, procedures, or practices.

Example: Types of External Documents used by PAS

Certificate	Lists parameters, methods, and matrices for which the location is certified/accredited to perform within the jurisdiction of the issuing regulatory agency or accreditation body.
Reference Document	Provide information, protocol, instructions, and/or requirements. Issued by the specifier. Examples include ISO/IEC, TNI, DoD and published referenced methods such as Standard Methods, ASTM, SW846, EPA, and federal and state regulatory bodies.
Project Document	Provides requirements necessary to meet individual client expectations for intended use of data. Examples include project quality assurance plans (QAPP), client-program technical specifications, contracts, and other agreements.

These document types are ranked to establish which documents takes precedence when there is an actual or perceived conflict between documents and to establish the hierarchal relationships between documents. The ranking system also provides information to document writers and reviewers to assure downline documents agree with documents of higher rank.

PAS Document Hierarchy

Rank	Document
1	Corporate Manual
2	Corporate Policy
3	Corporate SOP
4	Corporate SWI, Templates, Guides, Forms, Guidance
5	Local Manual
6	Local SOP
7	Local SWI, Templates, Guide, Forms, Guidance

Information and requirements from project documents are not incorporated into PAS policy or SOPs in order to maintain client confidentiality. These documents are managed as external documents and any requirements for work specified is followed when work for the project is performed. Project Documents are reviewed and maintained as part of the contract/incoming work review process (See Section 4.4). If the project document is less stringent than the PAS QMS, policies, or SOPs, and/or is less stringent than applicable federal or state requirements, PAS locations are still required to meet the minimum requirements of the PAS QMS and any applicable statutory or federal requirements in addition to the requirements specified in the project document.

Reference documents are not ranked because all PAS created documents, processes and procedures must be consistent with the applicable reference document(s) in addition to higher-ranking PAS documents.

See SOP ENV-SOP-CORQ-0015 *Document Management and Control* for more information.

4.2.6 Roles and Responsibilities

The roles and responsibilities for technical management and the quality manager is provided in section 4.1.5.2.

4.2.7 Change Management

When significant changes to the PAS QMS are planned, these changes are managed by corporate quality personnel to assure that the integrity of the QMS is maintained.

4.3 Document Control

4.3.1 General

PAS procedures for document control are provided in SOP ENV-SOP-CORQ-0015 *Document Management and Control*.

PAS locations use electronic document management software (eDMS) to perform the document control procedures of the SOP. This system provides centralized access to all documents used by PAS locations across the network. All PAS locations are required to use the eDMS system established for PAS (presently Qualtrax) unless an exemption has been granted by the PAS Corporate Quality Director.

eDMS automates the process for unique document identification, version control, approval, access, and archival and restricts access to archived documents except to authorized users to prevent the use of obsolete documents.

The local QM maintains a master list of controlled documents used at each location. The master list minimally includes the document control number, document title, and current revision status and is made available to personnel for their reference.

See SOP ENV-SOP-CORQ-0015 *Document Management and Control* for more information.

4.3.2 Document Approval and Issue

Documents that support the QMS are reviewed by qualified personnel and approved by management prior to release for use.

Only the approved versions of documents are available to personnel for use unless use of a draft document is authorized by management.

The managers responsible for authorization of each document is situation specific.

See SOP ENV-SOP-CORQ-0015 *Document Management and Control* for more information.

4.3.3 Document Review and Change

Unless a more frequent review is required by regulatory, certification or accreditation program documents are reviewed at least every two years to ensure the documents remains current, appropriate, and relevant.

Documents are also informally reviewed every time the document is used. Personnel are expected to refer to and follow instructions in controlled documents when they conduct their work activities. Consequently, any concerns or problems with the document should be caught and brought to the attention of management on an on-going basis.

Documents are revised whenever necessary to ensure the document remains usable and correct. Older document versions and documents no longer needed are made obsolete and archived for historical purposes.

PAS does not allow hand-edits to documents. If an interim change is needed pending re-issue of the document, the interim change is communicated to those that use the document using a formal communication channel, such as change in progress form, email, or memorandum.

The document review, revision, and archival process is managed by quality personnel at the location from which the document was released using the procedures established in SOP ENV-SOP-CORQ-0015 *Document Management and Control.*

4.4 Analytical Service Request, Tender, and Contract Review

PAS management and/or client service personnel perform thorough reviews of requests and contracts for analytical services to verify the location(s) performing the work has the capability, capacity, and resources necessary to successfully meet the customer's needs. These review procedures are described in SOP ENV-SOP-GBAY-0006 *Sample Management and Review of Analytical Requests*.

The procedures in this SOP(s) are established to ensure that:

- The PAS locations performing the work understand the purpose of data collection in order to ensure the test methods requested are appropriate for the intended use of the data and capable of meeting the client's data quality objectives;

- PAS locations and any external subcontractor(s) have the capability, capacity, and resources to meet the project requirements and expectations within the requested time frame for delivery of work product;
- Any concerns that arise from review are discussed and resolved with the client;
- Any discrepancies between the PAS QMS, statutory or regulatory requirements and the client request are resolved; and
- The results of review and any correspondence with the client related to this process and/or any changes made to the contract are recorded and retained for historical purposes.

Capability review confirms that the PAS locations contracted to perform the work and any internal or external subcontractors hold required certification/accreditation for the test method, matrix, and analyte and verifies the location can achieve the client's target compound list and data quality objectives (DQOs) for analytical sensitivity and reporting limits, QA/QC protocol, and hardcopy test report and electronic data deliverable (EDD) formats.

Capacity review verifies that the in-network locations and any potential subcontractors are able to manage the sample load and deliver work production within the delivery timeframe requested.

Resource review verifies that the location and any potential subcontractors have adequate qualified personnel with the skills and competency to perform the test methods and services requested and sufficient and proper equipment and instrumentation needed to perform the services requested.

4.5 Subcontracting (Internal and External)

The terms 'subcontract' and "subcontracting" refers to analytical work done by an organization external to Pace® (External Subcontracting) or by a Pace® location with an address different than the address listed on the cover page of the test report (Internal Subcontracting).

The PAS network offers comprehensive analytical capability and capacity to ensure Pace® can meet a diverse range of client needs for any type of project. If a PAS laboratory receives a request for analytical services and it cannot fulfill the project specifications, the location's client services team will collaborate with the client to place the work within the PAS network.

When it is not possible to place the work within network, the location will, with documented client approval, subcontract the work to a subcontractor that has the capabilities to meet the project specifications and can meet the same commitment agreed on between the location and the client.

Whenever work is subcontracted, the PAS location responsible for management of the project verifies each of these qualifications:

- The internal or external subcontractor has the proper accreditation/certifications required for the project and these are current; and
- The use of the internal or external subcontractor is approved by the client and/or regulatory agency when such approval is required by the customer. Record of customer approval is retained in the project record.

External subcontractors selected by Pace® must be pre-qualified by quality personnel to verify their QMS is similar to Pace® and complies with all relevant Standards such, as ISO/IEC 17025 and the TNI Standard(s) and/or federal and state regulatory requirements. The list of approved

subcontractors for each location is maintained by local quality personnel. Pre-qualification of a subcontractor does not eliminate the requirement for the PAS location placing work to verify the subcontractor has the certifications, capability, capacity, and resources to perform work on behalf of Pace® on a project-specific basis.

For all subcontracted work, the PAS location placing the work internally or externally is responsible to ensure project specifications are always communicated to and understood by the subcontractor.

4.6 Purchasing Services and Supplies

Vendors that provide services and supplies to PAS are qualified to meet the needs of Pace®. These needs include but are not limited to competitive pricing, capacity to fill purchase orders, quality of product, customer service, and business reputation and stability. Evidence of this qualification is the availability to purchase services and supplies from the vendor in the corporate purchasing system.

PAS locations may purchase goods and services from any supplier in the purchasing system.

The specifications (type, class, grade, tolerance, purity, etc.) of supplies, equipment, reagents, standard reference materials and other consumables used in the testing process are specified in SOPs. The SOP specifications are based on the governing requirements of the approved reference methods and any additional program driven regulatory specification, such as drinking water compliance.

All requisitions for materials and consumables are approved by local management who is responsible to ensure the services and supplies procured and received are fit for intended use.

4.7 Customer Service

Project details and management is managed by PAS client services personnel.

4.7.1 Commitment to Meet Customer Expectations

PAS personnel collaborate closely with our customers to ensure their needs are met and to establish their confidence in the capability of PAS to meet their needs for analytical services and expectations for service.

The project manager (PM) is the customer's primary point of contact for each analytical service request (work order). The PM gathers information from the customer to ensure the details of their request are understood. After samples are received, the PM monitors the progress of the project and alerts the customer of any delays or excursions that may adversely impact data usability. Supervisors are expected to keep the PM informed of project status and any delays or key issues, so that the PM can keep the client informed.

PAS encourages customers to visit our locations to learn more about the capabilities, observe performance and to meet personnel.

PAS customers expect confidentiality. Personnel will not divulge or release information to a third party without proper authorization unless the information is required for litigation purposes. See Section 4.1.5.4 of this manual and policy COR-POL-0004 *Code of Ethics and Professional Conduct* for more information on the policy for client confidentiality.

4.7.2 Customer Feedback

PAS actively seeks positive and negative feedback from customers through surveys and direct communication. Information from the client about their experience working with PAS and

their satisfaction with work product is used to enhance processes and practices and to improve decision making. Customer feedback is reviewed to identify risk and opportunity. Corrective, preventive, or continuous improvement actions are taken based on nature of and/or feedback trends.

Also see sections 4.9, 4.10, 4.11, 4.12, 4.14, and 4.15 for more information about how customer feedback is managed by PAS and used to enhance the QMS.

4.8 Complaints

A complaint is a formal expression of dissatisfaction with the performance of a service or product originating from a party external to Pace®. Complaints provide opportunities to improve processes and/or build stronger working relationships with clients.

The PAS complaint resolution process depends on the situation and the nature of the complaint.

Each complaint received is reviewed to determine if it is valid. If the complaint is valid, it is either addressed immediately by the person receiving the complaint or the nature of the complaint is further reviewed and investigated prior to resolution and follow up with the customer.

Complaints (and compliments) are recorded and reviewed during Annual Management Review (See Section 4.15).

4.9 Nonconforming Work

4.9.1 Definition of Nonconforming Work

Nonconforming work is work that does not conform to customer requirements, standard specifications, policies, and procedures, or that does not meet acceptance criteria.

The discovery of non-conforming work comes from various sources which include, but are not limited to:

- results of quality control samples and instrument calibrations;
- quality checks on consumables and materials;
- general observations of personnel;
- data review;
- proficiency testing;
- internal and external audits;
- complaints and feedback;
- management review and reports; and
- regulatory and certification and accreditation actions.

The way in which the laboratory or service center manages nonconforming work depends on the significance and impact (risk) of the issue. Some issues may simply require correction, others may require investigation, corrective action (See 4.11) and/or data recall (See 4.16). When the location releases data and test results associated with nonconforming QC and acceptance criteria, test results are qualified, or non-conformances are noted in the final analytical report to apprise the data user of the situation. (See 5.10)

Nonconforming work also includes unauthorized departure from l policies, procedures, and test methods. Authorized departures are explained in the following subsections. Situations that do not conform to these conditions are considered unauthorized departure(s).

4.9.1.1 Authorized Departure from SOPs

Departures from an SOP may sometimes be necessary to correct for an error in an SOP or to resolve a complex problem. For example, to mitigate a complex matrix interference.

An authorized departure from a test method SOP is one that has been reviewed and approved by the department leader, however named, of the work area in which the test method is performed. The leader, when authorizing a departure from an SOP, accepts full responsibility to ensure the departure does not conflict with Pace® or PAS policy or procedure, does not affect statutory, regulatory or program compliance and does not adversely affect data integrity or usability.

Departure from administrative or process-oriented SOPs must be approved by the local QM.

Documentation of the reason for the SOP departures must be retained with management approval. Approved departures from test method SOPs should be noted in the final test report to advise the data user.

See SOP ENV-SOP-CORQ-0016 *SOP for SOPs and SWI*, for more information.

4.9.1.2 Authorized Departure from Test Methods (Method Modifications)

When test results are associated to a published reference test method, the location's test method SOP must be consistent with the test method. If the test method is mandated for use by a specific regulatory program such as drinking water, wastewater or a certification or accreditation program, such as TNI/NELAC, the SOP must comply with or include these requirements, or the resulting data and test results cannot be used for regulatory compliance purposes.

If the procedures in the SOP are modified from the test method, these modifications must be clearly identified in the SOP. The conditions under which the location may establish an SOP that is modified from these reference method or regulatory program and what is considered a modification are specified in ENV-SOP-CORQ-0011 *Method Validation and Instrument Verification*.

Client requests to deviate from the test method are managed as client requests to depart from the test method SOP since it is the SOP that the location follows when performing work.

4.9.1.3 Stop Work Authority

Stop Work Authority provides PAS personnel with capability to stop work when there is a perceived unsafe condition or behavior that may result in an unwanted event.

All personnel have the authority to request a stop work order when necessary to preserve data integrity or safety of workers.

The need for the stop work order and resolution of the problem must be confirmed by subject matter experts and resumption of work must be approved as follows:

- For stop work orders related to environmental health and safety (EHS) and/or waste management, the decision to stop work may be made by any employee. These decisions must often be made in real-time to protect the safety of the worker. The decision to correct the problem, how, and/or to resume work after stop work has been initiated may be made by the Chief Compliance Officer or the EHS Director, or the deputies assigned to these positions.

- Any employee may recommend a stop work order for concerns related to data integrity. The need to stop work must be reviewed and affirmed by quality personnel to confirm the concern is valid. The decision to uphold the stop work order must minimally include the local QM, the QPM, and the Corporate Quality Director. The President, the Sr. VPO, the VPO, the Chief Compliance Officer and Chief Technical Officer may also be included in the decision making and resolution process depending on the situation and/or needs for correction to ensure protocols for investigation are followed. Resumption of work after correction may be made by the Corporate Quality Director, or the Quality Program Manager assigned to the location for which the stop work order was issued or by the deputies assigned to these positions.

4.10 Continuous Improvement

The PAS QMS is designed to achieve continuous improvement through the implementation of the quality policy and objectives outlined in this manual. Information about laboratory and service center activities and performance is gained from sources such as customer feedback, audits, QC, trend analysis, business analytics, management reports, proficiency testing, and management systems review. This information is subsequently used during the corrective action (see section 4.11) and preventive action (see section 4.12) processes and during annual review of the management system (see section 4.15) to establish goals and objectives for improvement.

PAS also promotes a continuous improvement culture based on the principles of lean manufacturing. These principles include 3P (Process, Productivity, Performance) and Kaizen. 3P is a platform used by Pace to share best practices and standardization across the network to achieve operational excellence. Kaizen is a team-based process used to implement tools and philosophies of lean to reduce waste and achieve flow with the purpose of improving both external and internal customer satisfaction. All activities of 3P and Lean must conform with the requirements of this quality manual and supporting policies and procedures.

4.11 Corrective Action

Corrective action is a process used to eliminate the cause of a detected nonconformity. It is different from a correction. A correction is an action taken to fix an immediate problem but that does not resolve the underlying cause of why the problem occurred. The objective of corrective action is to find the underlying cause(s) of the problem and to put in place fixes to prevent the problem from happening again. The corrective action process, referred to as CAPA, is one of the most effective tools used by PAS to prevent nonconforming work, identify risk and opportunity, and improve service to our customers.

PAS has two general processes for corrective action, the application of which process is used depends on the type of nonconformity:

Quality control (QC) exceptions (nonconformance) that occur during routine testing is investigated through troubleshooting and required actions for correction is specified in policies and SOPs. When action is not taken, cannot be taken, or is not successful, test results associated with the nonconforming work are qualified in the final test report. Documentation of the nonconformance and corrective action taken is documented in the analytical record.

A 7-stage corrective action process is used when there is a recurring problem. These problems are identified through various activities such as but not limited to quality control trends, internal and external audits, management review, customer feedback, and general observation.

The 7 Stage CAPA Process for PAS includes:

1) Identification and Containment
2) Evaluation
3) Investigation
4) Cause Analysis
5) Action Plan
6) Implementation
7) Follow Up and Effectiveness Review

PAS procedures for corrective action, are specified in corporate SOP ENV-SOP-CORQ-0018 *Procedure for Corrective and Preventive Action.* Some key concepts and activities related to the PAS corrective action process is provided in the next three subsections.

4.11.1 Cause Analysis (AKA Root Cause Analysis)

Cause analysis is the process of investigation used to identify the underlying cause(s) of the problem. After causal factors are identified, ways to mitigate the causal factors are identified and action(s) most likely to eliminate these factors are taken.

PAS uses different methods to conduct cause analysis. The most common approach is 5-Why, 4M, Fishbone Diagrams, or brainstorming may be appropriate depending on the situation. The method used is case specific and is documented in the CAPA record.

4.11.2 Effectiveness Review

Monitoring corrective actions taken for effectiveness is an essential part of the corrective action process. Effectiveness means the actions taken were appropriate and sustainable. Appropriate means the action(s) taken prevented recurrence of the problem since the time corrective action was taken and sustainable means the actions taken are still in place.

The data from CAPA records are used by PAS to identify opportunities for preventive action or to gain lessons learned when actions taken were not adequate to solve the problem. See Section 4.12 (Preventive Action) and 4.15 (Management Review) for more information.

4.11.3 Additional Audits

When cause analysis and investigation of a problem casts doubt on compliance with PAS policies, procedures, or to regulatory requirements; a special audit of the area of activity may be performed as part of the corrective action process. These special audits are used to

determine the scope of the problem and to provide information for the CAPA process. Additional full-scale audits are done when a grave issue or risk to the business is identified.

4.12 Preventive Action

Preventive action(s) are actions taken to eliminate the cause of a potential nonconformity before it happens.

Some examples of preventative action include, but are not limited to:

- Routine instrument maintenance (Preventative maintenance)
- Addition of Staff and Equipment
- Professional Development Activities
- Implementation of New Technology

PAS looks for opportunities for preventive action from a variety of sources including employee idea's, customer feedback, business partners input, trend analysis, business analytics, management reviews, proficiency testing results, and risk-benefit analysis.

PAS management evaluates the success of preventive actions taken in any given year during annual management review. See Section 4.15 for more information.

4.12.1 Change Management

Preventive actions may sometimes result in significant changes to processes and procedures used by PAS locations. PAS management evaluates the risks and benefits of change and includes in its implementation of change process, actions to minimize or eliminate any risk. The types of changes for which risk are considered and managed include infrastructure change, change in analytical service offerings, certification or accreditation status, instrumentation, LIMS changes, and changes in key personnel.

4.13 Control of Records

A record is a piece of evidence about the past, especially an account of an act or occurrence kept in writing or another permanent form. PAS records document activities and provide evidence of conformity to the requirements established in the QMS. These records may be hardcopy or electronic on any form of media.

4.13.1 General Requirements

4.13.1.1 Procedure

PAS requirements for control of records are specified in corporate policy ENV-POL-CORQ-0013 *Record Managemen*t.

The policy is established to assure quality and technical records are identified, retained, indexed, and filed to allow for retrieval during the entire retention timeframe. During storage, records are kept secure and protected from deterioration. At the end of the retention time, the records are disposed of properly in order to maintain client confidentiality and to protect the interests of the company.

In general, records fall into three categories: quality, technical, and administrative.

Examples of each are provided in the following table:

Record Type	Includes Records of:
Quality	Document Types listed in SOP ENV-SOP-CORQ-0015 Audits: Internal and External Certificates and Scopes of Accreditation Corrective & Preventive Action Management Review Data Investigations Method Validation Instrument Verification Training Records
Technical	Raw Data Logbooks Certificates of Traceability Analytical Record Test Reports & Project Information Technical Training Records & Demonstration of Capability
Administrative	Personnel Records Finance/Business

4.13.1.2 Record Legibility and Storage

Records are designed to be legible and to clearly identify the information recorded. Manual entries are made in indelible ink; automated entries are in a typeface and of sufficient resolution to be read. The records identify personnel that performed the activity or entered the information. Records are archived and stored in a way that they are retrievable. Access to archived records is controlled and managed.

For records stored electronically, the capability to restore or retrieve the electronic record is maintained for the entire retention period. Hardcopy records are filed and stored in a suitable environment to protect from damage, deterioration, or loss. Hardcopy records may be scanned to PDF for retention. Scanned records must be checked against the hardcopy to verify the scan is complete and legible.

Administrative records are kept for a minimum of 5 years and technical and quality records are kept for 10 years unless otherwise specified by the client or regulatory program.

The date from which retention time is calculated depends on the record. In general, the retention time of technical records of original observation and measurement is calculated from the date the record is created. If the technical record is kept in a chronological logbook, the date of retention may be calculated from the date the logbook is archived. The retention time of test reports and project records, which are considered technical records, is calculated from the date the test report was issued. The retention time of quality records is usually calculated from the date the record is archived.

Refer to the record management policy and the location specific SOP for more information.

4.13.1.3 Security

PAS locations are secure facilities and access to records is restricted to authorized personnel.

4.13.1.4 Electronic Records

The data systems used to store electronic records is backed up in accordance with SOP ENV-SOP-GBAY-0162 *Electronic Records Backup*. Access to archived records stored electronically is maintained by personnel responsible for management of the electronic system.

4.13.1.5 Electronic Signature Policy

Work done by PAS locations include activities that require the application of a signature. Some work product is in electronic format and signatures are applied electronically.

The Electronic Signatures in Global and National Commerce Act (E-Sign Act) clarifies that electronic signatures are legally valid and enforceable under United States law.

The PAS policy for use and application of electronic signatures is specified in corporate policy ENV-POL-CORQ-0014 *Electronic Signature Policy.*

All employees of PAS including temporary and contract personnel, must sign an Electronic Signature Agreement to acknowledge that they understand and accept that work activities performed by them may be authenticated with application of an electronic signature and that electronic signature has the same validity as a handwritten signature. Their signed agreement also confirms the individual has read and understands the policy and agrees to abide by the requirements for use of electronic signature stated in the policy.

4.13.2 Technical Records

In addition to the requirements specified in subsections 4.13.1.1 through 4.13.1.5, the requirements in the following subsections also apply to technical records.

4.13.2.1 Description

Technical records are the accumulation of data and information generated from the analytical process. These records may include forms, worksheets, workbooks, checklists, notes, raw data, calibration records, final test reports, and project record. The accumulated record needs to provide adequate detail to historically reconstruct the process and identify the personnel that performed the tasks associated with a test result.

4.13.2.2 Real Time Recordkeeping

Personnel are instructed and expected to always record observations, data, and calculations at the time they are made. PAS managers are responsible to assure that data entries, whether made electronically or on hardcopy, are identifiable to the task.

4.13.2.3 Error Correction

Errors in records must never be erased, deleted, or made illegible. Use of correction fluid, such as white-out is prohibited. In hardcopy records, the error is corrected by a single strike through the original entry and the new entry recorded alongside or footnoted to allow for readability. Corrections are initialed and dated by the person making the correction. If the correction is not self-explanatory, a reason for the correction is recorded.

For electronic records, equivalent measures of error correction or traceability of changes made is kept. For example, audit trails provide records of change.

Maintenance of proper practices for error correction is monitored through the tiered data review process described in Section 5.9.3. Records are reviewed throughout the data review process. Individuals performing these reviews flag errors that are not properly corrected and bring these to the attention of the department manager or supervisor of the work area in which the record was generated so that the problem may be addressed and corrected with the individual(s) that did not make the correction properly.

4.14 Audits

Quality personnel, or their designees, perform internal systems and technical audits to assess implementation of the QMS, compliance to this manual, policy, and procedures that make up the QMS. Since the processes in this manual are based on the requirements from relevant and applicable Standards for the operation and management of laboratories when operations are assessed against the PAS QMS, compliance with regulatory program requirements and accreditation/certification program requirements are also assessed.

PAS locations are also audited by external parties such as regulatory agencies, customers, consultants, and non-government assessment bodies (NGAB).

Information from internal and external audits is used by local and corporate management to address deficiencies and to identify opportunities to improve customer service and quality of work, including reliability and usability of data and test results.

Deficiencies, observations, and recommendations from audits are managed by the local QM using the CAPA process. See Section 4.11 for more information.

4.14.1 Internal Audit

The PAS internal audits are conducted to ensure practice matches what we say we do and what we say we do is compliant with the PAS QMS and relevant standards and requirements.

The internal audit program is managed by the local QM who prepares an audit plan at the beginning of each calendar year. The schedule is prepared to assure that all work areas are reviewed over the course of the year and test methods are audited every two years, unless a more frequent test method audit is required by program. Conformance to the schedule is monitored on a monthly basis.

PAS management is responsible to ensure the audit schedule is maintained. PAS supervisors are expected to cooperate with the quality personnel to provide them with complete access to the work area, personnel, and records needed to conduct the audit.

Internal audits may be performed by non-quality personnel when the auditor is approved by the local QM. Non-quality personnel may not audit their own work activities unless it can be demonstrated that an effective and objective audit will be conducted. The person conducting the audit should be trained, qualified, and familiar enough with the objectives and policies of the PAS QMS and knowledgeable with process and test method SOPs related to the activities audited. The auditors should be trained in auditing practices in order to perform a thorough and effective evaluation.

Test method audits include reviews of test reports to verify the product is consistent with customer/project requirements, the work was conducted in accordance with policy and SOPs, the SOP complies with the cited reference method, test results are accurate, and of known and documented quality and properly qualified, when necessary.

Special audits are performed as needed to follow up on a specific issue such as a client complaint, negative feedback, concerns of data integrity or ethics, or a problem identified through other audits. Special audits may be scheduled or unscheduled. Unscheduled internal audits are conducted whenever doubts are cast on compliance with regulatory requirements or its own policies and procedures. These unscheduled internal audits may be conducted at any time and may be performed without an announcement to the location or work area audited.

When observations and findings from any audit (internal or external) cast doubt on the validity of testing results, the location takes immediate action to investigate the problem and take corrective action. (Also see 4.11 and 4.16)

4.14.1.1 Corporate Compliance Audit

PAS locations may also be audited by corporate personnel at discretion. The purpose of the corporate compliance audit is to assess whether the location's practices, processes and procedures conform with the PAS QMS and to identify risk and opportunity.

4.15 Management Review

Local management conducts an annual business review of each location under their purview to assess performance and to establish goals, objectives, and action plans for the upcoming year.

The procedure used to conduct this review is specified in corporate SOP ENV-SOP-CORQ-0005 *Management Review*.

At a minimum, the following topics are reviewed and discussed during annual management review:

- Changes in internal and external issues relevant to the location;
- Fulfillment of objectives and initiatives;
- suitability of policies and procedures, including EHS and waste management;
- status of actions from previous performance reviews;
- The outcome of recent internal audits;
- Corrective and preventive actions;

- Assessments by external bodies;
- The results of interlaboratory comparisons or proficiency tests;
- Changes in the volume and type of the work;
- Customer and personnel feedback, including complaints;
- Effectiveness of improvements / preventive actions made since last review;
- Adequacy of resources;
- results of risk identification;
- Proficiency testing performance and other measures related to the assurance of validity of test results; other relevant factors, such as QC trends and training status.

The discussion and results of this review are documented in a report prepared by local management. This report includes a determination of the effectiveness of the management system and its processes, goals, and objectives for improvements in the coming year with timelines and responsibilities, and any other need for change.

Goals and action items from annual management systems review are shared with local employees and with corporate management to highlight focus areas for improvement in addition to areas in which the location has excelled.

4.16 Data Integrity

PAS procedures for the investigation and response to events that may affect data integrity are described in the corporate SOPs for data inquiries and data recall and corrective and preventive action, however named.

Customers whose data are affected by these events are notified in a timely manner, usually within 30 days after the impact of the problem is understood. Some accreditation programs also require notification to the accreditation body (AB) within a certain timeframe from date of discovery when the underlying cause of the issue impacts accreditation. PAS locations must follow any program or project specific client notification requirements for notification, when applicable.

5.0 TECHNICAL REQUIREMENTS

5.1 General

Multiple factors contribute to the correctness and reliability of the technical work performed by PAS. These factors fall under these broad categories:

- Human Performance
- Facility and Environmental Conditions
- Test Method Performance and Validation
- Measurement Traceability
- Handling of Samples

The impact of each of these factors varies based on the type of work performed. To minimize negative effects from each of these factors, PAS accounts for the contribution from each of these categories when developing test method and process (administrative) SOPs, evaluating personnel qualifications and competence, and in the selection of equipment and supplies used.

5.2 Personnel

5.2.1 Personnel Qualifications

The PAS program for personnel management is structured to ensure personnel are selected, qualified, and competent to perform the roles and responsibilities of their position based on education, experience, and training.

Qualifications, duties, responsibilities, and authorities of each position are specified in job descriptions maintained by corporate HR (See Section 5.2.4). These job descriptions provide the general basis for the selection of personnel for hire and are used by the location to communicate to personnel the duties, responsibilities, and authorities of their position. Qualification records may include but are not limited to diploma, transcripts, and curriculum vitae (CV).

The term "personnel" refers to individuals employed by PAS directly as full-time, part-time, or temporary, and individuals employed by PAS by contract, such as through an employment agency. The term "personnel" is used interchangeably with the term "employee" throughout this manual. For purposes of this manual, these terms are equivalent.

The personnel management program is structured to establish and maintain records for each of the following:

- Selection of personnel;
- Training of personnel;
- Supervision of personnel;
- Authorization of personnel; and
- Monitoring Competence of personnel.

5.2.1.1 Competence

Competence is the ability to apply a skill or series of skills to complete a task or series of tasks correctly within defined expectations.

Competence for technical personnel authorized by PAS to provide opinion and interpretation of data to customers also includes the demonstrated ability to:

- Apply knowledge, experience, and skills needed to safely and properly use equipment, instrumentation, and materials required to carry out testing and other work activities in accordance with manufacturer specifications and location SOPs;
- Understand and apply knowledge of general regulatory requirements necessary to achieve regulatory compliance in work product; and

- Understand the significance of departures and deviations from procedure that may occur during the analytical testing process and the capability and initiative to troubleshoot and correct the problem, document the situation and decision-making process, and to properly qualify the data and analytical results.

PAS requirements for the competence of personnel (education, qualification, work experience, technical skills, and responsibilities) are specified in job descriptions created by management and kept by human resources (HR). The job description provides the basis for the selection of personnel for each position.

An employee is considered competent when he/she has completed the required training specified in Section 5.2.2 and documentation of training is complete.

5.2.2 Training (Required)

Pace® training requirements are outlined in Pace® policies COR-POL-0023 *Mandatory Training Policy* and COR-POL-0004 *Code of Ethics and Professional Conduct.*

5.2.2.1 Required Training Requirements

The PAS training program includes these elements:

- Scheduling
- Execution
- Documentation and Tracking
- Evaluation of Effectiveness

Required training is scheduled by corporate training personnel, local quality personnel, and the employee's direct supervisor.

Training on required topics, processes and procedure is delivered using various methods that incorporate techniques that appeal to the main learning styles: visual, aural, linguistic, and kinesthetic. Techniques include, on-the-job, instructor-led, self-study, eLearning, and blended.

The employee's direct supervisor is responsible for oversight of completion of the employee's required training and for providing adequate time to the employee to complete training assignments. The supervisor and employee are responsible to make sure the employee's training status and training records for all required training is current, complete, and documentation of training is available.

Training status is tracked by the local QM, who provides the status to local management at least monthly or more frequently, as necessary, to ensure required training for personnel is complete and up to date.

The following subsections further describe the required PAS training program for new hire training and on-going training.

5.2.2.1.1 New Hire Required Training

New hire training requirements apply to new personnel and to existing employees starting in a new position or different work area.

Required new hire training includes training on each of the following:

- Ethics and Data Integrity (See 5.2.2.1.3)
- Quality Manual / Quality Management System (See 5.2.2.1.4)
- Safety Manual and any training requirements specified in the manual.
- Policies & SOPs relevant to their job tasks
- Technical personnel that prepare and test samples must also successfully complete an initial demonstration of capability (IDOC) for the test methods performed before independently testing customer samples. (See 5.2.2.1.5). Independent testing means without direct supervision of the work activity by the supervisor or a qualified trainer.

All required training must be documented and verified complete by the local QM before the employee is authorized to work independently on client samples. Until then, the employee's direct supervisor is responsible for all work produced by the new employee under their supervision.

5.2.2.1.2 On-Going Required Training

Personnel receive on-going training in each of the following topics:

- Ethics and Data Integrity (See 5.2.2.1.3)
- Quality Manual / Quality Management System (See 5.2.2.1.4)
- Safety
- Changes to Policies & SOPs, relevant to their job activities.
- New Policies & SOPS, relevant to their job activities.
- Technical personnel must also successfully complete on-going demonstration of capability (CDOC) for all test methods performed on an annual basis. (See 5.2.2.1.5)

All required training must be documented and verified complete by the local QM with training records readily accessible in accordance with the corporate policy for Record Management (ENV-POL-CORQ-0013).

5.2.2.1.3 Ethics and Data Integrity Training

Data integrity training is provided to all new personnel and refresher data integrity training is provided to all employees on an annual basis. Personnel are required to acknowledge they understand that any infractions of the PAS data integrity procedures will result in a detailed investigation that could lead to profound consequences

including immediate termination, debarment, or civil/criminal prosecution.

Completion of data integrity training is documented using the mechanism established by Pace® to provide evidence that the employee has participated in training on this topic and understand their obligations related to data integrity.

The following topics and activities are covered:

- Policy for honesty and full disclosure in all analytical reporting;
- Prohibited Practices;
- How and when to report data integrity issues;
- Record keeping. The training emphasizes the importance of proper written documentation on the part of the analyst with respect to those cases where analytical data may be useful, but are in one sense or another partially nonconforming;
- Training Program, including discussion regarding all data integrity procedures;
- Data integrity training documentation;
- In-depth procedures for data monitoring; and
- Specific examples of breaches of ethical behavior such as improper data manipulations, adjustments of instrument time clocks, and inappropriate changes in concentrations of standards.

All PAS personnel, including contract and temporary, are required to sign an "Attestation of Ethics and Confidentiality" at the time of hire and/or during annual refresher training or as specified in the ethics policy. This document clearly identifies inappropriate and questionable behavior. Violations of this document result in profound consequences, including prosecution and termination, if necessary.

Also see SOP-ENV-COR-POL-0004 *Code of Ethics and Professional Conduct* for more information.

5.2.2.1.4 Management System Documents Training

The Quality Manual policies, and SOPs are the documents used by regulatory bodies and Pace® customers to verify capability, competency, and compliance with their requirements and expectations.

In addition to on-the-job training, employees must have a signed Read and Acknowledgement Statement (R&A) on record for the quality manual, and the policies and SOPs relating to his/her job

responsibilities. This statement, whether signed by the employee electronically or by wet signature, confirms that the employee has received, read, and understands the content of the document, that the employee agrees to follow the document when carrying out their work tasks; and the employee understands that unauthorized change to procedures in an SOP is not allowed except in accordance with the SOP departure policy (See 4. 9.1).

See SOP ENV-CORQ-0016 *Standard Operating Procedures and Standard Work Instructions* for more information.

5.2.2.1.5 Demonstration of Capability (DOC) Requirements

An initial demonstration of capability (IDOC) must be completed and validated prior to authorization for the employee to work independently on client samples for the test method. After successful IDOC, the employee must demonstrate continued proficiency (CDOC) for the test method on an annual basis. If more than a year has passed since the employee last performed the method; then capability must be re-established with an IDOC.

Successful DOC is one where the DOC replicate data has been compiled, reviewed, and verified by the employee's supervisor and/or manager to be complete and to have met acceptance criteria and the DOC record has been validated by quality personnel for completeness and compliance, and placed in the employee's training file for accessibility and reference.

Demonstration of capability (DOC) procedures and requirements vary by technology.

For example, a DOC for chemistry test methods where spiking is appropriate, is based on the employee's capability to achieve acceptable precision and accuracy for each analyte reported by the laboratory for the test method using the laboratory's test method SOP.

DOC procedures and requirements must be specified in the laboratory's test method SOP or a stand-alone SOP. Refer to these SOPs for more information.

5.2.2.1.6 Effectiveness of Training

Effectiveness of individual employee training is measured by their demonstrated ability to comprehend the training material and apply knowledge and skills gained to their job task. Measurements include but are not limited to:

- Testing of the employee's knowledge of the QMS, policies, and technical and administrative procedures through various mechanisms, such as quizzes, observation, and interviews.

- Demonstrated ability to convey information correctly and factually in written and verbal communication to internal and external parties.
- Demonstrated ability to carry out tasks in accordance with SOPs and other work instructions.
- Demonstrated ability to make sound decisions based on guidance and information available.
- Demonstrated initiative to seek help or guidance when the employee is unsure of how to proceed.

5.2.2.2 Supplemental Learning

Supplemental learning objectives may be established for newly hired personnel to aid in their development of administrative and technical skills. These learning objectives and materials, referred to as Learning Plans (LP), are created and maintained by the PAS 3P program and managed by the employee's direct supervisor.

Pace® also offers a wide variety of supplemental learning courses that are made available to all employees for professional development. These learning materials, maintained by Pace® corporate training personnel, are accessed via the company's employee portal, PaceConnect. The learning may be self-initiated based on an employee's interest or may be assigned to the employee at the discretion of management as professional development as part of an employee's annual goals.

Supplemental learning courses and learning plan activities are not prerequisites for competency (Section 5.2.1.1) and are not considered part of the required PAS QMS training program.

5.2.3 Personnel Supervision

Every employee is assigned a direct supervisor, however named, who is responsible for their supervision.

General supervisory responsibilities may include but are not limited to:

- Hiring Employees
- Training Employees
- Performance Management
- Development, oversight, and execution of personnel training plans
- Monitoring personnel work product to assure the work is conducted in accordance with this quality manual, policies, SOPs, and other documents that support the QMS.

5.2.4 Job Descriptions

Job Descriptions that define the required education, qualifications, experience, skills, roles and responsibilities, and reporting relationships for each Pace® position are established by top management and kept by corporate HR. The job descriptions apply to employees who are

directly employed by Pace®, part-time, temporary, technical, and administrative and by those that are under contract with Pace® through other means.

The job descriptions include the education, expertise, and experience required for the position and the responsibilities and duties, including any supervisory or managerial duties assigned to the position.

5.2.5 Authorization of Technical Personnel

Technical personnel are authorized by local quality personnel to perform the technical aspects of their position after quality personnel have verified that the employee meets the qualifications for the position, has successfully completed required training (Section 5.2.2.1), and the employee has completed initial demonstrated capability (Section 5.2.2.1.5). After initial authorization, technical personnel are expected to maintain a current and complete training record, demonstrate on-going capability at least annually for each test method performed, and produce reliable results through accurate analysis of certified reference materials, proficiency testing samples, and/or routine quality control samples in order to remain authorized to continue to perform their duties.

Records to support authorization including, education, experience, training, and other evaluations are kept by the location where the employee works.

5.3 Accommodations and Facilities

5.3.1 Facilities

PAS laboratories and service centers are designed to support the correct performance of procedures and to not adversely affect measurement integrity or safety. Access to PAS facilities is controlled by various measures, such as card access, locked doors, staffed main entry.

5.3.2 Environmental Conditions

Each location is equipped with energy sources, lighting, heating, and ventilation necessary to facilitate proper performance of calibrations and tests. The location ensures that housekeeping, electromagnetic interference, humidity, line voltage, temperature, sound, and vibration levels are appropriately controlled to ensure the integrity of specific measurement results and to prevent adverse effects on accuracy or increases in the uncertainty of each measurement.

Environmental conditions are monitored, controlled, and recorded as required by the relevant specifications, methods, and procedures. Operations are stopped if it is discovered that the environmental conditions would jeopardize the integrity of analytical results or other work product.

5.3.3 Separation of Incompatible Activities

The layout and infrastructure of each work area including air handling systems, power supplies, and gas supplies of each work area is specifically designed for the type of analytical activity performed. Effective separation between incompatible work activities is maintained. For example, sample storage, preparation, and chemical handling for volatile organic analysis (VOA) is kept separate from semi-volatile organic (SVOA).

Samples known or suspected to contain high concentration of analytes are separated from other samples to avoid the possibility for cross-contamination. If contamination is found, the source of contamination is investigated and resolved in accordance with applicable SOPs.

5.3.4 Security

Security is maintained by controlled access to the building and by surveillance of work areas by authorized personnel. Access is controlled to each area depending on the required personnel, the sensitivity of the operations performed, and potential safety concerns.

5.3.5 Good Housekeeping

PAS locations must maintain good housekeeping practices in work areas to maintain a standard of cleanliness necessary for analytical integrity and personnel health and safety.

5.4 Test Methods

5.4.1 General Requirements

The laboratory uses test methods and procedures that are appropriate for the scope of analytical services the laboratory offers.

Instructions on the use and operation of equipment and sample handling, preparation, and analysis of samples are provided in SOPs. The instructions in SOPs may be supplemented with other documents including, but not limited to, standard work instructions (SWI), manuals, guides, project documents and reference documents.

These documents are managed using the procedures described in SOP ENV-SOP-CORQ-0015 *Document Management and Control* and SOP ENV-SOP-CORQ-0016 *Standard Operating Procedures and Standard Work Instructions.*

5.4.2 Method Selection

The test methods and protocols used by the laboratory are selected to meet the needs of the customer, are appropriate for the items tested, for the intended use of the data, and to conform with applicable federal, statutory, or program requirements.

The test methods offered by PAS are industry accepted methods published by international, regional, or national standards. Each PAS laboratory bases its procedure on the latest approved edition of a method unless it is not appropriate or possible to do so, or unless regulatory requirements specify otherwise.

The laboratory confirms that it can perform the test method and achieve desired outcome before analyzing samples (see section 5.4.5). If there is a change in the published analytical method, then the confirmation is repeated.

When a customer does not specify the test method(s) to be used, the laboratory may suggest test methods that are appropriate for the intended use of the data and the type of samples to be tested. The laboratory will also inform customers when test methods requested are considered inappropriate for their purpose and/or out of date. This discourse takes place during review of analytical service requests (See Section 4.4).

5.4.3 PAS Developed Methods

A PAS developed method is a method developed from scratch (no published source method), a procedure that modifies the chemistry from the source method, or a procedure that exceeds the scope and application of the source method.

PAS developed methods must be validated prior to use (see section 5.4.5) and the procedure documented in a test method SOP.

The requirements for non-standard methods (Section 5.4.4) also apply to PAS developed methods.

5.4.4 Non-standard Methods

A non-standard method is a method that is not published or approved for use by conventional industry standards for the intended purpose of the data. Non-standard methods must be validated prior to use (see section 5.4.5) and the procedure developed and documented in a test method SOP.

At a minimum, the following information must be included in the procedure:

- Title / Identification of Method;
- Scope and Application;
- Description of the type of item to be analyzed;
- Parameters or quantities and ranges to be determined;
- Apparatus and equipment, including technical performance requirements;
- Reference standards and reference materials required;
- Environmental conditions required and any stabilization period needed; and
- Description of the procedure, including:
    - Affixing identification marks, handling, transporting, storing, and preparing of items;
    - Checks to be made before the work is started;
    - Verifying equipment function and, where required, calibrating and/or adjusting the equipment before each use;
    - Method of recording the observations and results;
    - Any safety measures to be observed;
    - Criteria and/or requirements for approval/rejection;
    - Data to be recorded and method of analysis and presentation; and
    - Uncertainty or procedure for estimating uncertainty.

Use of a non-standard method for testing must be agreed upon with the customer. The agreement, which is retained by the laboratory in the project record, must include the specifications of the client's requirements, the purpose of testing, and their authorization for use of the non-standard method.

5.4.5 Method Validation

5.4.5.1 Validation Description

Validation is the process of confirmation and the provision of objective evidence that the stated requirements for a specific method/procedure are fulfilled.

The laboratory's requirements and procedures for method validation are outlined in SOP ENV-SOP-CORQ-0011 *Method Validation and Instrument Verification.*

5.4.5.2 Validation Summary

All test methods offered by the laboratory are validated before use to confirm the procedure works and the data and results achieved meet the goals for the method and repeated when there are major changes to the laboratory procedure.

Results of validation are retained are kept in accordance with method validation SOP and the corporate policy ENV-CORQ-POL-0013 *Record Management*.

5.4.5.3 Validation of Customer Need

The validation process includes review of accuracy, precision, sensitivity, selectivity, linearity, repeatability, reproducibility, robustness, and cross-sensitivity of the procedure against general customer needs to ensure the laboratory's procedure will meet those needs.

The following subsections explain some concepts as they are applied to chemistry. The applications of these same concepts may differ for other technologies such as microbiology, radiochemistry, whole effluent toxicity (WET), and asbestos or other validation concepts may apply to these disciplines. Refer to the laboratory's test method SOPs for more information.

5.4.5.3.1 Accuracy

Accuracy is the degree to which the result of a measurement, calculation, or specification conforms to the correct value or a standard. When the result recovers within a range from the known value (control limit); the result generated using the laboratory's test method SOP is considered accurate.

5.4.5.3.2 Precision

Precision refers to the closeness of two or more measurements to each other. It is measured by calculating the relative percent difference (RPD) or relative standard deviation (RSD) from results of separate analysis of the same sample. Precision provides information about repeatability, reproducibility, and robustness of the laboratory's procedure.

5.4.5.3.3 Limits of Detection (LOD) (Chemistry)

The LOD is the minimum result which can be reliably discriminated from a blank with a predetermined confidence level. The LOD

establishes the limit of method sensitivity and is also known as the detection limit (DL) or the method detection limit (MDL).

Values below the LOD cannot be reliably measured and are not reported by the laboratory unless otherwise specified by regulatory program or test method.

The LOD is established during method validation and after major changes to the analytical system or procedure that affect sensitivity are made.

The laboratory's procedure for LOD determination is specified in SOP ENV-SOP-GBAY-0106 *Determination of the LOD and LOQ*.

For chemistry methodology, the local SOP must comply with the current version of each of the following documents:

- EPA document EPA-821-R-16-006 *Definition and Procedure for the Determination of the Method Detection Limit;*
- 2016 TNI Standard V1M4; and
- TNI GUID-3-109-Rev. 0, *V1M4 2016 Standard Update Guidance on Detection and Quantitation.*

5.4.5.3.4 Limits of Quantitation (LOQ) and Reporting Limit (RL)

This section describes these concepts for chemistry. For non-chemistry technologies, such as microbiology, refer to laboratory SOPs.

The LOQ is the minimum level, concentration, or quantity of a target analyte that can be reported with a specified degree of confidence.

The LLOQ is the value of the lowest calibration standard included in the calibration curve. The LLOQ establishes the lower limit of quantitation; it is not the same concept as the LOQ, however, the LOQ and LLOQ may be the same value.

The LOQ and LLOQ represent quantitative sensitivity of the test method.

- The LOQ must always be equal to or greater than the LLOQ and the LLOQ must always be greater than the LOD.
- Any reported value (detect or non-detect) less than the LLOQ is a qualitative value.

The RL is the value to which the presence of a target analyte is reported as detected or not detected. The RL is project-defined based on project data quality objectives (DQO). In the absence of

project specific requirements, the RL is usually set to the LOQ or the LLOQ.

The laboratory's procedures for LOQ determination must be specified in the same SOP for LOD determination, (See Section 5.4.5.3.3) The LLOQ for each method must be specified in the test method SOP.

Linearity is a mathematical concept applied to calibration models that employ multiple points to establish a calibration range used for quantitative analysis. Linearity is measured differently based on the calibration model. In general, if linearity is demonstrated then the slope of the response of standards are sufficiently close to one another. The accuracy of the linear regression and non-linear curves is verified by checking percent error or relative standard error (RSE), which is the process of refitting calibration data back to the model to determine if the results are accurate. For linear curves that use average calibration or response factor, error is measured by relative standard difference (RSD).

Linearity also establishes the range of quantitation for the test method used which directly impacts the sensitivity of the test method and uncertainty in measurement results. As previously noted, the LLOQ establishes the lower limit of quantitation. Similarly, the upper range of linearity establishes the upper limit of quantitation. In general, results outside of this range are considered qualitative values. However, inorganic test methods sometimes allow for extension of the linear range above the upper limit of quantitation when accuracy at this value is verified.

Linearity can also be used to establish repeatability, reproducibility, and robustness of the laboratory's test method. When linearity is demonstrated using a specific calibration model during method validation, then use of this same calibration model to achieve linearity on a day-to-day basis confirms the laboratory's method is repeatable, reproducible, and robust.

5.4.5.3.5 Demonstration of Capability (DOC)

The DOC performed during method validation confirms that the procedure demonstrated acceptable precision and accuracy.

5.4.6 Measurement Uncertainty

The location provides an estimate of uncertainty in testing measurements with analytical results on request, or when required. For example, for radiochemistry uncertainty is always reported with the test result

For chemistry methodologies, the uncertainty of the test method is reflected in the control limits used to evaluate QC performance for the test method. (See 5.9.1.1.9). ISO/IEC states that when a well-recognized test method specifies limits to the values of the major source of

uncertainty of measurement and specifies the form of presentation of calculated results, the laboratory has satisfied the requirements on analytical uncertainty by following the test method and reporting instructions.

When measurement uncertainty cannot be satisfied through control limits, the location will provide a reasonable estimation of uncertainty. A reasonable estimation is based on knowledge of method performance and previous experience. When estimating the analytical uncertainty, all uncertainty components which are of importance in the given situation are considered.

5.4.7 Control of Data

PAS has policies and processes in place to assure that reported data is free from calculation and transcription errors, that quality control is reviewed and evaluated before data is reported, and to address manual calculation and integration.

5.4.7.1 Calculations, Data Transfer, Reduction and Review

Whenever possible, calculations, transfer of data, and data reduction are performed using validated software programs (See 5.4.7.2).

If manual calculations are performed, the results of these calculations are verified during the data review process outlined in section 5.9.3.

5.4.7.1.1 Manual Integration

The PAS policy and procedures for manual integration are provided in corporate SOP ENV-SOP-CORQ-0006 *Manual Integration*.

This SOP includes the conditions under which manual integration is allowed and the requirements for documentation.

Required documentation of manual integration includes:

- complete audit trail to permit reconstruction of before and after results;
- identification of the analyst that performed the integration and the reason the integration was performed; and
- identification of the individual(s) that reviewed the integration and verified the integration was done and documented in compliance with the SOP.

5.4.7.2 Use of Computers and Automated Acquisition

Whenever possible, PAS uses software and automation for the acquisition, processing, recording, reporting, storage, and/or retrieval of data.

Software applications developed by PAS are validated by corporate IT for adequacy before release for routine use. Commercial off the shelf software is considered sufficiently validated when the location follows the manufacturer or vendor's manual for set-up and use. Records of validation are kept by the corporate information technology (IT) group or by the group that performed the validation.

The PAS process for the protection of data stored in electronic systems includes:

- Individual usernames and passwords for Laboratory Information Management Systems (LIMS) and auxiliary systems used to store or process data.
- Employee Training in Computer Security Awareness
- Validation of spreadsheets used for calculations to verify formulas and logic yield correct results and protection of these cells to prevent unauthorized change.
- Operating system and file access safeguards
- Protection from Computer Viruses
- Regular system backup; and testing of retrieved data
- Verification the software application works as expected and is adequate for use and fulfills compliance requirements, such as the need to record date/time of data generation.
- Change control to assure requests for changes are reviewed and approved by management before the change is made.
- Communication channels to assure all staff are aware of changes made.
- Version Control and maintenance of historical records.

5.5 Equipment

5.5.1 Availability of Equipment

Each PAS location is furnished with all equipment and instrumentation necessary to correctly perform the tests offered in compliance with the specifications of the test method and to achieve the accuracy and sensitivity required.

When a regulation, program, or reference test method requires Class A glassware for quantitative measurements, only Class A glassware may be used. Plastic graduated cylinders, even if marketed by the vendor as comparable to Class A glassware, may not be used when Class A glassware is specified because ASTM's definition and tolerances for Class A glass cannot be applied to other materials.

5.5.2 Calibration

Equipment and instrumentation are checked prior to use to verify it performs within tolerance for its intended application.

5.5.2.1 Support Equipment

The location confirms support equipment is in proper working order, uniquely identified, and meets the specifications for use prior to placement in service. Periodic checks are performed to verify tolerance and accuracy are performed thereafter in accordance with a support equipment maintenance scheduled maintained by local quality personnel. Equipment that does not meet specifications is removed from

service until repaired or replaced. Records of repair and maintenance activities are maintained.

Procedures used to conduct and record these checks are outlined in SOP ENV-SOP-GBAY-0115 *Support Equipment*.

5.5.2.2 Analytical Instruments

Analytical instruments are checked prior to placement in service in accordance with SOP ENV-SOP-CORQ-0011 *Method Validation and Instrument Verification.* After the initial service date, the calibration of instruments and verification calibration is performed in accordance with local test method SOPs.

The calibration procedures in the test method SOPs comply with the requirements for acceptable calibration practices outlined in corporate policy ENV-POL-CORQ-0005 *Acceptable Calibration Practices*, the reference methods, and any applicable regulatory or program requirements.

5.5.3 Equipment Use and Operation

Equipment is operated and maintained by personnel that are trained on the test method SOP. Up-to-date instructions and procedures for the use and maintenance of analytical equipment are included in SOPs and/or supplemental documents such as standard work instructions (SWI) or instrument manuals which are made readily accessible in the work area to all laboratory personnel.

5.5.4 Equipment Identification

Each piece of equipment must be uniquely identified by serial number or any other unique ID system. The identifier is included in the equipment list maintained by the quality department and may not be reused or used interchangeably. New equipment and replacement equipment must be assigned a new unique ID.

5.5.5 Equipment Lists and Records

5.5.5.1 Equipment List

Each PAS location maintains a list of equipment that includes information about the equipment including a description, manufacturer, serial number, date placed in service, condition when received, identity, and the work area where the equipment is used. The date of purchase is tracked by the procurement record. The equipment list(s) for each location covered by this manual is provided in Appendix E.

5.5.5.2 Equipment Records

In addition to the equipment list, the location maintains records of equipment that include:

- Verification that equipment conforms with specifications.
- Calibration records including dates, results, acceptance criteria, and next calibration dates.
- Maintenance plan and records

- Records of damage, malfunction, or repair

The laboratory follows an equipment maintenance program designed to optimize performance and to prevent instrument failure which is described in SOP ENV-SOP-GBAY-0098 *Preventative, Routine, or Non-routine Maintenance*.

The maintenance program includes routine maintenance activities which are performed as recommended by the manufacturer at the frequency recommended and non-routine maintenance, which is performed to resolve a specific problem such as degradation of peak resolution, shift in calibration relationship, loss of sensitivity, or repeat failure of instrument performance checks and quality control samples.

Maintenance is performed by PAS personnel or by outside service providers.

All maintenance activities performed by PAS personnel are recorded by the individual(s) that performed the activity at the time the maintenance was performed in an instrument maintenance log.

The maintenance record minimally includes the date of maintenance, the initials of the person(s) performing maintenance, a description of the activity performed, why (when the maintenance is non-routine), and the return to analytical control. When maintenance is performed by an external vendor, the service must be maintained and accessible for easy retrieval. The location must provide personnel with unrestricted access to instrument maintenance logs in order to promote good instrument maintenance and recordkeeping practices.

If an instrument must be moved, the location will use safe practices for handling and transport to minimize damage and contamination.

5.5.6 Out of Service Protocol

Equipment that has been subjected to overloading, mishandling, gives suspect results, has been shown to be defective, or is performing outside of specified limits is taken out of service and either removed from the work area or labeled to prevent accidental use until it has been repaired and verified to perform correctly.

When analytical equipment is taken out of service because it no longer meets tolerance specifications, the potential effect of the nonconformance may have had on previously reported analytical results should be evaluated. (See section 4.9).

5.5.7 Calibration Status

The location labels support equipment to indicate calibration status, whenever practicable or otherwise maintains the calibration status in a visible location in the work area. These procedures are described in SOP ENV-SOP-GBAY-0115 *Support Equipment.*

The calibration status of analytical instruments is documented in the analytical record. Analysts verify on-going acceptability of calibration status prior to use and with instrument performance check standards. These procedures are described in test method SOPs.

5.5.8 Returned Equipment Checks

When equipment or an instrument is sent out for service, the location using the equipment ensures that the function and calibration status of the equipment is checked and shown to be satisfactory before the equipment is returned to service.

5.5.9 Intermediate Equipment Checks

The location performs intermediate checks on equipment to verify the on-going calibration status. For example, most test methods require some form of continuing calibration verification check, and these procedures are included in the test method SOP. Periodic checks of support equipment are also performed; see SOP ENV-SOP-GBAY-0115 *Support Equipment* for more information.

5.5.10 Safeguarding Equipment Integrity

The location safeguards equipment integrity using a variety of mechanisms that include but are not limited to:

- Adherence to manufacturer's specification for instrument use so that settings do not exceed manufacturer's recommendation or stress the performance of the equipment.
- Established maintenance programs.
- Transparent maintenance records and unrestricted access to maintenance logs.
- Validation and approval of software before use.
- Audits to confirm instrument settings are consistent with SOPs.
- On-the-job training for safe and proper use of laboratory equipment.

5.6 Measurement Traceability

5.6.1 General

Measurement traceability refers to a property of a measurement result whereby the result can be related to a reference through an unbroken chain of calibration, each contributing to the measurement uncertainty. Traceability requires an established calibration hierarchy of equipment (instruments) used during testing including equipment used for subsidiary measurements. The location assures this equipment is calibrated prior to being put into service and that the reference standard and materials used for calibration are traceable to the international standard of units (SI) or national measurement standard.

When strict traceability to SI units cannot be made, the location establishes traceability with the use of reference standards and equipment obtained from competent suppliers that provide calibration certificates and/or certificates of analysis (COA).

5.6.2 Equipment Correction Factors

When correction factors are used to adjust results the PAS personnel will assure that results in computer software are also updated.

5.6.3 Specific Requirements

5.6.3.1 Requirements for Calibration Laboratories

The laboratory does not offer calibration services to customers; therefore, ISO/IEC and TNI requirements for calibration laboratories do not apply.

5.6.3.2 Requirements for Testing Laboratories

The laboratory has procedures in place to verify equipment is calibrated prior to being put into service (See 5.5.2) and ensures the reference standard and materials used for calibration are traceable to the international standard of units (SI) or national measurement standard. When strict traceability to SI units cannot be made, the laboratory establishes traceability with the use of reference standards and equipment obtained from competent suppliers that provide calibration certificates and/or certificates of analysis (COA).

5.6.4 Reference Standards and Reference Materials

5.6.4.1 Reference Standards

The laboratory uses reference standards of measurement to verify adequacy of working weights and thermometers. The working weights are the weight(s) used for daily balance calibration checks and the working thermometers are used for daily temperature measurements.

Working weights and thermometers must be periodically checked to verify on-going adequacy for use between calibrations performed by an external calibration laboratory using reference standards traceable to SI or a national standard and that are used solely for verification purposes.

For example:

- An acceptable reference standard to check working thermometers against include a NIST Certified Thermometer or a NIST Traceable Thermometer that is not used for any other purpose than to check the adequacy of the working thermometer.
- An acceptable reference standard for the working weights is a set of Class S weights that is not used for any other purpose than to verify the weights used daily.

The working weights must be checked against the reference standard annually and all weight sets must be recertified by an ISO accredited calibration body every 5 years. In this application, “annually” means within thirteen (13) months from the date of the last check.

Working thermometers must be checked against the reference thermometer prior to placement in service to establish a correction factor (CF)[1] and then re-checked annually (±13 months from date of last check) or if battery operated, every three (3) months (±100 days from date of last check).

Exceptions to the 3-month recheck for battery operated sensors are allowed when the sensor is embedded in a unit and the manufacturer/vendor has evidence to show that the accuracy of the sensor is not affected by battery life.

Liquid in Glass NIST Certified reference thermometers must be recertified by an ISO/IEC accredited calibration laboratory every 5 years. If the reference thermometer is NIST Traceable or is a digital NIST Certified thermometer, the reference thermometer must be recertified annually by an ISO/IEC 17025 accredited calibration laboratory or service provider that provides traceability to a national standard.

If criteria for the intermediate checks or recertification is not acceptable, the impact on previously reported results is evaluated using the process for evaluation of nonconforming work (See 4.9).

See SOP ENV-SOP-GBAY-0115 *Support Equipment* for more information.

5.6.4.2 Reference Materials

The location purchases chemical reference materials (also known as stock standards) from vendors that are accredited to ISO 17034 or Guide 34. Purchased reference materials must be received with a Certificate of Analysis (COA) where available. If a reference material cannot be purchased with a COA, it must be verified by analysis and comparison to a certified reference material and/or there must be a demonstration of capability for characterization. COA are reviewed for adequacy and retained by the laboratory for future reference.

All prepared standards, reference materials, and reagents are verified to meet the requirements of the test method through routine analyses of quality control samples.

The laboratory procedure for traceability and use of these materials is provided in SOP ENV-SOP-GBAY-0145 *Laboratory Supply Procedures*.

This SOP includes each of the following requirements:

- Procedures for documentation of receipt and tracking. The record of entry includes name of the material, the lot number, receipt date, and expiration date.
- Storage conditions and requirements. Reference materials must be stored separately from samples, extracts, and digestates.
- Requirements to assure that preparations of intermediate or working solutions are recorded and assigned a unique identification number for tracking. Records of preparation include the lot number of the stock standard(s) used, the type and lot number of the solvent, the formulation, date, expiration date, and the preparer's initials. The lot number of the working standards is recorded in the analytical record to provide traceability to the standard preparation record. The preparation record provides traceability to the COA, which is traceable to SI or the national measurement standard.
- A requirement that the expiration dates of prepared standards may not exceed the expiration date of the parent standard. Standards, reference materials, and

reagents are not used after their expiration dates unless it is not possible to procure a new standard and the reliability of the expired material is verified and documented by the location using a procedure approved by corporate quality personnel. Otherwise, the expired material is promptly removed from the work area or clearly labeled as acceptable for qualitative/troubleshooting purposes only.

- The second source materials used for verification of instrument calibration are obtained from a different manufacturer or may be a different lot from the same manufacturer.
- Procedures to check reference materials for degradation and replacement of material if degradation or evaporation is suspected.
- Procedures for labeling. At a minimum, the container must identify the material, the ID of the material and the expiration date. Original containers should also be labeled with date opened.

5.6.4.3 Intermediate Checks

Checks to confirm the calibration status of reference standards and materials must be included in test method SOPs. These checks include use of second source standards and reference materials reserved only for the purpose of calibration checks.

5.6.4.4 Transport and Storage

The location handles and transports reference standards and materials in a manner that protects the integrity of the materials. Reference standard and material integrity is protected by separation from incompatible materials and/or minimizing exposure to degrading environments or materials. Standards and reference materials are stored separately from samples, extracts, and digestates. All standards are stored according to the manufacturer's recommended conditions. Temperatures colder than the manufacturer's recommendation are acceptable if it does not compromise the integrity of the material (e.g., remains in liquid state and does not freeze solid). In the event a standard is made from more than a single source with different storage conditions, the standard will be stored according to the conditions specified in the analytical method.

See the applicable analytical SOPs for specific reference material storage and transport protocols.

5.7 Sampling

Sampling refers to the field collection of samples and to subsamples taken by the laboratory for analysis from the field collected sample.

Subsampling procedures are included in each test method SOP or a stand-alone SOP to assure the aliquot used for testing is representative of the field collected sample.

The requirements in the following subsections apply when field sampling is performed by PAS.

5.7.1 Sampling Plans and SOPs

When PAS performs field collection of samples, sampling is carried out in accordance with a written sampling plan and sampling SOPs. These documents are made readily accessible at the sampling location. Sampling plans and SOPs are, whenever reasonable, based on appropriate governing methods and address the factors to be controlled to ensure the validity of the analytical results.

5.7.2 Customer Requested Deviations

When the customer requires deviations, additions, or exclusions from the documented sampling plan and/or procedure, the laboratory records the client's change request in detail with the sampling record, communicates the change to sampling personnel, and includes this information in the final test report.

5.7.3 Recordkeeping

PAS assures the sampling record includes the sampling procedure used, any deviations from the procedure, the date and time of sampling, the identification of the sampler, environmental conditions (if relevant), and the sampling location.

5.8 Sample Management & Handling

5.8.1 Procedures

The location's procedures for sample management and handling are outlined in SOP ENV-SOP-GBAY-0006 *Sample Management and Review of Analytical Requests.*

The procedures in these SOPs are established to maintain the safe handling and integrity of samples from transport, storage, to disposal and during all processing steps to maintain client confidentiality, and to protect the interests of PAS and its customers.

5.8.1.1 Chain of Custody

All samples received by the location must be accompanied with a Chain of Custody (COC) record. The COC provides information about the samples collected and submitted for testing and documents the possession of samples from time of collection to receipt by the location.

The COC record must minimally include the following information:

- Client name, address, phone number;
- Project Reference;
- Client Sample Identification (Client ID);
- Date, Time, and Location of Sampling;
- Sampler's Name or Initials;
- Matrix;
- Type of container, and total number collected for each sample;
- Preservatives;

- Analyses Requested;
- Mode of collection;
- Any special instructions; and
- The date and time and signature of each sample transfer from time of collection to receipt in the location. When the signature field on CoC includes company. Personnel relinquishing and/or receiving samples are expected to record this information. When the COC is transported inside the cooler, independent couriers do not sign the COC and the shipping manifests and/or air bills are the records of possession during transport. The shipping manifest must be retained as part of the COC record and included in the test report when required (See Section 5.10.3).

A complete and legible COC is required. If the location observes that the COC is incomplete or illegible, the client is contacted for resolution. The COC must be filled out in indelible ink. Personnel correct errors by drawing a single line through the initial entry, so the entry is not obscured, entering the correct information, and initialing, and dating the change.

5.8.1.2 Legal Chain of Custody

Legal chain of custody is a chain of custody protocol used for evidentiary or legal purposes. The protocol is followed by the location when requested by customer or when mandated by a regulatory program.

Legal chain of custody (COC) protocol establishes an intact, continuous record of the physical possession*, storage, and disposal of “samples” which includes sample aliquots, and sample extracts/digestates/distillates.

Legal COC records account for all time periods associated with the samples and identifies all individuals who physically handled individual samples. Legal COC begins at the point established by legal authority, which is usually at the time the sample containers are provided by the location for sample collect or when sample collection begins.

*A sample is in someone’s custody if:

- It is in one’s physical possession;
- It is in one’s view after being in one’s physical possession;
- It has been in one’s physical possession and then locked or sealed so that no one can tamper with it; and/or
- It is kept in a secure area, restricted to authorized personnel only.

Refer to SOP ENV-SOP-GBAY-0006 *Sample Management and Review of Analytical Requests* for more information.

5.8.2 Unique Identification

Each sample is assigned a unique identification number (Lab ID) after the sample has been checked and accepted by PAS in accordance with the PAS sample acceptance policy (See 5.8.3). The Lab ID is affixed to the sample container using a durable label.

The unique identification of samples also applies to subsamples, and prepared samples.

The lab ID is linked to the field ID (client ID) in the receipt and log-in record. Both IDs are linked to the testing activities performed on the sample and the documentation records of the test.

Also see 5.8.4.

5.8.3 Sample Receipt Checks and Sample Acceptance Policy

The location checks the condition and integrity of samples on receipt and compares the labels on the sample containers to the COC record. Any problem or discrepancy is recorded. If the problem impacts the suitability of the sample for analysis or if the documentation is incomplete, the client is notified for resolution. Decisions and instructions from the client are maintained in the project record.

5.8.3.1 Sample Receipt Checks

The following checks are performed:

- Verification that the COC is complete and legible.
- Verification that each sample's container label includes the client sample ID, the date and time of collection and the preservative in indelible ink.
- The container type and preservative are appropriate for each test requested.
- Adequate volume is received for each test requested.
- Visual inspection for damage or evidence of tampering.
- Visual inspection for presence of headspace in VOA vials. (VOA = volatile organic analysis).
- Thermal Preservation: For chemical testing methods for which thermal preservation is required, temperature on receipt is typically considered acceptable if the measurement is above freezing but <6°C unless otherwise specified by federal, statutory, program or test method requirements. Refer to the location's SOP for sample receipt for specific thermal preservation requirements.

  For samples that are hand-delivered to the location immediately after sample collection, there must be evidence that the chilling process began immediately after sample collection and prior to delivery of the samples to the laboratory or service center, such as arrival of the samples on ice.
- Chemical Preservation
- Holding Time: Sample receiving personnel are trained to recognize tests where the holding time is 48 hours or less and to expedite the log-in of these samples.

Except for tests with immediate holding times (15 minutes from time of collection or less), when samples are received out of hold, the location will notify the client and request instruction. If the decision is made to proceed with analysis, the final test report will include notation of this instruction.

5.8.3.2 Sample Acceptance Policy

PAS maintains a sample acceptance policy in accordance with regulatory guidelines to clearly establish the circumstances in which sample receipt is accepted or rejected.

When receipt does not meet criteria for any one of these conditions, the location must document the noncompliance, contact the customer, and either reject the samples or fully document any decisions to proceed with testing. In accordance with regulatory specifications, test results associated with receipt conditions that do not meet criteria are qualified in the final test report.

All samples received must meet each of the following criteria:

- Be listed on a complete and legible COC;
- Be received in properly labeled sample containers;
- Be received in appropriate containers that identify preservative;
- The COC must include the date and time of collection for each sample;
- The COC must include the test method requested for each sample;
- Be in appropriate sample containers with clear documentation of the preservatives used;
- Be received within holding time. Any samples received beyond the holding time will not be processed without prior customer approval;
- Have sufficient sample volume to proceed with the analytical testing. If insufficient sample volume is received, analysis will not proceed without customer approval; and
- Be received within appropriate temperature ranges unless program requirements or customer contractual obligations mandate otherwise.

  Samples that are delivered to the location immediately after collection are considered acceptable if there is evidence that the chilling process has been started. For example, by the arrival of the samples on ice. If samples arrive that are not compliant with these temperature requirements, the customer will be notified. The analysis will NOT proceed unless otherwise directed by the customer. If less than 72 hours remain in the hold time for the analysis, the analysis may be started while the customer is contacted to avoid missing the hold time. Data associated with any deviations from the above sample acceptance policy requirements will be appropriately qualified.

5.8.4 Sample Control and Tracking

The samples are controlled and tracked using the Laboratory Information Management System (LIMS). The LIMS stores information about the samples and project. The process of entering information into the LIMS is called log-in and these procedures are described in SOP ENV-SOP-GBAY-0006 *Sample Management and Review of Analytical Requests.* After log-in, a label is generated and affixed to each sample container. Information on this label, such as the lab ID, links the sample container to the information in LIMS.

At a minimum, the following information is entered during log-in:

- Client Name and Contact Information;
- The laboratory ID linked to the client ID;
- Date and time of sample collection;
- Date and time of sample receipt;
- Matrix; and
- Tests Requested.

5.8.5 Sample Storage, Handling, and Disposal

The location procedures for sample storage, handling and disposal are detailed in SOPs ENV-SOP-GBAY-0006 *Sample Management and Review of Analytical Requests.*

5.8.5.1 Sample Storage

The samples are stored according to method and regulatory requirements as per test method SOPs. Samples are stored away from all standards, reagents, or other potential sources of contamination and stored in a manner that prevents cross contamination. Volatile samples are stored separately from other samples. All sample fractions, extracts, leachates, and other sample preparation products are stored in the same manner as actual samples or as specified by the analytical method.

Refrigerated storage areas are maintained at ≤6°C (but not frozen) and freezer storage areas are maintained at <-10°C, unless otherwise required per method or program. The temperature of each storage area is checked and documented at least once for each day of use. If the temperature falls outside the acceptable limits, then corrective actions are taken and appropriately documented.

The location is operated under controlled access protocols to ensure sample and data integrity. Visitors must register at the front desk and be properly escorted while on-site. Samples are taken to the appropriate storage location immediately after sample receipt and log-in procedures are completed. All sample storage areas have limited access. Samples are removed from storage areas by designated personnel and returned to the storage areas as soon as possible after the required sample quantity has been taken.

5.8.5.2 Sample Retention and Disposal

The procedures used by the location for sample retention and disposal are detailed in SOP ENV-SOP-GBAY-0126 *Waste Handling and Management.*

In general, unused sample volume and prepared samples such as extracts, digestates, distillates and leachates (samples) are retained by the location for the timeframe necessary to protect the interests of the location and the customer.

Samples may be stored at ambient temperature when all analyses are complete, the hold time is expired, the report has been delivered, and/or when allowed by the customer or program. Samples requiring storage beyond the minimum sample retention time due to special requests or contractual obligations may be stored at ambient temperature unless the location has a capacity, and their presence does not compromise the integrity of other samples.

After this period expires, non-hazardous samples are properly disposed of as non-hazardous waste. The preferred method for disposition of hazardous samples is to return the excess sample to the customer.

5.9 Assuring the Quality of Test Results

5.9.1 Quality Control (QC) Procedures

The location monitors the validity and reliability of test results using quality control (QC) samples that are prepared and analyzed concurrently with field samples in the same manner as field samples. QC results are always associated to and reported with the field samples they were prepared and analyzed with from the same preparation or analytical batch. See the glossary for definition of preparation and analytical batch.

The results of QC performed during the testing process are used by the location to assure the results of analysis are consistent, comparable, accurate, and/or precise within a specified limit. When the results are not within acceptance criteria or expectations for method performance, correction and corrective action(s) are taken. These actions may include retesting or reporting of data with qualification to alert the end user of the situation.

Other QC measures performed include the use of certified reference materials (see 5.6.4), participation in interlaboratory proficiency testing (see 5.9.1.2), verification that formulae used for reduction of data and calculation of results is accurate (see 5.9.3), on-going monitoring of environmental conditions that could impact test results (see 5.3.2), and evaluation and verification of method selectivity and sensitivity (see 5.4.5).

QC results are also used by the location to monitor performance statistical trends over time and to establish acceptance criteria when no method or regulatory criteria exist. (See 5.9.1.1.9)).

5.9.1.1 Essential QC

Although the general principles of QC for the testing process apply to all testing, the QC protocol used for each test depends on the type of test performed.

QC protocol used by the location to monitor the validity of the test are specified in test method SOPs. The SOP includes QC type, frequency, acceptance criteria, corrective actions, and procedures for reporting of nonconforming work.

These requirements in the SOP conform to the reference method and any applicable regulations or certification and accreditation program requirement for which results of the test are used. When a project requires more stringent QC protocol than specified in the SOP, project specification is followed. When the project requires less

stringent QC protocol, the project specification may be followed as an authorized departure from the SOP when the project specifications meet the requirements in the mandated method and any regulatory compliance requirements for which the data will be used.

The following are examples of essential QC for chemistry. These concepts may not apply to other technologies and disciplines such as microbiology, radiochemistry, whole effluent toxicity, and/or asbestos. For essential QC for these disciplines, refer to test method SOPs.

5.9.1.1.1 Second Source Standard (ICV/QCS)

The second source standard is a standard obtained from a different vendor than the vendor of the standards used for calibration, or from a different lot from the same vendor, when only one vendor is available. It is a positive control used to verify the accuracy of instrument calibration relative to the purity of the standards used for calibration. This check may be referred to in published test methods and quality system standards as the initial calibration verification (ICV) or a quality control sample (QCS). The second source standard is analyzed immediately after the calibration and before analysis of any samples. When the ICV is not within acceptance criteria, a problem with the purity or preparation of the standards may be indicated. The source of the problem should be investigated and corrected prior to further use of the calibration/instrument for sample analysis.

5.9.1.1.2 Continuing Calibration Verification (CCV)

The CCV is used to determine if the analytical response has significantly changed since calibration. If the response of the CCV is within criteria, the calibration is considered valid. If not, there is a problem that requires further investigation and correction. Actions taken are technology and method specific.

5.9.1.1.3 Method Blank (MB) / Other Blanks

The MB is a negative control used to assess for contamination during the prep/analysis process. The MB consists of a clean matrix, similar to the associated samples that is known to be free of analytes of interest. The MB, unless otherwise specified by the test method, is processed with, and carried through all preparation and analytical steps as the associated samples.

The criteria used to assess for contamination depends on the intended use of data. In general, detections in the MB above the RL or ½ the RL indicate contamination. When contamination is evident, the source is investigated, and corrections are taken to reduce or eliminate it. Analytical results associated with MB that does not meet criteria are qualified in the final test report.

Other types of blanks that serve as negative controls in the process may include:

- Trip Blanks (VOA)
- Storage Blanks
- Equipment Blanks
- Field Blanks
- Calibration Blanks
- Cleanup Blanks
- Instrument Blanks

5.9.1.1.4 Laboratory Control Sample (LCS)

The LCS is a positive control used to measure the accuracy of process in a blank matrix. The LCS is spiked by the laboratory with a known amount of analyte. The spike is a standard solution that is pre-made or prepared from a certified reference standard. Like the MB, unless otherwise specified in the test method, the LCS is processed with and carried through all preparation and analytical steps as the associated samples.

When the percent recovery (%R) of the LCS is within the established control limit, sufficient accuracy has been achieved. If not, the source of the problem is investigated and corrected, and the procedure may be repeated. Analytical results associated with LCS that does not meet criteria are qualified in the final test report.

5.9.1.1.5 Matrix Spike (MS) and Matrix Spike Duplicate (MSD)

The MS and MSD are replicates of a client sample that is spiked with known amount of target analyte. Matrix spikes measure the effect the sample matrix has on precision and accuracy of test results.

Matrix spike results mostly provide information on the effect of the matrix to the client whose sample was used and on samples of the same matrix from the same sampling site, during the same sampling event. Consequently, matrix spikes should be client designated. When there is not a client-specified MS for any sample in the batch, the location randomly selects a sample from the batch; the sample selected at random is called a “batch” matrix spike.

The MS/MSD results for percent recovery and relative percent difference are checked against control limits. However, because the performance of matrix spikes is matrix-dependent and specific to the customer whose sample was used as the MS/MSD, the results of matrix spikes are not used for quality control on the batch.

5.9.1.1.6 Sample Duplicate (SD)

A sample duplicate is a second replicate of sample that is used to measure precision.

The relative percent difference between replicates are evaluated against the established acceptance criteria for relative percent difference (RPD) when this criterion is applicable. If RPD is not met, associated test results are reported with qualification.

5.9.1.1.7 Surrogates

Surrogates are compounds that mimic the chemistry of target analytes but are not expected to occur naturally in real world samples. Surrogates are added to each sample and matrix QC samples (MS, MSD, SD) at known concentration to measure the impact of the matrix on the accuracy of method performance. Surrogates are also added to the positive and negative control samples (MB, LCS) to evaluate performance in a clean matrix, and included in the calibration standards and calibration check standards.

The percent recovery of surrogates is evaluated against method-specified limits or statistically derived in-house limits. Project-specific limits and/or program-specific limits are used when required. Results with surrogate recovery out of limits in samples are reported with qualification. Samples with surrogate failures can also be re-extracted and/or re-analyzed to confirm that the out-of-control value was caused by the matrix of the sample and not by some other systematic error.

5.9.1.1.8 Internal Standards

Internal Standards are compounds not expected to occur naturally in field samples. They are added to every standard and sample at a known concentration prior to analysis for the purpose of adjusting the response factor used in quantifying target analytes. The location follows specific guidelines for the treatment of internal standard recoveries and further information can be found in the applicable test method SOP.

5.9.1.1.9 QC Acceptance Criteria and Control Limits

The QC acceptance criteria are specified in test method SOPs. The criteria in the SOP are based on the requirements in the published test method or regulatory program. When there are no established acceptance criteria, the location develops acceptance criteria in accordance with recognized industry standards.

Some methods and programs require the location to establish control limits for LCS, MS/MSD, and surrogate evaluation using historical data. PAS developed limits are referred to as “in-house” control limits. In-house control limits represent ± 3 Standard Deviations (99% confidence level) from the average recovery of at least 20 data points generated using the same preparation and analytical procedure in a similar matrix.

See SOP ENV-SOP-GBAY-0116 *Control Charting and Trend Analysis* for more information about the procedures used to establish in-house control limits.

5.9.1.2 Proficiency Testing (PT)

PAS locations participate in interlaboratory proficiency testing (PT) studies to measure performance of the test method and to identify or solve analytical problems. PT samples measure location performance through the analysis of unknown samples provided by an external source.

The frequency of PT participation is based on the certification and accreditation requirements held by the laboratory. The PT samples are obtained from accredited proficiency testing providers (PTP) and treated as field samples which means they are included in the location's normal analytical processes and do not receive extraordinary attention due to their nature.

PAS locations do not share PT samples with other PAS locations, does not communicate with other PAS locations regarding current PT sample results during the duration of the study, and does not attempt to obtain the assigned value of any PT sample from the PT provider.

PT results scored unacceptable are investigated and correction action taken, when necessary.

Refer to corporate policy ENV-POL-CORQ-0002 *PT Policy* for more information.

5.9.2 QC Corrective Action

When the results of QC are not within acceptance criteria or expectations for method performance, correction and corrective action(s) are taken per the specifications in the test method SOP. These actions may include retesting or reporting of data with qualification to alert the end user of the situation.

5.9.3 Data Review

PAS locations use a tiered system for data review. The tiered process provides sequential checks to verify data transfer is complete; manual calculations, if performed, are correct, manual integrations are appropriate and documented, calibration and QC requirements are met, appropriate corrective action was taken when required, test results are properly qualified, process and test method SOPs were followed, project specific requirements were met, when applicable, and the test report is complete.

The sequential process includes three tiers referred to as primary review, secondary review, and administrative/completeness review.

Detailed procedures for the data review process are described in SOP ENV-SOP-GBAY-0120 *Data Review and Final Report Process*. The general expectations for the tiered review process are described in the following sections:

5.9.3.1 Primary Review

Primary review is performed by the individual that performed the task. All PAS personnel are responsible for review of their work product to assure it is complete, accurate, documented, and consistent with policy and SOPs.

Checks performed during primary review include but are not limited to:

- Verification that data transfer and acquisition is complete
- Manual calculations, if performed, are documented and accurate
- Manual integrations, if performed, are documented, and comply with SOP ENV-SOP-CORQ-006 *Manual Integration*
- Calibration and QC criteria were met, and/or proper correction and corrective actions were taken, and data and test results associated with QC and criteria exceptions are properly qualified
- Work is consistent with SOPs and any other relevant instructional document such as SWI, program requirements, or project QAPP

5.9.3.2 Secondary Review

Secondary review is performed by a qualified peer or supervisor. Secondary review is a repeat of the checks performed during primary review by another person. In addition to the checks of primary review, secondary review includes chromatography review to check the accuracy of quantitative analyte identification.

5.9.3.3 Completeness Review

Completeness review is an administrative review performed prior to release of the test report to the customer. Completeness review verifies that the final test report is complete and meets project specification. This review also assures that information necessary for the client's interpretation of results are explained in the case narrative or footnoted in the test report.

5.9.3.4 Data Audits

Test reports may be audited by local quality personnel to verify compliance with SOPs and to check for data integrity, technical accuracy, and compliance with the PAS QMS and any applicable federal, statutory, and program requirements. The reports chosen for the data audits are selected at random and these audits are not usually done prior to issuance of the test report to the customer.

If any problems with the data or test results are found during the data audit, the impact of the nonconforming work is evaluated using the process described in Section 4.9.

Also see Section 4.14 for internal audits.

5.9.4 Calibration Certificates

PAS does not perform calibration activities for its customers and calibration certificates are not offered or issued.

5.9.5 Opinions and Interpretations

The location provides objective data and information to its customers of sufficient detail for their interpretation and decision making. Objective data and information are based solely on fact and does not attempt to explain the meaning (interpret) or offer a view or judgement (opinion). Sometimes the customer may request the location provide opinion or interpretation to assist them with their decisions about the data.

When opinions and interpretations are included in the test report, the location will document the basis upon which the opinions and interpretations have been made and clearly identify this content as opinion or interpretation in the test report.

Examples of opinion and interpretation include but are not limited to:

- A viewpoint on how a nonconformance impacts the quality of the data or usability of results.
- Recommendations for how the customer should use the test results and information.
- Suggestions or guidance to the customer for improvement.

5.9.6 Subcontractor Reports

When analytical work has been subcontracted to an organization external to PAS, the test report from the subcontractor is included in its entirety as an amendment to the final test report.

Test results performed by multiple locations within the PAS network (internal subcontracting) may be merged into a single test report so long as the test report issued clearly identifies the location and address of each network location that performed testing, and which tests each PAS location performed. (See 5.10.2)

5.9.7 Electronic Transmission of Results

When test results and/or reports are submitted to the customer through electronic transmission, the procedures established in this manual for confidentiality and protection of data apply.

5.9.8 Format of Test Reports

The test formats offered by PAS are designed to accommodate each type of analytical test method performed and to minimize the possibility of misunderstanding or misuse of analytical results. The format of electronic data deliverables (EDD) follows the specifications for the EDD.

5.9.9 Amendments to Test Reports

Test reports that are revised or amended by the location after date of release of the original final test report to the customer are issued as a new test report that is clearly identified as an amendment or revision and that includes a reference to the originally issued final test report.

The customer is the organization doing business with PAS external to PAS.

Changes made to test results and data before the final test report is issued to the customer are not amendments or revisions, these are corrections to errors found during the location's data verification and review process.

The procedure for report amendments and revision are outlined in SOP ENV-SOP-GBAY-0120 *Data Review and Final Report Process*.

5.10 Reporting

5.10.1 General Requirements

PAS offers a wide variety of test report formats to meet project needs of Pace® customers and that comply with federal and state regulatory programs.

The type and level of deliverable, including the electronic data deliverable (EDD) format are established between PAS and the customer during the contracting process. The report specifications include the test report format, protocol for the reporting limit (RL), conventions for the reporting of results less than the limit of quantitation (LOQ), and specification for the use of project or program specific data qualifiers. Information about review of analytical service requests is provided in Section 4.4.

5.10.2 Test Reports: Required Items

Regardless of deliverable or report requested, every test report issued by the location includes each of the following items:

a) A Title

b) The name and address of the location issuing the test report and for each location where testing was performed if different than address of the location issuing the report. When testing is done at multiple PAS locations, the report must clearly identify which PAS location performed each test method;

c) Unique identification of the test report and on each page an identification number to link each page to the test report, and clear identification of the end of the report.

d) The name and address of the customer

e) Identification of test methods used

f) Cross reference between client sample identification number (Sample ID) and the identification number for the sample (Lab ID) to provide unambiguous identification of samples.

g) The date of receipt of samples, condition of samples on receipt, and identification of any instance where receipt of the samples did not meet sample acceptance criteria.

h) Date and times of sample collection, receipt, preparation, and analysis.

i) Test results and units of measurement, and qualification of results associated with QC criteria exceptions, and identification of reported results outside of the calibration range.

j) All chains of custody (COC) including records of internal transfer between locations within PAS,

k) Name, title, signature of the person(s) authorizing release of the test report and date of release.

l) A statement that the results in the test report relate only to the items tested.

m) Statement that the test report may not be reproduced except in full without written approval from PAS.

5.10.3 Test Reports: Supplemental Items

5.10.3.1 Supplemental Requirements

The following items are included in the test report when required or relevant:

a) Shipping manifests / bill of ladings as applicable when common couriers are utilized for shipment of samples,

b) Explanation of departure from test method SOPs including, what the departure was and why it was necessary.

c) Statistical methods used. (Required for Whole Effluent Toxicity)

d) For solid samples, specification that results are reported on a dry weight or wet weight basis.

e) Signed Affidavit, when required by client or regulatory agency.

f) A statement of compliance / non-compliance with requirements or specifications (client, program, or standard) that includes identification of test results that did not meet acceptance criteria.

g) When requested by the client, statement of estimated measurement uncertainty. In general, for environmental testing, estimated uncertainty of measurement is extrapolated from LCS control limits. Control limits incorporate the expected variation of the data derived from the laboratory's procedure. When the control limits are specified by the test method or regulatory program, the control limits represent the expected variation of the test method and/or matrices for which the test method was designed.

h) Opinions and Interpretations

i) If a claim of accreditation/certification is included in the test report, identification of any test methods or analytes for which accreditation/certification is not held by the location if the accrediting body offers accreditation/certification for the test method/analyte. The fields of accreditation/certification vary between agencies, and it cannot be presumed that because accreditation/certification is not held that it is offered or required.

j) Certification Information, including certificate number and issuing body.

For PAS locations accredited to ISO/IEC 17025:2017:

- Data included in the test report provided by a customer should be clearly identified. The test report should also include a statement that the test results apply only to the samples as received.

5.10.3.2 Test Reports: Sampling Information

The following items are included in the test report when samples are collected by PAS or when this information is necessary for the interpretation of test results:

a) Date of Sampling.

b) Unambiguous identification of material samples.

c) Location of sampling including diagrams, sketches, or photographs.

d) Reference to the sampling plan and procedures used.

e) Details of environmental conditions at time of sample that may impact test results.

f) Any standard or other specification for the sampling method or procedure, and deviations, additions to or exclusions from the specification concerned.

6.0 REVISION HISTORY

This Version (Version 4):

Section	Description of Change
Header / All	Added registered trademark after Pace as required by branding guidelines
Header	Updated the years associated with the copyright.
Signature Page	Removed Cover Page applied by MasterControl eDMS
Approval Signatory	Changed name of this page to “Management Personnel” and updated Job Titles.
All	Changed references to “laboratory” with PAS or location, where appropriate.
All	Replaced stand-alone acronym “ENV” with “PAS” except where “ENV” is embedded in document control numbers.
All	Corrected spelling, typographical, and format errors.
Various	Added language to clarify the examples in the manual are provided for chemistry, these examples may not apply in the same way to other disciplines such as radiochemistry, microbiology, asbestos, or whole effluent toxicity (WET).
1.0	Corrected Parent Company Information.
1.2	Added definitions for “location,” “laboratory” and “service center” for QMS and compliance purposes.
1.2.1	Updated job titles to match current structure.
1.2.2	Revised language for clarity.
1.2.3	Removed specificity to allow for more options
4.1.4	Updated to describe current scope of organization
4.1.4.1	Updated to describe current organization structure
4.1.5.1.1	Updated to match new organization structure and job titles
4.1.5.2	Updated to match new organization structure and job titles
4.1.5.2.1	Updated to clarify qualifications and meaning of “absent”
4.1.5.3	Updated to clarify impartiality
4.1.5.4	Reorganized section for clarity
4.2.1.1	Added statement that the organization structure is designed to safeguard impartiality
4.2.2.1	Added requirement to post compliance alertline posters in work area.
4.2.1.3	Added requirement for policies and procedures to be available in work area (previously implied but not explicitly stated)
4.2.5.1	Clarified hierarchy and application of project documents
4.5	Updated requirements for internal and external subcontracting

4.8	Updated complaint handling requirements to clarify that only valid complaints are acted on with corrective action.
4.9.1.3	Added roles responsible for authorizing return to work after stop work order.
4.11	Main and subsections updated for clarity
4.14	Main and subsections updated for clarity
5.2.2 Subsections	Content reorganized and language related to documentation of training and authorization of personnel revised to clarify expectations. Requirements of DOCs modified to clarify procedure described in manual pertains to chemistry methodology; other approaches to DOC acceptable for other disciplines such as microbiology, radiochemistry, asbestos, whole effluent toxicity.
5.4.5.3.3	Added reference documents for which the local SOP for LOD must comply with.
5.5	Added language to clarify existing requirements.
5.6.4	Clarified requirements for reference standards for working weights and thermometers and defined meaning of terms “annual” and “quarterly.” Included examples of acceptable reference standards for adequacy checks.
5.8.1	Added recommendation for Pace® personnel to add “Pace®” next to their signature on the CoC when receiving samples since the CoC form has signature/company, implying the company affiliation must be added.
5.10.3.1	Included ISO/IEC 17025:2017 to add disclaimer to test reports (applies to laboratories accredited to ISO/IEC 17025:2017 only).

This document supersedes the following documents:

Document Number	Title	Version
ENV-MAN-GBAY-0001	Quality Manual	00
ENV-MAN-GBAY-0001	Quality Manual	01
ENV-MAN-GBAY-0001	Quality Manual	02
ENV-MAN-GBAY-0001	Quality Manual	03

7.0 APPENDICES

7.1 Appendix A: Certification / Accreditation Listing

Disclaimer: The certifications / accreditation lists provided in this Appendix are those that were held by the PAS location on the effective date of this manual. This information is subject to change without notice and must not be considered valid proof of certification or accreditation status. This manual is not updated with each change made. Current certificates are accessible via the eDMS Portal for PAS employees. External parties should contact the location for the most current information.

7.1.1 PAS-Green Bay

Authority	ID	Authority	ID
Florida Department of Health, Bureau of Laboratories	E87948	Virginia Department of General Services	460263
Georgia, Environmental Protection Division	E87948	Wisconsin Department of Natural Resources	405132750
Illinois EPA	200050	Wisconsin Department of Agriculture, Trade and Consumer Protection	105-444
Kentucky Environmental and Public Protection Cabinet	82	Wisconsin Department of Health Services, Bureau of Environmental and Occupational Health, Radioactive Materials License	009-1093-01
Louisiana Department of Environmental Quality	04168	USDA Soil Permit Regulated by 7 CFR330	P330-21-00008
Minnesota Department of Health	055-999-334	USDA Compliance Agreement	WI-Soil-2020-01
New York Department of Health	12064	US Fish and Wildlife Service Import/Export License	51774A
North Dakota Department of Health Chemistry Division	R-150	US DOT Hazardous Materials Certificate of Registration	061719550153BD
South Carolina Department of Health and Environmental Control	83006001	Commercial Emergency Alarm Permit (Brown County Ordinance)	0166B-1241
Texas Commission on Environmental Quality	T104704529-22-9	A2LA	6154.01

7.2 Appendix B: Capability Listing

The capabilities listed in this Appendix were held by the location referenced on the effective date of this manual. This information is subject to change without notice. External parties should contact the location for the most current information.

Table Legend:

- Air = Air
- DW = Drinking Water
- NPW = Non-Potable Water
- SCM = Solid and Chemical Materials
- Waste = Non-Aqueous Phase Liquid (NAPL), Oil
- Tissue = Biota and Tissue

7.2.1 PAS-Green Bay

Parameter	Method	Matrices				
		DW	NPW	SCM	Waste	Tissue
Lipids	ENV-SOP-GBAY-0131					x[1]
Homogenization	ENV-SOP-GBAY-0129					x[1]
Dry Weight	ASTM D2974-87			x	x	x
ASTM Leach	ASTM D3987-85			x		
Flashpoint	EPA 1010A		x	x		
Specific Conductance	EPA 120.1		x			
TCLP Leach	EPA 1311		x	x	x	
SPLP Leach	EPA 1312		x	x	x	
Solids, Total (TS)	SM 2540 B		x			
Solids, Total Dissolved (TDS)	SM 2540 C		x			
Solids, Total Suspended (TSS)	SM 2540 D		x			
Solids, Total Volatile Suspended (TVSS)	SM 2540 E		x			
Solids, Total Volatile (TVS)	EPA 160.4		x	x		
Solids, Volatile Suspended (TVSS)	EPA 160.4		x			
Solids, Total Percent	SM 2540 G			x		
AVS/SEM[1]	EPA 1629			x		
Turbidity	EPA 180.1		x			
Turbidity	SM 2130 B		x			
Ion Chromatography	EPA 300.0	x	x	x		
Ion Chromatography	EPA 9056A		x			

Acidity, Total	EPA 305.1		x			
Parameter	**Method**	**Matrices**				
		DW	**NPW**	**SCM**	**Waste**	**Tissue**
Acidity, Total	SM 2310 B		x	x		
Alkalinity, Total	EPA 310.2		x			
Alkalinity, Total	SM 2320 B		x			
Cyanide, Total	EPA 335.4		x			
Cyanide, Total	EPA 9012B		x	x		
Ammonia, Total	EPA 350.1		x	x		
Total Kjeldahl Nitrogen	EPA 351.2		x	x		
Nitrogen, NO2/NO3	EPA 353.2		x	x		
Phosphorous, Total	EPA 365.4		x	x		
Chemical Oxygen Demand	EPA 410.4		x			
pH	EPA 9040C		x	x		
pH	SM 4500-H+-B		x			
pH	EPA 9045D			x		
Carbon, Total Organic	SM 5310C		x			
Carbon, Total Organic (Quad/Mod)	EPA 9060A		x	x		
Carbon, Total Organic	Lloyd Kahn			x		
Carbon, Total Organic	Walkley-Black			x		
Paint Filter Liquid Test	EPA 9095A			x		
Iron, Ferrous	HACH 8146		x			
Iron, Ferric Calculation	EPA6010/6020 - HACH 8146		x			
Apparent Color	SM 2120 B		x			
Specific Gravity	SM 2710 F		x			
Chromium, Hexavalent	SM 3500-Cr B		x			
Oxygen, Dissolved	SM 4500-O G		x			
Sulfide	SM 4500-S F		x			
Biochemical Oxygen Demand / Carbonaceous Biological Oxygen	SM 5210 B		x	x		
Heterotrophic Plate Count	SM 9215B		x[1]	x[1]		
Coliform, Fecal	SM 9222D	x[1]	x[1]			
Coliform, Total	SM 9223B		x[1]			
Mercury, Low Level	EPA 1631E		x	x		x

Mercury, Total	EPA 7470A		x			
Parameter	**Method**	**Matrices**				
		DW	**NPW**	**SCM**	**Waste**	**Tissue**
Mercury, Total	EPA 7471B			x		x
Mercury, Total	EPA 245.1		x			
Mercury, Total	EPA 245.6					x
Mercury, Total[1]	EPA 7473					x
ICP-Metals	SW846 6010D /EPA 200.7		x	x		
ICPMS-Metals	SW846 6020B/ EPA 200.8		x	x		x
TPH-Diesel	SW846 8015C/D		x	x	x	
Diesel Range Organics	WI Modified DRO		x	x	x	
Organochlorine Pesticide/ Toxaphene/Chlorinated Camphenes/Technical Chlordane	SW846 8081A / 8081B / EPA 608.3		x	x		x
Polychlorinated Biphenyls (PCB)	SW846 8082 / 8082A / EPA 608.3		x	x		x
Polyaromatic Hydrocarbons (PAH)	SW846 8270E – SIM /EPA 625.1 SIM		x	x		x
Semi-Volatile Organics	SW846 8270E /EPA 625.1		x	x		
TPH-Gasoline	SW846 8015C		x	x		
Gasoline Range Organics	WI Modified GRO		x	x		
Methane, Ethene, Ethane	SW846 8015C Mod		x[1]			
PVOC	SW846 8021B / EPA 602		x	x		
Volatile Organics	SW846 8260B / 8260D /EPA 624.1		x	x		

[1] = Laboratory does not hold TNI Accreditation for this test method.

7.3 Appendix C: Glossary

This glossary provides common terms and definitions used by PAS. **It is not intended to be a complete list of all terms and definitions used.** The definitions have been compiled mostly from the TNI Standard and DoD QSM. Although this information has been reproduced with care, errors cannot be entirely excluded. Definitions for the same term also vary between sources. When the meaning of a term used in a PAS document is different from this glossary or when the glossary does not include the term, the term and definition is included or defined in context in the laboratory document.

Term	Definition
3P Program	PAS-The continuous improvement program used by PAS that focuses on Process, Productivity, and Performance.
Acceptance Criteria	TNI- Specified limits placed on characteristics of an item, process, or service defined in requirement documents.
Accreditation	TNI- The process by which an agency or organization evaluates and recognizes a laboratory as meeting certain predetermined qualifications or standards, thereby accrediting the laboratory. DoD- Refers to accreditation in accordance with the DoD ELAP.
Accreditation Body (AB)	TNI- The organization having responsibility and accountability for environmental laboratory accreditation and which grants accreditation under this program. DoD- Entities recognized in accordance with the DoD-ELAP that are required to operate in accordance with ISO/IEC 17011, *Conformity assessment: General requirements for accreditation bodies accrediting conformity assessment bodies*. The AB must be a signatory, in good standing, to the International Laboratory Accreditation Cooperation (ILAC) mutual recognition arrangement (MRA) that verifies, by evaluation and peer assessment, that its signatory members are in full compliance with ISO/IEC 17011 and that its accredited laboratories comply with ISO/IEC 17025.
Accuracy	TNI- The degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations; a data quality indicator.
Activity, Absolute	TNI- Rate of nuclear decay occurring in a body of material, equal to the number of nuclear disintegrations per unit time. NOTE: Activity (absolute) may be expressed in becquerels (Bq), curies (Ci), or disintegrations per minute (dpm), and multiples or submultiples of these units.
Activity, Areic	TNI- Quotient of the activity of a body of material and its associated area.
Activity, Massic	TNI- Quotient of the activity of a body of material and its mass; also called specific activity.
Activity, Volumic	TNI- Quotient of the activity of a body of material and its volume; also called activity concentration. NOTE: In this module [TNI Volume 1, Module 6], unless otherwise stated, references to activity shall include absolute activity, areic activity, massic activity, and volumic activity.
Activity Reference Date	TNI- The date (and time, as appropriate to the half-life of the radionuclide) to which a reported activity result is calculated. NOTE: The sample collection date is most frequently used as the Activity Reference Date for environmental measurements, but different programs may specify other points in time for correction of results for decay and ingrowth.
Aliquot	DoD- A discrete, measured, representative portion of a sample taken for analysis.
American Society for Testing and Materials (ASTM)	An international standards organization that develops and publishes voluntary consensus standards for a wide range of materials, products, systems and services.
Analysis	DoD- A combination of sample preparation and instrument determination.
Analysis Code (Acode)	All the set parameters of a test, such as Analytes, Method, Detection Limits and Price.
Analysis Sequence	A compilation of all samples, standards and quality control samples run during a specific amount of time on a particular instrument in the order they are analyzed.
Analyst	TNI- The designated individual who performs the "hands-on" analytical methods and associated techniques and who is the one responsible for applying required laboratory practices and other pertinent quality controls to meet the required level of quality.

Analyte	TNI- A substance, organism, physical parameter, property, or chemical constituent(s) for which an environmental sample is being analyzed. DoD- The specific chemicals or components for which a sample is analyzed; it may be a group of chemicals that belong to the same chemical family and are analyzed together.
Analytical Method	DoD- A formal process that identifies and quantifies the chemical components of interest (target analytes) in a sample.
Analytical Uncertainty	TNI- A subset of Measurement Uncertainty that includes all laboratory activities performed as part of the analysis.
Aliquot	DoD- A discrete, measured, representative portion of a sample taken for analysis.
Annual (or Annually)	Defined by PAS as every 12 months ± 30 days.
Assessment	TNI - The evaluation process used to measure or establish the performance, effectiveness, and conformance of an organization and/or its system to defined criteria (to the standards and requirements of laboratory accreditation). DoD- An all-inclusive term used to denote any of the following: audit, performance evaluation, peer review, inspection, or surveillance conducted on-site.
Atomic Absorption Spectrometer	Instrument used to measure concentration in metals samples.
Atomization	A process in which a sample is converted to free atoms.
Audit	TNI- A systematic and independent examination of facilities, equipment, personnel, training, procedures, record-keeping, data validation, data management, and reporting aspects of a system to determine whether QA/QC and technical activities are being conducted as planned and whether these activities will effectively achieve quality objectives.
Batch	TNI- Environmental samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents. A **preparation batch** is composed of one to 20 environmental samples of the same quality systems matrix, meeting the above-mentioned criteria and with a maximum time between the start of processing of the first and last sample in the batch to be 24 hours or the time-frame specified by the regulatory program. An **analytical batch** is composed of prepared environmental samples (extracts, digestates or concentrates) which are analyzed together as a group. An analytical batch can include prepared samples originating from various quality system matrices and can exceed 20 samples.
Batch, Radiation Measurements (RMB)	TNI- An RMB is composed of 1 to 20 environmental samples that are counted directly without preliminary physical or chemical processing that affects the outcome of the test (e.g., non-destructive gamma spectrometry, alpha/beta counting of air filters, or swipes on gas proportional detectors). The samples in an RMB share similar physical and chemical parameter, and analytical configurations (e.g., analytes, geometry, calibration, and background corrections). The maximum time between the start of processing of the first and last in an RMB is 14 calendar days.
Bias	TNI- The systematic or persistent distortion of a measurement process, which causes errors in one direction (i.e., the expected sample measurement is different from the sample's true value).
Blank	TNI and DoD- A sample that has not been exposed to the analyzed sample stream in order to monitor contamination during sampling, transport, storage or analysis. The blank is subjected to the usual analytical and measurement process to establish a zero baseline or background value and is sometimes used to adjust or correct routine analytical results (See Method Blank). DoD- Blank samples are negative control samples, which typically include field blank samples (e.g., trip blank, equipment (rinsate) blank, and temperature blank) and laboratory blank samples (e.g., method blank, reagent blank, instrument blank, calibration blank, and storage blank).
Blind Sample	A sub-sample for analysis with a composition known to the submitter. The analyst/laboratory may know the identity of the sample but not its composition. It is used to test the analyst's or laboratory's proficiency in the execution of the measurement process.
BNA (Base Neutral Acid compounds)	A list of semi-volatile compounds typically analyzed by mass spectrometry methods. Named for the way they can be extracted out of environmental samples in an acidic, basic or neutral environment.
BOD (Biochemical Oxygen Demand)	Chemical procedure for determining how fast biological organisms use up oxygen in a body of water.

Calibration	TNI- A set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards. 1) In calibration of support equipment, the values realized by standards are established through the use of reference standards that are traceable to the International System of Units (SI); 2) In calibration according to test methods, the values realized by standards are typically established through the use of Reference Materials that are either purchased by the laboratory with a certificate of analysis or purity, or prepared by the laboratory using support equipment that has been calibrated or verified to meet specifications.
Calibration Curve	TNI- The mathematical relationship between the known values, such as concentrations, of a series of calibration standards and their instrument response.
Calibration Method	A defined technical procedure for performing a calibration.
Calibration Range	DoD- The range of values (concentrations) between the lowest and highest calibration standards of a multi-level calibration curve. For metals analysis with a single-point calibration, the low-level calibration check standard and the high standard establish the linear calibration range, which lies within the linear dynamic range.
Calibration Standard	TNI- A substance or reference material used for calibration.
Certified Reference Material (CRM)	TNI- Reference material accompanied by a certificate, having a value, measurement uncertainty, and stated metrological traceability chain to a national metrology institute.
Chain of Custody	An unbroken trail of accountability that verifies the physical security of samples, data, and records.
Chain of Custody Form (COC)	TNI- Record that documents the possession of the samples from the time of collection to receipt in the laboratory. This record generally includes: the number and type of containers; the mode of collection, the collector, time of collection; preservation; and requested analyses.
Chemical Oxygen Demand (COD)	A test commonly used to indirectly measure the amount of organic compounds in water.
Client (referred to by ISO as Customer)	Any individual or organization for whom items or services are furnished or work performed in response to defined requirements and expectations.
Code of Federal Regulations (CFR)	A codification of the general and permanent rules published in the Federal Register by agencies of the federal government.
Comparability	An assessment of the confidence with which one data set can be compared to another. Comparable data are produced through the use of standardized procedures and techniques.
Completeness	The percent of valid data obtained from a measurement system compared to the amount of valid data expected under normal conditions. The equation for completeness is: % Completeness = (Valid Data Points/Expected Data Points)*100
Confirmation	TNI- Verification of the identity of a component through the use of an approach with a different scientific principle from the original method. These may include, but are not limited to: second-column confirmation; alternate wavelength; derivatization; mass spectral interpretation; alternative detectors; or additional cleanup procedures. DoD- Includes verification of the identity and quantity of the analyte being measured by another means (e.g., by another determinative method, technology, or column). Additional cleanup procedures alone are not considered confirmation techniques.
Conformance	An affirmative indication or judgment that a product or service has met the requirements of the relevant specifications, contract, or regulation; also the state of meeting the requirements.
Congener	A member of a class of related chemical compounds (e.g., PCBs, PCDDs).
Consensus Standard	DoD- A standard established by a group representing a cross-section of a particular industry or trade, or a part thereof.
Continuing Calibration Blank (CCB)	A blank sample used to monitor the cleanliness of an analytical system at a frequency determined by the analytical method.
Continuing Calibration Check Compounds (CCC)	Compounds listed in mass spectrometry methods that are used to evaluate an instrument calibration from the standpoint of the integrity of the system. High variability would suggest leaks or active sites on the instrument column.
Continuing Calibration Verification	DoD- The verification of the initial calibration. Required prior to sample analysis and at periodic intervals. Continuing calibration verification applies to both external and internal standard calibration techniques, as well as to linear and non-linear calibration models.
Continuing Calibration Verification (CCV) Standard	Also referred to as a Calibration Verification Standard (CVS) in some methods, it is a standard used to verify the initial calibration of compounds in an analytical method. CCVs are analyzed at a frequency determined by the analytical method.

Continuous Emission Monitor (CEM)	A flue gas analyzer designed for fixed use in checking for environmental pollutants.
Continuous Improvement Plan (CIP)	The delineation of tasks for a given laboratory department or committee to achieve the goals of that department.
Contract Laboratory Program (CLP)	A national network of EPA personnel, commercial labs, and support contractors whose fundamental mission is to provide data of known and documented quality.
Contract Required Detection Limit (CRDL)	Detection limit that is required for EPA Contract Laboratory Program (CLP) contracts.
Contract Required Quantitation Limit (CRQL)	Quantitation limit (reporting limit) that is required for EPA Contract Laboratory Program (CLP) contracts.
Control Chart	A graphic representation of a series of test results, together with limits within which results are expected when the system is in a state of statistical control (see definition for Control Limit)
Control Limit	A range within which specified measurement results must fall to verify that the analytical system is in control. Control limit exceedances may require corrective action or require investigation and flagging of non-conforming data.
Correction	DoD- Action taken to eliminate a detected non-conformity.
Corrective Action	DoD- The action taken to eliminate the causes of an existing non-conformity, defect, or other undesirable situation in order to prevent recurrence. A root cause analysis may not be necessary in all cases.
Corrective and Preventative Action (CAPA)	The primary management tools for bringing improvements to the quality system, to the management of the quality system's collective processes, and to the products or services delivered which are an output of established systems and processes.
Critical Value	TNI- Value to which a measurement result is compared to make a detection decision (also known as critical level or decision level). NOTE: The Critical Value is designed to give a specified low probability α of false detection in an analyte-free sample, which implies that a result that exceeds the Critical Value, gives high confidence $(1-\alpha)$ that the radionuclide is actually present in the material analyzed. For radiometric methods, α is often set at 0.05.
Customer	DoD- Any individual or organization for which products or services are furnished or work performed in response to defined requirements and expectations.
Data Integrity	TNI- The condition that exists when data are sound, correct, and complete, and accurately reflect activities and requirements.
Data Quality Objective (DQO)	Systematic strategic planning tool based on the scientific method that identifies and defines the type, quality, and quantity of data needed to satisfy a specified use or end user.
Data Reduction	TNI- The process of transforming the number of data items by arithmetic or statistical calculation, standard curves, and concentration factors, and collating them into a more usable form.
Definitive Data	DoD- Analytical data of known quantity and quality. The levels of data quality on precision and bias meet the requirements for the decision to be made. Data that is suitable for final decision-making.
Demonstration of Capability (DOC)	TNI- A procedure to establish the ability of the analyst to generate analytical results of acceptable accuracy and precision. DoD- A procedure to establish the ability of the analyst to generate analytical results by a specific method that meet measurement quality objectives (e.g., for precision and bias).
Department of Defense (DoD)	An executive branch department of the federal government of the United States charged with coordinating and supervising all agencies and functions of the government concerned directly with national security.
Detection Limit (DL)	DoD- The smallest analyte concentration that can be demonstrated to be different than zero or a blank concentration with 99% confidence. At the DL, the false positive rate (Type 1 error) is 1%. A DL may be used as the lowest concentration for reliably reporting a detection of a specific analyte in a specific matrix with a specific method with 99% confidence.
Detection Limit (DL) for Safe Drinking Water Act (SDWA) Compliance	TNI- Laboratories that analyze drinking-water samples for SDWA compliance monitoring must use methods that provide sufficient detection capability to meet the detection limit requirements established in 40 CFR 141. The SDWA DL for radioactivity is defined in 40 CFR Part 141.25.c as the radionuclide concentration, which can be counted with a precision of plus or minus 100% at the 95% confidence level (1.96σ where σ is the standard deviation of the net counting rate of the sample).
Deuterated Monitoring Compounds (DMCs)	DoD- SIM specific surrogates as specified for GC/MS SIM analysis.

Diesel Range Organics (DRO)	A range of compounds that denote all the characteristic compounds that make up diesel fuel (range can be state or program specific).
Digestion	DoD- A process in which a sample is treated (usually in conjunction with heat and acid) to convert the target analytes in the sample to a more easily measured form.
Document Control	The act of ensuring that documents (and revisions thereto) are proposed, reviewed for accuracy, approved for release by authorized personnel, distributed properly and controlled to ensure use of the correct version at the location where the prescribed activity is performed.
Documents	DoD- Written components of the laboratory management system (e.g., policies, procedures, and instructions).
Dry Weight	The weight after drying in an oven at a specified temperature.
Duplicate (also known as Replicate or Laboratory Duplicate)	The analyses or measurements of the variable of interest performed identically on two subsamples of the same sample. The results of duplicate analyses are used to evaluate analytical or measurement precision but not the precision of sampling, preservation or storage internal to the laboratory.
Electron Capture Detector (ECD)	Device used in GC methods to detect compounds that absorb electrons (e.g., PCB compounds).
Electronic Data Deliverable (EDD)	A summary of environmental data (usually in spreadsheet form) which clients request for ease of data review and comparison to historical results.
Eluent	A solvent used to carry the components of a mixture through a stationary phase.
Elute	To extract, specifically, to remove (absorbed material) from an absorbent by means of a solvent.
Elution	A process in which solutes are washed through a stationary phase by movement of a mobile phase.
Environmental Data	DoD- Any measurements or information that describe environmental processes, locations, or conditions; ecological or health effects and consequences; or the performance of environmental technology.
Environmental Monitoring	The process of measuring or collecting environmental data.
Environmental Protection Agency (EPA)	An agency of the federal government of the United States which was created for the purpose of protecting human health and the environment by writing and enforcing regulations based on laws passed by Congress.
Environmental Sample	A representative sample of any material (aqueous, non-aqueous, or multimedia) collected from any source for which determination of composition or contamination is requested or required. Environmental samples can generally be classified as follows: • Non Potable Water (Includes surface water, ground water, effluents, water treatment chemicals, and TCLP leachates or other extracts) • Drinking Water - Delivered (treated or untreated) water designated as potable water • Water/Wastewater - Raw source waters for public drinking water supplies, ground waters, municipal influents/effluents, and industrial influents/effluents • Sludge - Municipal sludges and industrial sludges. • Soil - Predominately inorganic matter ranging in classification from sands to clays. • Waste - Aqueous and non-aqueous liquid wastes, chemical solids, and industrial liquid and solid wastes
Equipment Blank	A sample of analyte-free media used to rinse common sampling equipment to check effectiveness of decontamination procedures.
Extracted Internal Standard Analyte	Isotopically labeled analogs of analytes of interest added to all standards, blanks and samples analyzed. Added to samples and batch QC samples prior to the first step of sample extraction and to standards and instrument blanks prior to analysis. Used for isotope dilution methods.
Facility	A distinct location within the company that has unique certifications, personnel and waste disposal identifications.
False Negative	DoD- A result that fails to identify (detect) an analyte or reporting an analyte to be present at or below a level of interest when the analyte is actually above the level of interest.
False Positive	DoD- A result that erroneously identifies (detects) an analyte or reporting an analyte to be present above a level of interest when the analyte is actually present at or below the level of interest.
Field Blank	A blank sample prepared in the field by filling a clean container with reagent water and appropriate preservative, if any, for the specific sampling activity being undertaken.
Field Measurement	Determination of physical, biological, or radiological properties, or chemical constituents that are measured on-site, close in time and sPAS to the matrices being sampled/measured, following accepted test methods. This testing is performed in the field outside of a fixed-laboratory or outside of an enclosed structure that meets the requirements of a mobile laboratory.

Field of Accreditation	TNI- Those matrix, technology/method, and analyte combinations for which the accreditation body offers accreditation.
Field of Proficiency Testing (FoPT)	TNI- Matrix, technology/method, analyte combinations for which the composition, spike concentration ranges and acceptance criteria have been established by the PTPEC.
Finding	TNI- An assessment conclusion referenced to a laboratory accreditation standard and supported by objective evidence that identifies a deviation from a laboratory accreditation standard requirement. DoD- An assessment conclusion that identifies a condition having a significant effect on an item or activity. An assessment finding may be positive, negative, or neutral and is normally accompanied by specific examples of the observed condition. The finding must be linked to a specific requirement (e.g., this standard, ISO requirements, analytical methods, contract specifications, or laboratory management systems requirements).
Flame Atomic Absorption Spectrometer (FAA)	Instrumentation used to measure the concentration of metals in an environmental sample based on the fact that ground state metals absorb light at different wavelengths. Metals in a solution are converted to the atomic state by use of a flame.
Flame Ionization Detector (FID)	A type of gas detector used in GC analysis where samples are passed through a flame which ionizes the sample so that various ions can be measured.
Gas Chromatography (GC)	Instrumentation which utilizes a mobile carrier gas to deliver an environmental sample across a stationary phase with the intent to separate compounds out and measure their retention times.
Gas Chromatograph/ Mass Spectrometry (GC/MS)	In conjunction with a GC, this instrumentation utilizes a mass spectrometer which measures fragments of compounds and determines their identity by their fragmentation patterns (mass spectra).
Gasoline Range Organics (GRO)	A range of compounds that denote all the characteristic compounds that make up gasoline (range can be state or program specific).
Graphite Furnace Atomic Absorption Spectrometry (GFAA)	Instrumentation used to measure the concentration of metals in an environmental sample based on the absorption of light at different wavelengths that are characteristic of different analytes.
High Pressure Liquid Chromatography (HPLC)	Instrumentation used to separate, identify and quantitate compounds based on retention times which are dependent on interactions between a mobile phase and a stationary phase.
Holding Time	TNI- The maximum time that can elapse between two specified activities. 40 CFR Part 136- The maximum time that samples may be held prior to preparation and/or analysis as defined by the method and still be considered valid or not compromised. For sample prep purposes, hold times are calculated using the time of the start of the preparation procedure. DoD- The maximum time that may elapse from the time of sampling to the time of preparation or analysis, or from preparation to analysis, as appropriate.
Homogeneity	The degree to which a property or substance is uniformly distributed throughout a sample.
Homologue	One in a series of organic compounds in which each successive member has one more chemical group in its molecule than the next preceding member. For instance, methanol, ethanol, propanol, butanol, etc., form a homologous series.
Improper Actions	DoD- Intentional or unintentional deviations from contract-specified or method-specified analytical practices that have not been authorized by the customer (e.g., DoD or DoE).
Incremental Sampling Method (ISM)	Soil preparation for large volume (1 kg or greater) samples.
In-Depth Data Monitoring	TNI- When used in the context of data integrity activities, a review and evaluation of documentation related to all aspects of the data generation process that includes items such as preparation, equipment, software, calculations, and quality controls. Such monitoring shall determine if the laboratory uses appropriate data handling, data use and data reduction activities to support the laboratory's data integrity policies and procedures.
Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)	Analytical technique used for the detection of trace metals which uses plasma to produce excited atoms that emit radiation of characteristic wavelengths.
Inductively Coupled Plasma- Mass Spectrometry (ICP/MS)	An ICP that is used in conjunction with a mass spectrometer so that the instrument is not only capable of detecting trace amounts of metals and non-metals but is also capable of monitoring isotopic speciation for the ions of choice.
Infrared Spectrometer (IR)	An instrument that uses infrared light to identify compounds of interest.

Initial Calibration (ICAL)	The process of analyzing standards, prepared at specified concentrations, to define the quantitative response relationship of the instrument to the analytes of interest. Initial calibration is performed whenever the results of a calibration verification standard do not conform to the requirements of the method in use or at a frequency specified in the method.
Initial Calibration Blank (ICB)	A blank sample used to monitor the cleanliness of an analytical system at a frequency determined by the analytical method. This blank is specifically run in conjunction with the Initial Calibration Verification (ICV) where applicable.
Initial Calibration Verification (ICV)	DoD- Verifies the initial calibration with a standard obtained or prepared from a source independent of the source of the initial calibration standards to avoid potential bias of the initial calibration.
Injection Internal Standard Analyte	Isotopically labeled analogs of analytes of interest (or similar in physiochemical properties to the target analytes but with a distinct response) to be quantitated. Added to all blanks, standards, samples and batch QC after extraction and prior to analysis.
Instrument Blank	A clean sample (e.g., distilled water) processed through the instrumental steps of the measurement process; used to determine instrument contamination.
Instrument Detection Limits (IDLs)	Limits determined by analyzing a series of reagent blank analyses to obtain a calculated concentration. IDLs are determined by calculating the average of the standard deviations of three runs on three non-consecutive days from the analysis of a reagent blank solution with seven consecutive measurements per day.
Interference, spectral	Occurs when particulate matter from the atomization scatters incident radiation from the source or when the absorption or emission from an interfering species either overlaps or is so close to the analyte wavelength that resolution becomes impossible.
Interference, chemical	Results from the various chemical processes that occur during atomization and later the absorption characteristics of the analyte.
Internal Standard	TNI and DoD- A known amount of standard added to a test portion of a sample as a reference for evaluating and controlling the precision and bias of the applied analytical method.
International Organization for Standardization (ISO)	An international standard-setting body composed of representatives from various national standards organizations.
Intermediate Standard Solution	Reference solutions prepared by dilution of the stock solutions with an appropriate solvent.
International System of Units (SI)	The coherent system of units adopted and recommended by the General Conference on Weights and Measures.
Ion Chromatography (IC)	Instrumentation or process that allows the separation of ions and molecules based on the charge properties of the molecules.
Isomer	One of two or more compounds, radicals, or ions that contain the same number of atoms of the same element but differ in structural arrangement and properties. For example, hexane (C6H14) could be n-hexane, 2-methylpentane, 3-methylpentane, 2,3-dimethylbutane, 2,2-dimethylbutane.
Laboratory	A body that calibrates and/or performs testing..
Laboratory Control Sample (LCS)	TNI- (also known as laboratory fortified blank (LFB), spiked blank, or QC check sample): A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes and taken through all sample preparation and analytical steps of the procedure unless otherwise noted in a reference method. It is generally used to establish intra-laboratory or analyst-specific precision and bias or to evaluate the performance of all or a portion of the measurement system.
Laboratory Duplicate	Aliquots of a sample taken from the same container under laboratory conditions and processed and analyzed independently.
Laboratory Information Management System (LIMS)	DoD- The entirety of an electronic data system (including hardware and software) that collects, analyzes, stores, and archives electronic records and documents.
Learning Management System (LMS)	A web-based database used by the laboratories to track and document training activities. The system is administered by the corporate training department and each laboratory's learn centers are maintained by a local administrator.
Legal Chain-of-Custody Protocols	TNI- Procedures employed to record the possession of samples from the time of sampling through the retention time specified by the client or program. These procedures are performed at the special request of the client and include the use of a Chain-of-Custody (COC) Form that documents the collection, transport, and receipt of compliance samples by the laboratory. In addition, these protocols document all handling of the samples within the laboratory.

Limit(s) of Detection (LOD)	TNI- The minimum result, which can be reliably discriminated from a blank with predetermined confidence level. DoD- The smallest concentration of a substance that must be present in a sample in order to be detected at the DL with 99% confidence. At the LOD, the false negative rate (Type II error) is 1%. A LOD may be used as the lowest concentration for reliably reporting a non-detect of a specific analyte in a specific matrix with a specific method at 99% confidence.
Limit(s) of Quantitation (LOQ)	TNI- The minimum levels, concentrations, or quantities of a target variable (e.g., target analyte) that can be reported with a specified degree of confidence. DoD- The smallest concentration that produces a quantitative result with known and recorded precision and bias. For DoD/DoE projects, the LOQ shall be set at or above the concentration of the lowest initial calibration standard and within the calibration range.
Linear Dynamic Range	DoD- Concentration range where the instrument provides a linear response.
Liquid chromatography/ tandem mass spectrometry (LC/MS/MS)	Instrumentation that combines the physical separation techniques of liquid chromatography with the mass analysis capabilities of mass spectrometry.
Lot	TNI- A definite amount of material produced during a single manufacturing cycle, and intended to have uniform character and quality.
Management	Those individuals directly responsible and accountable for planning, implementing, and assessing work.
Management System	System to establish policy and objectives and to achieve those objectives.
Manager (however named)	The individual designated as being responsible for the overall operation, all personnel, and the physical plant of the environmental laboratory. A supervisor may report to the manager. In some cases, the supervisor and the manager may be the same individual.
Matrix	TNI- The substrate of a test sample.
Matrix Duplicate	TNI- A replicate matrix prepared in the laboratory and analyzed to obtain a measure of precision.
Matrix Spike (MS) (spiked sample or fortified sample)	TNI- A sample prepared, taken through all sample preparation and analytical steps of the procedure unless otherwise noted in a referenced method, by adding a known amount of target analyte to a specified amount of sample for which an independent test result of target analyte concentration is available. Matrix spikes are used, for example, to determine the effect of the matrix on a method's recovery efficiency.
Matrix Spike Duplicate (MSD) (spiked sample or fortified sample duplicate)	TNI- A replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte.
Measurement Performance Criteria (MPC)	DoD- Criteria that may be general (such as completion of all tests) or specific (such as QC method acceptance limits) that are used by a project to judge whether a laboratory can perform a specified activity to the defined criteria.
Measurement Quality Objective (MQO)	TNI- The analytical data requirements of the data quality objectives are project- or program-specific and can be quantitative or qualitative. MQOs are measurement performance criteria or objectives of the analytical process. Examples of quantitative MQOs include statements of required analyte detectability and the uncertainty of the analytical protocol at a specified radionuclide activity, such as the action level. Examples of qualitative MQOs include statements of the required specificity of the analytical protocol, e.g., the ability to analyze for the radionuclide of interest given the presence of interferences.
Measurement System	TNI- A method, as implemented at a particular laboratory, and which includes the equipment used to perform the test and the operator(s). DoD- A test method, as implemented at a particular laboratory, and which includes the equipment used to perform the sample preparation and test and the operator(s).
Measurement Uncertainty	DoD- An estimate of the error in a measurement often stated as a range of values that contain the true value within a certain confidence level. The uncertainty generally includes many components which may be evaluated from experimental standard deviations based on repeated observations or by standard deviations evaluated from assumed probability distributions based on experience or other information. For DoD/DoE, a laboratory's Analytical Uncertainty (such as use of LCS control limits) can be reported as the minimum uncertainty.
Method	TNI- A body of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, quantification), systematically presented in the order in which they are to be executed.

Method Blank	TNI- A sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or interferences are present at concentrations that impact the analytical results for sample analyses.
Method Detection Limit (MDL)	TNI- One way to establish a Detection Limit; defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte.
Method of Standard Additions	A set of procedures adding one or more increments of a standard solution to sample aliquots of the same size in order to overcome inherent matrix effects. The procedures encompass the extrapolation back to obtain the sample concentration.
Minimum Detectable Activity (MDA)	TNI- Estimate of the smallest true activity that ensures a specified high confidence, $1 - \beta$, of detection above the Critical Value, and a low probability β of false negatives below the Critical Value. For radiometric methods, β is often set at 0.05. NOTE 1: The MDS is a measure of the detection capability of a measurement process and as such, it is an a priori concept. It may be used in the selection of methods to meet specified MQOs. Laboratories may also calculate a "sample specific" MDA, which indicates how well the measurement process is performing under varying real-world measurement conditions, when sample-specific characteristics (e.g., interferences) may affect the detection capability. However, the MDA must never be used instead of the Critical Value as a detection threshold. NOTE 2: For the purpose of this Standard, the terms MDA and minimum detectable concentration (MDC) are equivalent.
Minimum Reporting Limit (MRL)	the lowest concentration of standard used for calibration – Drinking Water Manual
MintMiner	Commercial software program used to scan large amounts of chromatographic data to monitor for errors or data integrity issues.
Mobile Laboratory	TNI- A portable enclosed structure with necessary and appropriate accommodation and environmental conditions for a laboratory, within which testing is performed by analysts. Examples include but are not limited to trailers, vans, and skid-mounted structures configured to house testing equipment and personnel.
National Environmental Laboratory Accreditation Conference (NELAC)	See definition of The NELAC Institute (TNI).
National Institute of Occupational Safety and Health (NIOSH)	National institute charged with the provision of training, consultation and information in the area of occupational safety and health.
National Institute of Standards and Technology (NIST)	TNI- A federal agency of the US Department of Commerce's Technology Administration that is designed as the United States national metrology institute (or NMI).
National Pollutant Discharge Elimination System (NPDES)	A permit program that controls water pollution by regulating point sources that discharge pollutants into U.S. waters.
Negative Control	Measures taken to ensure that a test, its components, or the environment do not cause undesired effects, or produce incorrect test results.
Nitrogen Phosphorus Detector (NPD)	A detector used in GC analyses that utilizes thermal energy to ionize an analyte. With this detector, nitrogen and phosphorus can be selectively detected with a higher sensitivity than carbon.
Nonconformance	An indication or judgment that a product or service has not met the requirement of the relevant specifications, contract, or regulation; also the state of failing to meet the requirements.
Not Detected (ND)	The result reported for a compound when the detected amount of that compound is less than the method reporting limit.
Operator Aid	DoD- A technical posting (such as poster, operating manual, or notepad) that assists workers in performing routine tasks. All operator aids must be controlled documents (i.e., a part of the laboratory management system).
Performance Based Measurement System (PBMS)	An analytical system wherein the data quality needs, mandates or limitations of a program or project are specified and serve as criteria for selecting appropriate test methods to meet those needs in a cost-effective manner.
Physical Parameter	TNI- A measurement of a physical characteristic or property of a sample as distinguished from the concentrations of chemical and biological components.

Photo-ionization Detector (PID)	An ion detector which uses high-energy photons, typically in the ultraviolet range, to break molecules into positively charged ions.
Polychlorinated Biphenyls (PCB)	A class of organic compounds that were used as coolants and insulating fluids for transformers and capacitors. The production of these compounds was banned in the 1970's due to their high toxicity.
Positive Control	Measures taken to ensure that a test and/or its components are working properly and producing correct or expected results from positive test subjects.
Post-Digestion Spike	A sample prepared for metals analyses that has analytes spike added to determine if matrix effects may be a factor in the results.
Power of Hydrogen (pH)	The measure of acidity or alkalinity of a solution.
Practical Quantitation Limit (PQL)	Another term for a method reporting limit. The lowest reportable concentration of a compound based on parameters set up in an analytical method and the laboratory's ability to reproduce those conditions.
Precision	TNI- The degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves; a data quality indicator. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms.
Preservation	TNI and DoD- Any conditions under which a sample must be kept in order to maintain chemical, physical, and/or biological integrity prior to analysis.
Primary Accreditation Body (Primary AB)	TNI- The accreditation body responsible for assessing a laboratory's total quality system, on-site assessment, and PT performance tracking for fields of accreditation.
Procedure	TNI- A specified way to carry out an activity or process. Procedures can be documented or not.
Proficiency Testing (PT)	TNI- A means to evaluate a laboratory's performance under controlled conditions relative to a given set of criteria, through analysis of unknown samples provided by an external source.
Proficiency Testing Program (PT Program)	TNI- The aggregate of providing rigorously controlled and standardized environmental samples to a laboratory for analysis, reporting of results, statistical evaluation of the results and the collective demographics and results summary of all participating laboratories.
Proficiency Testing Provider (PT Provider)	TNI- A person or organization accredited by a TNI-approved Proficiency Testing Provider Accreditor to operate a TNI-compliant PT Program.
Proficiency Testing Provider Accreditor (PTPA)	TNI- An organization that is approved by TNI to accredit and monitor the performance of proficiency testing providers.
Proficiency Testing Reporting Limit (PTRL)	TNI- A statistically derived value that represents the lowest acceptable concentration for an analyte in a PT sample, if the analyte is spiked into the PT sample. The PTRLs are specified in the TNI FoPT tables.
Proficiency Testing Sample (PT)	TNI- A sample, the composition of which is unknown to the laboratory, and is provided to test whether the laboratory can produce analytical results within the specified acceptance criteria.
Proficiency Testing (PT) Study	TNI- a) Scheduled PT Study: A single complete sequence of circulation and scoring of PT samples to all participants in a PT program. The study must have the same pre-defined opening and closing dates for all participants; b) Supplemental PT Study: A PT sample that may be from a lot previously released by a PT Provider that meets the requirements for supplemental PT samples given in Volume 3 of this Standard [TNI] but that does not have a pre-determined opening date and closing date.
Proficiency Testing Study Closing Date	TNI- a) Scheduled PT Study: The calendar date by which all participating laboratories must submit analytical results for a PT sample to a PT Provider; b) Supplemental PT Study: The calendar date a laboratory submits the results for a PT sample to the PT Provider.
Proficiency Testing Study Opening Date	TNI- a) Scheduled PT Study: The calendar date that a PT sample is first made available to all participants of the study by a PT Provider; b) Supplemental PT Study: The calendar date the PT Provider ships the sample to a laboratory.
Protocol	TNI- A detailed written procedure for field and/or laboratory operation (e.g., sampling, analysis) that must be strictly followed.
Qualitative Analysis	DoD- Analysis designed to identify the components of a substance or mixture.
Quality Assurance (QA)	TNI- An integrated system of management activities involving planning, implementation, assessment, reporting and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the client.
Quality Assurance Manual (QAM)	A document stating the management policies, objectives, principles, organizational structure and authority, responsibilities, accountability, and implementation of an agency, organization, or laboratory, to ensure the quality of its product and the utility of its product to its users.
Quality Assurance Project Plan (QAPP)	A formal document describing the detailed quality control procedures by which the quality requirements defined for the data and decisions pertaining to a specific project are to be achieved.

Quality Control (QC)	TNI- The overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer; operational techniques and activities that are used to fulfill requirements for quality; also the system of activities and checks used to ensure that measurement systems are maintained within prescribed limits, providing protection against "out of control" conditions and ensuring that the results are of acceptable quality.
Quality Control Sample (QCS)	TNI- A sample used to assess the performance of all or a portion of the measurement system. One of any number of samples, such as Certified Reference Materials, a quality system matrix fortified by spiking, or actual samples fortified by spiking, intended to demonstrate that a measurement system or activity is in control.
Quality Manual	TNI- A document stating the management policies, objectives, principles, organizational structure and authority, responsibilities, accountability, and implementation of an agency, organization, or laboratory, to ensure the quality of its product and the utility of its product to its users.
Quality System	TNI and DoD- A structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products (items), and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required quality assurance and quality control activities.
Quality System Matrix	TNI and DoD- These matrix definitions shall be used for purposes of batch and quality control requirements and may be different from a field of accreditation matrix: • **Air and Emissions**: Whole gas or vapor samples including those contained in flexible or rigid wall containers and the extracted concentrated analytes of interest from a gas or vapor that are collected with a sorbant tube, impinger solution, filter, or other device • **Aqueous**: Any aqueous sample excluded from the definition of Drinking Water or Saline/Estuarine. Includes surface water, groundwater effluents, and TCLP or other extracts. • **Biological Tissue**: Any sample of a biological origin such as fish tissue, shellfish or plant material. Such samples shall be grouped according to origin. • **Chemical Waste**: A product or by-product of an industrial process that results in a matrix not previously defined. • **Drinking Water**: Any aqueous sample that has been designated a potable or potentially potable water source. • **Non-aqueous liquid**: Any organic liquid with <15% settleable solids • **Saline/Estuarine**: Any aqueous sample from an ocean or estuary, or other salt water source such as the Great Salt Lake. • **Solids**: Includes soils, sediments, sludges, and other matrices with >15% settleable solids.
Quantitation Range	DoD- The range of values (concentrations) in a calibration curve between the LOQ and the highest successively analyzed initial calibration standard used to relate instrument response to analyte concentration. The quantitation range (adjusted for initial sample volume/weight, concentration/dilution and final volume) lies within the calibration range.
Quantitative Analysis	DoD- Analysis designed to determine the amounts or proportions of the components of a substance.
Random Error	The EPA has established that there is a 5% probability that the results obtained for any one analyte will exceed the control limits established for the test due to random error. As the number of compounds measured increases in a given sample, the probability for statistical error also increases.
Raw Data	TNI- The documentation generated during sampling and analysis. This documentation includes, but is not limited to, field notes, electronic data, magnetic tapes, untabulated sample results, QC sample results, print outs of chromatograms, instrument outputs, and handwritten records.
Reagent Blank (method reagent blank)	A sample consisting of reagent(s), without the target analyte or sample matrix, introduced into the analytical procedure at the appropriate point and carried through all subsequent steps to determine the contribution of the reagents and of the involved analytical steps.
Reagent Grade	Analytical reagent (AR) grade, ACS reagent grade, and reagent grade are synonymous terms for reagents that conform to the current specifications of the Committee on Analytical Reagents of the American Chemical Society.
Records	DoD- The output of implementing and following management system documents (e.g., test data in electronic or hand-written forms, files, and logbooks).

Reference Material	TNI- Material or substance one or more of whose property values are sufficiently homogenized and well established to be used for the calibration of an apparatus, the assessment of a measurement method, or for assigning values to materials.
Reference Method	TNI- A published method issued by an organization generally recognized as competent to do so. (When the ISO language refers to a "standard method", that term is equivalent to "reference method"). When a laboratory is required to analyze by a specified method due to a regulatory requirement, the analyte/method combination is recognized as a reference method. If there is no regulatory requirement for the analyte/method combination, the analyte/method combination is recognized as a reference method if it can be analyzed by another reference method of the same matrix and technology.
Reference Standard	TNI- Standard used for the calibration of working measurement standards in a given organization or at a given location.
Relative Percent Difference (RPD)	A measure of precision defined as the difference between two measurements divided by the average concentration of the two measurements.
Reporting Limit (RL)	The level at which method, permit, regulatory and customer-specific objectives are met. The reporting limit may never be lower than the Limit of Detection (i.e., statistically determined MDL). Reporting limits are corrected for sample amounts, including the dry weight of solids, unless otherwise specified. There must be a sufficient buffer between the Reporting Limit and the MDL. DoD- A customer-specified lowest concentration value that meets project requirements for quantitative data with known precision and bias for a specific analyte in a specific matrix.
Reporting Limit Verification Standard (RLVS)	A standard analyzed at the reporting limit for an analysis to verify the laboratory's ability to report to that level.
Representativeness	A quality element related to the ability to collect a sample reflecting the characteristics of the part of the environment to be assessed. Sample representativeness is dependent on the sampling techniques specified in the project work plan.
Requirement	Denotes a mandatory specification; often designated by the term "shall".
Retention Time	The time between sample injection and the appearance of a solute peak at the detector.
Revocation	TNI- The total or partial withdrawal of a laboratory's accreditation by an accreditation body.
Sample	Portion of material collected for analysis, identified by a single, unique alphanumeric code. A sample may consist of portions in multiple containers, if a single sample is submitted for multiple or repetitive analysis.
Sample Condition Upon Receipt Form (SCURF)	Form used by sample receiving personnel to document the condition of sample containers upon receipt to the laboratory (used in conjunction with a COC).
Sample Delivery Group (SDG)	A unit within a single project that is used to identify a group of samples for delivery. An SDG is a group of 20 or fewer field samples within a project, received over a period of up to 14 calendar days. Data from all samples in an SDG are reported concurrently.
Sample Receipt Form (SRF)	Letter sent to the client upon login to show the tests requested and pricing.
Sample Tracking	Procedures employed to record the possession of the samples from the time of sampling until analysis, reporting and archiving. These procedures include the use of a chain-of-custody form that documents the collection, transport, and receipt of compliance samples to the laboratory. In addition, access to the laboratory is limited and controlled to protect the integrity of the samples.
Sampling	TNI- Activity related to obtaining a representative sample of the object of conformity assessment, according to a procedure.
Selected Ion Monitoring (SIM)	A mode of analysis in mass spectrometry where the detector is set to scan over a very small mass range, typically one mass unit. The narrower the range, the more sensitive the detector. DoD- Using GC/MS, characteristic ions specific to target compounds are detected and used to quantify in applications where the normal full scan mass spectrometry results in excessive noise.
Selectivity	TNI- The ability to analyze, distinguish, and determine a specific analyte or parameter from another component that may be a potential interferent or that may behave similarly to the target analyte or parameter within the measurement system.
Sensitivity	TNI- The capability of a method or instrument to discriminate between measurement responses representing different levels (e.g., concentrations) of a variable of interest.
Serial Dilution	The stepwise dilution of a substance in a solution.
Shall	Denotes a requirement that is mandatory whenever the criterion for conformance with the specification requires that there be no deviation. This does not prohibit the use of alternative approaches or methods for implementing the specification as long as the requirement is fulfilled.

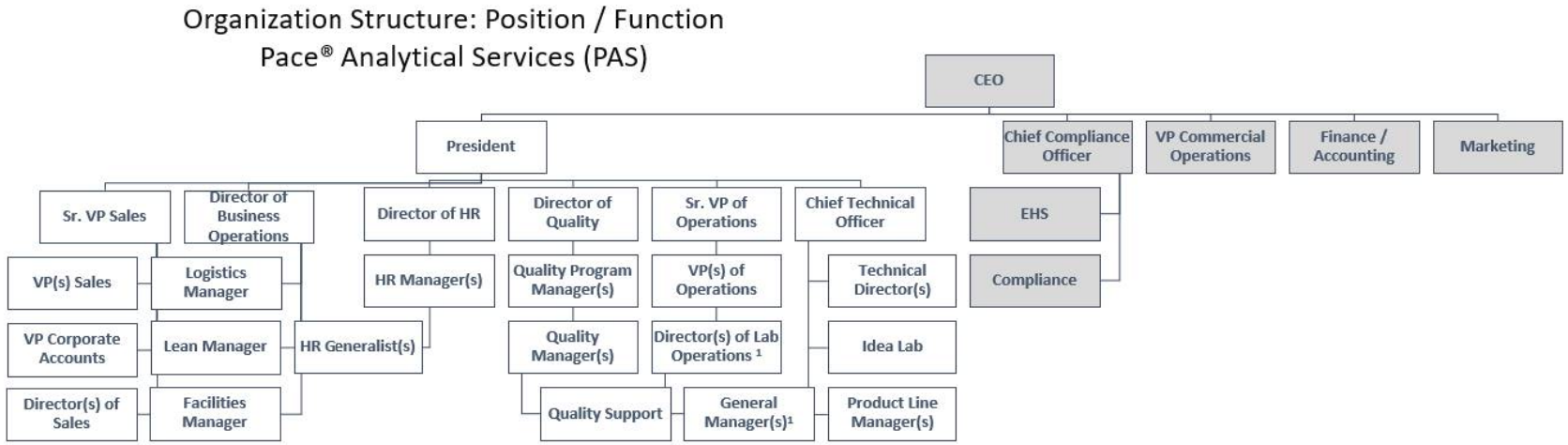
Should	Denotes a guideline or recommendation whenever noncompliance with the specification is permissible.
Signal-to-Noise Ratio (S/N)	DoD- A measure of signal strength relative to background noise. The average strength of the noise of most measurements is constant and independent of the magnitude of the signal. Thus, as the quantity being measured (producing the signal) decreases in magnitude, S/N decreases and the effect of the noise on the relative error of a measurement increases.
Source Water	TNI- When sampled for drinking water compliance, untreated water from streams, rivers, lakes, or underground aquifers, which is used to supply private and public drinking water supplies.
Spike	A known mass of target analyte added to a blank sample or sub-sample; used to determine recovery efficiency or for other quality control purposes.
Standard (Document)	TNI- The document describing the elements of a laboratory accreditation that has been developed and established within the consensus principles of standard setting and meets the approval requirements of standard adoption organizations procedures and policies.
Standard (Chemical)	Standard samples are comprised of a known amount of standard reference material in the matrix undergoing analysis. A standard reference material is a certified reference material produced by US NIST and characterized for absolute content, independent of analytical test method.
Standard Blank (or Reagent Blank)	A calibration standard consisting of the same solvent/reagent matrix used to prepare the calibration standards without the analytes. It is used to construct the calibration curve by establishing instrument background.
Standard Method	A test method issued by an organization generally recognized as competent to do so.
Standard Operating Procedure (SOP)	TNI- A written document that details the method for an operation, analysis, or action with thoroughly prescribed techniques and steps. SOPs are officially approved as the methods for performing certain routine or repetitive tasks.
Standard Reference Material (SRM)	A certified reference material produced by the US NIST or other equivalent organization and characterized for absolute content, independent of analytical method.
Statement of Qualifications (SOQ)	A document that lists information about a company, typically the qualifications of that company to compete on a bid for services.
Stock Standard	A concentrated reference solution containing one or more analytes prepared in the laboratory using an assayed reference compound or purchased from a reputable commercial source.
Storage Blank	DoD- A sample of analyte-free media prepared by the laboratory and retained in the sample storage area of the laboratory. A storage blank is used to record contamination attributable to sample storage at the laboratory.
Supervisor	The individual(s) designated as being responsible for a particular area or category of scientific analysis. This responsibility includes direct day-to-day supervision of technical employees, supply and instrument adequacy and upkeep, quality assurance/quality control duties and ascertaining that technical employees have the required balance of education, training and experience to perform the required analyses.
Surrogate	DoD- A substance with properties that mimic the analyte of interest. It is unlikely to be found in environmental samples and is added to them for quality control purposes.
Suspension	TNI- The temporary removal of a laboratory's accreditation for a defined period of time, which shall not exceed 6 months or the period of accreditation, whichever is longer, in order to allow the laboratory time to correct deficiencies or area of non-conformance with the Standard.
Systems Audit	An on-site inspection or assessment of a laboratory's quality system.
Target Analytes	DoD- Analytes or chemicals of primary concern identified by the customer on a project-specific basis.
Technical Director	Individual(s) who has overall responsibility for the technical operation of the environmental testing laboratory.
Technology	TNI- A specific arrangement of analytical instruments, detection systems, and/or preparation techniques.
Test	A technical operation that consists of the determination of one or more characteristics or performance of a given product, material, equipment, organism, physical phenomenon, process or service according to a specified procedure. The result of a test is normally recorded in a document sometimes called a test report or a test certificate.
Test Method	DoD- A definitive procedure that determines one or more characteristics of a given substance or product.
Test Methods for Evaluating Solid Waste, Physical/ Chemical (SW-846)	EPA Waste's official compendium of analytical and sampling methods that have been evaluated and approved for use in complying with RCRA regulations.

Test Source	TNI- A radioactive source that is tested, such as a sample, calibration standard, or performance check source. A Test Source may also be free of radioactivity, such as a Test Source counted to determine the subtraction background, or a short-term background check.
The NELAC Institute (TNI)	A non-profit organization whose mission is to foster the generation of environmental data of known and documented quality through an open, inclusive, and transparent process that is responsive to the needs of the community. Previously known as NELAC (National Environmental Laboratory Accreditation Conference).
Total Petroleum Hydrocarbons (TPH)	A term used to denote a large family of several hundred chemical compounds that originate from crude oil. Compounds may include gasoline components, jet fuel, volatile organics, etc.
Toxicity Characteristic Leaching Procedure (TCLP)	A solid sample extraction method for chemical analysis employed as an analytical method to simulate leaching of compounds through a landfill.
Traceability	TNI- The ability to trace the history, application, or location of an entity by means of recorded identifications. In a calibration sense, traceability relates measuring equipment to national or international standards, primary standards, basic physical conditions or properties, or reference materials. In a data collection sense, it relates calculations and data generated throughout the project back to the requirements for the quality of the project.
Training Document	A training resource that provides detailed instructions to execute a specific method or job function.
Trip Blank	This blank sample is used to detect sample contamination from the container and preservative during transport and storage of the sample. A cleaned sample container is filled with laboratory reagent water and the blank is stored, shipped, and analyzed with its associated samples.
Tuning	A check and/or adjustment of instrument performance for mass spectrometry as required by the method.
Ultraviolet Spectrophotometer (UV)	Instrument routinely used in quantitative determination of solutions of transition metal ions and highly conjugated organic compounds.
Uncertainty, Counting	TNI- The component of Measurement Uncertainty attributable to the random nature of radioactive decay and radiation counting (often estimated as the square root of observed counts (MARLAP). Older references sometimes refer to this parameter as Error, Counting Error or Count Error (c.f., Total Uncertainty).
Uncertainty, Expanded	TNI- The product of the Standard Uncertainty and a coverage factor, k, which is chosen to produce an interval about the result that has a high probability of containing the value of the measurand (c.f., Standard Uncertainty). NOTE: Radiochemical results are generally reported in association with the Total Uncertainty. Either if these estimates of uncertainty can be reported as the Standard Uncertainty (one-sigma) or as an Expanded Uncertainty (k-sigma, where $k > 1$).
Uncertainty, Measurement	TNI- Parameter associated with the result of a measurement that characterizes the dispersion of the values that could reasonably be attributed to the measurand.
Uncertainty, Standard	TNI- An estimate of the Measurement Uncertainty expressed as a standard deviation (c.f., Expanded Uncertainty).
Uncertainty, Total	TNI- An estimate of the Measurement Uncertainty that accounts for contributions from all significant sources of uncertainty associated with the analytical preparation and measurement of a sample. Such estimates are also commonly referred to as Combined Standard Uncertainty or Total Propagated Uncertainty, and in some older references as the Total Propagated Error, among other similar items (c.f., Counting Uncertainty).
Unethical actions	DoD- Deliberate falsification of analytical or quality control results where failed method or contractual requirements are made to appear acceptable.
United States Department of Agriculture (USDA)	A department of the federal government that provides leadership on food, agriculture, natural resources, rural development, nutrition and related issues based on public policy, the best available science, and effective management.
United States Geological Survey (USGS)	Program of the federal government that develops new methods and tools to supply timely, relevant, and useful information about the Earth and its processes.
Unregulated Contaminant Monitoring Rule (UCMR)	EPA program to monitor unregulated contaminants in drinking water.
Validation	DoD- The confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled.

Verification	TNI- Confirmation by examination and objective evidence that specified requirements have been met. In connection with the management of measuring equipment, verification provides a means for checking that the deviations between values indicated by a measuring instrument and corresponding known values of a measured quantity are consistently smaller than the maximum allowable error defined in a standard, regulation or specification peculiar to the management of the measuring equipment.
Voluntary Action Program (VAP)	A program of the Ohio EPA that gives individuals a way to investigate possible environmental contamination, clean it up if necessary and receive a promise from the State of Ohio that no more cleanup is needed.
Whole Effluent Toxicity (WET)	The aggregate toxic effect to aquatic organisms from all pollutants contained in a facility's wastewater (effluent).

7.4 Appendix D: Organization Chart(s)

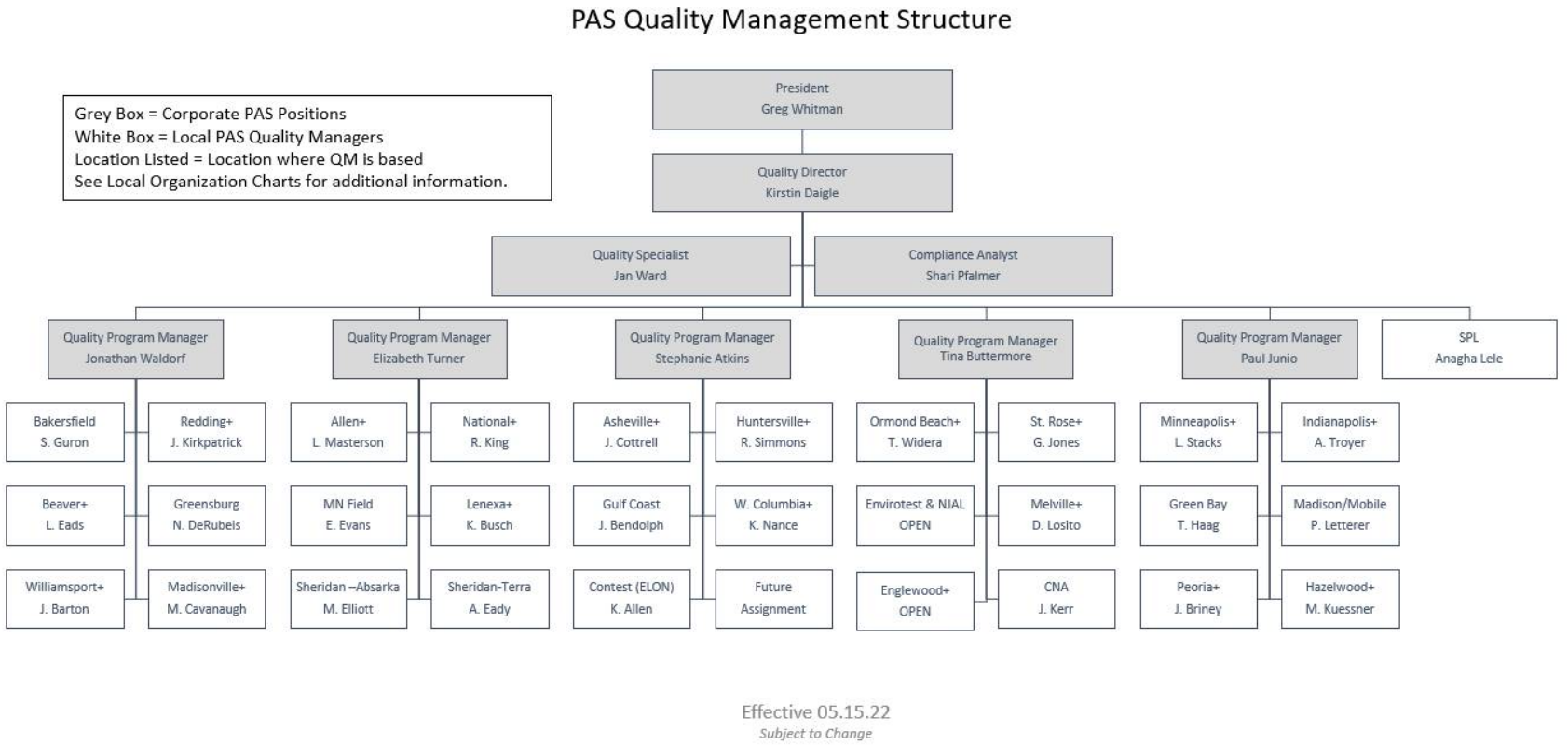
7.4.1 PAS Corporate Organization Chart(s)



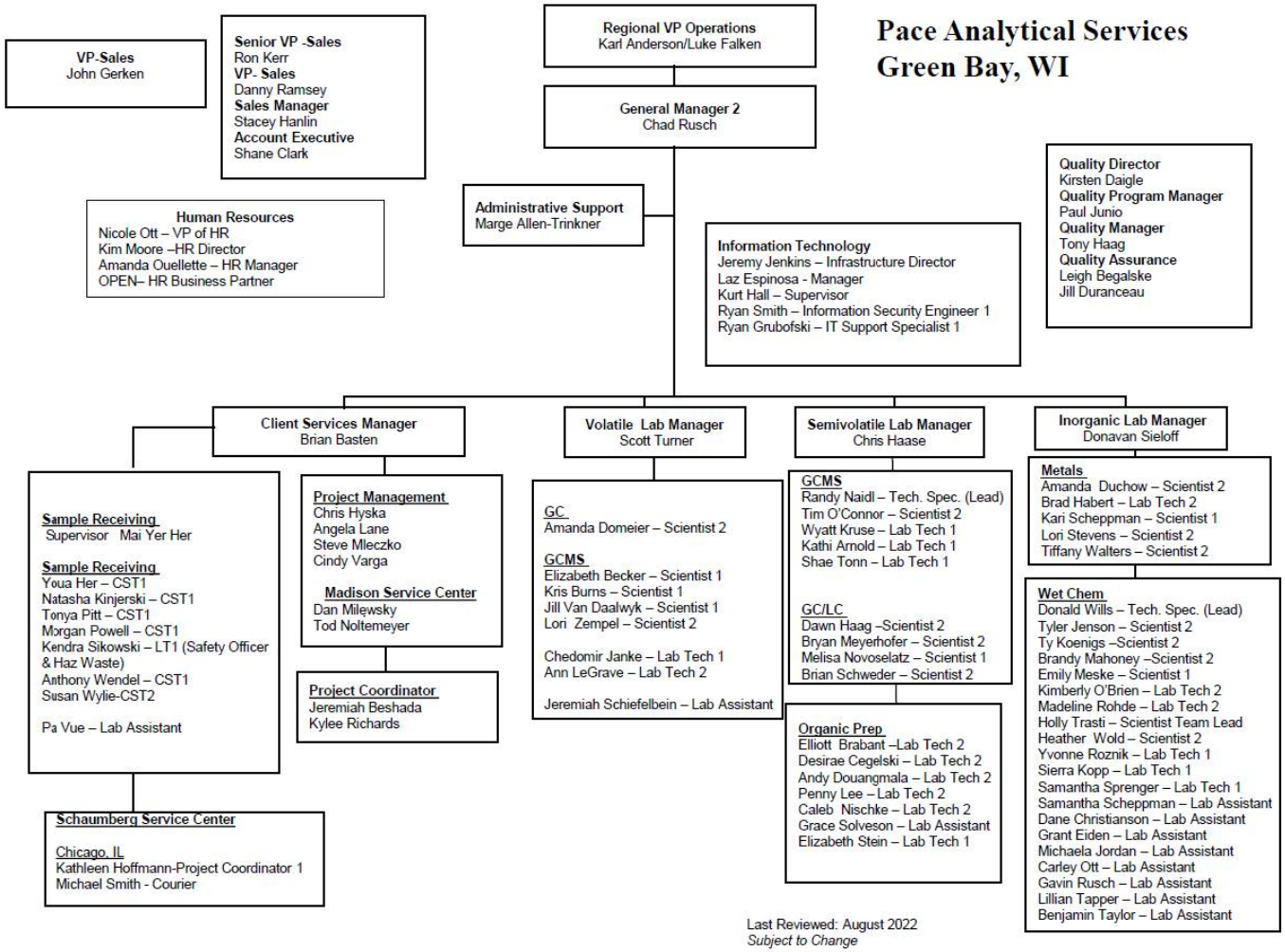
White Box = PAS Positions / Functions
Grey Box = Pace®Corporate Positions / Functions
1= Positions not Assigned to all Locations – see location specific organization charts

Effective 05.15.22
Subject to Change

7.4.2 PAS Quality Systems Management Organization Chart



7.4.3 Pace® Green Bay – Organization Chart



7.5 Appendix E: Equipment Listing

The equipment listed represents equipment were held by each location on the effective date of this manual. This information is subject to change without notice. External parties should contact the location for the most current information.

7.5.1 PAS-Green Bay

Equipment List: PAS-Green Bay

Description	Manufacturer	Model	Serial Number	Service Date	Condition	Location	Internal ID	Location of Manual
Quick Trace Mercury Analyzer	Cetac	M-7500	051104QTA	6/15/11	New	Metals Dept	40HG2	At Instrument
Direct Mercury Analyzer	Milestone	DMA-80	10070875	11/3/11	New	Metals Dept	40HG4	On-line
ICPMS	Thermo	X Series 2	01301C	6/11/08	New	Metals Dept	40ICM2	On-line
ICPMS	Thermo	ICAP RQ	ICAPRQ03452	NA	New	Metals	40ICM4	On-line
ICP	Thermo	ICAP 6500	20073913	10/1/04	New	Metals Dept	40ICP2	On-line
ICP	Thermo	ICAP Pro	ICAPPRO60274	4/1/22	New	Metals Dept	40ICP3	On-line
Low Level Mercury	Analytik Jena	Mercur	K170A0130	10/18/10	New	LL Hg	40LHG4	On-line
Low Level Mercury	Cetac	M-8000	111003QM8	8/17/12	New	LL Hg	40LHG5	On-line
GC/FID	Hewlett Packard	5890 Series II	3140A38457	10/1/04	Used	SVOA	40GCS1	At instrument
GC/ECD	Agilent	6890N	US10538012	8/1/10	Used	SVOA	40GCS7	At instrument
GC/ECD	Hewlett-Packard	6890	US00031701	10/1/04	Used	SVOA	40GCS8	At instrument
GC/ECD	Hewlett-Packard	6890	US00021961	10/1/04	Used	SVOA	40GCS9	At instrument
GC/ECD	Agilent	6890	US00040655	10/1/04	Used	SVOA	40GCSB	At instrument
GC/ECD	Hewlett-Packard	6890	US00024921	10/1/04	Used	SVOA	40GCSC	At instrument
GC/FID	Agilent	7890	CN10912008	5/19/09	New	SVOA	40GCSF	At instrument
GC/ECD	Agilent	7890B	CN14043012	3/1/14	New	SVOA	40GCSG	At instrument
GC/ECD	Hewlett-Packard	6890	US10344089	3/1/14	New	SVOA	40GCSH	At instrument
GC/ECD	Agilent	6890	US10443037	3/1/14	New	SVOA	40GCSJ	At instrument
GC/MS	Hewlett-Packard	6890	US81221570	2/1/00	New	SVOA	40MSS2	At instrument
GC/MS	Hewlett-Packard	6890	US00024414	4/1/99	New	SVOA	40MSS4	At instrument
GC/MS	Hewlett-Packard	5890	3310A49571	10/1/04	Used	SVOA	40MSS6	At instrument
GC/MS	Agilent	7890A	CN10752040	8/5/10	New	SVOA	40MSS7	At instrument
GC/MS	Agilent	7890A	CN10705029	9/4/13	New	SVOA	40MSS8	At instrument
GC/MS	Agilent	6890N	US10540022	6/1/14	Used	SVOA	40MSS9	At instrument
GC/MS	Agilent	7890B	15483197	1/14/16	New	SVOA	40MSSA	At instrument
GC/MS	Agilent	8890	US1949A020	1/14/20	New	SVOA	40MSSB	At instrument
GC/PID/FID	Hewlett-Packard	5890	3310A48054	3/1/92	New	VOA	40GCV1	At instrument
GC/PID/FID	Hewlett-Packard	5890	3310A48054	3/1/92	New	VOA	40GCV2	At instrument
GC/PID/FID	Hewlett-Packard	5890	3140A39241	6/1/93	New	VOA	40GCV3	At instrument
GC/PID/FID	Hewlett-Packard	5890	3336A60500	12/1/95	New	VOA	40GCV4	At instrument

Description	Manufacturer	Model	Serial Number	Service Date	Condition	Location	Internal ID	Location of Manual
GC/FID	Hewlett-Packard	5890	2843A20939	7/1/95	New	VOA	40GCV8	At instrument
GC/MS	Hewlett-Packard	5890	3235A46437	5/14/93	New	VOA	40MSV1	At instrument
GC/MS	Hewlett-Packard	6890	US00032794	10/18/04	New	VOA	40MSV2	At instrument
GC/MS	Agilent	6850	CN10719006	3/6/08	New	VOA	40MSV3	At instrument
GC/MS	Hewlett-Packard	6890	US00040707	9/25/02	New	VOA	40MSV7	At instrument
GC/MS	Agilent	6850	CN1065-1003	7/9/07	New	VOA	40MSV8	At instrument
GC/MS	Hewlett-Packard	7890	CN10031128	4/14/10	New	VOA	40MSVA	At instrument
GC/MS	Hewlett-Packard	7890A	CN10811039	2/5/13	New	VOA	40MSVB	At instrument
GC/MS	Hewlett-Packard	7890B	CN13283076	8/12/13	New	VOA	40MSVC	At instrument
GC/MS	Hewlett-Packard	7890B	CN13283076	8/12/13	New	VOA	40MSVD	At instrument
GC/MS	Hewlett-Packard	7890B	CN13133031	1/28/20	Used	VOA	40MSVE	At instrument
Oxygen Meter	YSI	5000	14F101753	8/20/14	New	Wet Chem.	40WET2	At instrument
Turbidi-meter	Hach	2100P	950400007487	10/1/04	Used	Wet Chem	40WET6	At instrument
Conductivity Meter	Mettler Toledo	FiveEasy Plus FP30	C129191955	9/1/21	New	Wet Chem	40WETK	At instrument
pH Meter	Orion Star	A211	X38338	7/25/17	New	Wet Chem	40WETF	At instrument
EH Meter	Accumet	AB15	AB81200474	7/15/09	Used	Wet Chem	40WET9	At instrument
pH Meter	Orion Star	A211	X38362	7/25/17	New	Wet Chem	40WETG	At instrument
pH Meter	Orion Star	A211	X5433	2/26/20	New	Wet Chem	40WETI	At instrument
pH Meter	Orion Star	A211	C3026	3/2/20	New	Wet Chem	40WETJ	At instrument
BOD AutoEZ	Thermo/Orion	10060020	A0117	9/5/12	New	Wet Chem	40WETE	At instrument
pH Meter	Orion Star	A211	X38338	7/25/17	New	Wet Chem	40WETF	At instrument
pH Meter	Orion Star	A211	X38338	7/25/17	New	Wet Chem	40WETG	At instrument
Flashpoint	Tanaka	Apm-8fc	34602	2/24/22	New	Wet Chem	40WETL	At instrument
Direct Reading Spectro-photometer	Hach	DR 2000	960300039446	10/1/04	Used	Wet Chem	40WTA1	At instrument
Apollo	Tekmar/ Dohrmann	Apollo 9000	99174002	10/1/04	Used	Wet Chem	40WTA5	At instrument
Fusion	Teledyne	14-9600-100	US08105007	10/1/04	Used	Wet Chem	40WTA7	At instrument
Ion Chromato-graph	Thermo Scientific	ICS-110	12051009	8/3/12	New	Wet Chem	40WTAB	At instrument
Quick Chem 8500 Series II	Lachat	8500 Series 2	120600001428	8/13/12	New	Wet Chem	40WTAC	At instrument
Ion Chromato-graph	Thermo Scientific	ICS-1100	13040963	7/16/13	New	Wet Chem	40WTAD	At instrument

Description	Manufacturer	Model	Serial Number	Service Date	Condition	Location	Internal ID	Location of Manual
Quik Chem 8500 Series II	Lachat	8500 Series 2	140500001688	6/10/14	New	Wet Chem	40WTAE	At instrument
Ion Chromato-graph	Thermo Scientific	Aquion	160640270	8/19/16	New	Wet Chem	40WTAF	At instrument
Analytik Jena	Analytik Jena	Multi EA 4000	N4-167/N	8/1/17	New	Wet Chem	40WTAG	At instrument
Quik Chem 8500 Series II	Lachat	8500 Series 2	191000002249	12/6/19	New	Wet Chem	40WTAH	At instrument
Omnis Titrator	Metrohm	110010010	001000158371	12/9/19	New	Wet Chem	40WTAI	At instrument
TOC-VWP	Shimadzu	TOC-VWP	H51725600347	12/16/19	New	Wet Chem	40WTAJ	At instrument
Ion Chromato-graph	Thermo Scientific	ICS-1100	11121052	2/11/21	Used	Wet Chem	40WTAK	At instrument

8.0 ADDENDUM: PROGRAM REQUIREMENTS

Section 8.0 provides additional requirements the locations covered by this manual are required to follow when performing work under the program. Only requirements that are not covered by the main body of the manual are listed in addendum.

8.1 DoD/DOE

PAS-Green Bay maintains accreditation for DoD/DoE Environmental Laboratory Approval Program (ELAP)

This addendum outlines additional policies and processes established by this laboratory to maintain compliance with DoD/DOE program specific requirements as outlined in the DoD/DOE Consolidated Quality Systems Manual (QSM) for Environmental Laboratories. The QSM incorporates ISO/IEC 17025 and the TNI Standard and includes additional program-specific requirements for laboratories that perform analytical testing services for DoD and DOE, and which must be followed for DoD / DOE projects.

Section 4.2.5: Supporting Documents

In addition to the requirements specified in Section 4.2.5, technical SOPs used for DoD/DOE testing must also include instructions for equipment and instrument maintenance, computer software/hardware, and troubleshooting.

The review frequency for technical SOPs used for DoD/DOE testing is annual, instead of every 2 years.

Section 4.4: Review of Analytical Service Requests

If the DoD/DOE customer requests a statement of conformity, the standard used for the decision rule must be communicated to and agreed on with the customer and identified in the final test report.

Laboratory requests to deviate from the requirements specified in the DoD/DOE QSM must be requested on a project-basis and include technical justifications for the deviation. These requests are submitted to and approved by the DoD/DOE project chemist or contractor, however name, in addition to the PAS client.

For DoD / DOE projects, will also seek clarification from the customer when the customer has requested an incorrect, obsolete, or improper method for the intended use of data; the laboratory needs to depart from its test method SOP in order to meet project-specific data quality objectives; information in project planning documents is missing or is unclear,

Section 4.5: Subcontracting

In addition to written client approval of any subcontractor for testing, the customer is notified of the laboratory's intent to use a subcontractor for any management system element (such as data review, data processing, project management or IT support) and consent for subcontracting is obtained approved in writing by the DoD/DOE customer and record of consent kept in the project record.

Section 4.6: Purchasing and Supplies

The laboratory procedure for records of receipt of materials and supplies used in testing also include a specification to record the date opened (DOE only).

Section 4.9.3: Nonconforming Work

The laboratory's procedure for client notification includes the 15-business day DoD /DOE timeframe for notification of the problem and the 30-business day timeframe for submission of the corrective action plan or corrective actions taken. This procedure also includes the DoD/DOE requirement for AB notification of discovery.

Section 4.13: Control of Records

Technical Records: The laboratory's procedure for logbooks includes measures to prevent the removal of or addition of pages to the logbook (applies to both hardcopy and electronic). Hardcopy logbooks are version controlled, pre-numbered and bound. Initials and entries are signed or initialed and dated by the person making the entry and the entry is made at the time the activity is performed and in chronological order. Each page of the logbook must be closed by the last person making the entry on the page. Closure is recorded by the initial and date of the person making the last entry.

Section 5.4.5.3.3: Limit of Detection

For DoD/DOE the LOD is an estimate of the minimum amount of an analyte that can be reliably detected by an analytical process. For clarification, the LOD is the analyte concentration necessary to distinguish its presence from its absence. The LOD may be used as the lowest concentration for reliably reporting a non-detect (ND). The LOD is specific to each suite of analyte, matrix, and method including sample preparation.

After each DL determination, the laboratory establishes the LOD by spiking a quality system matrix at a concentration of least 2X but no greater than 4X the DL (i.e., 2X DL $\leq$ LOD Spike $\leq$ 4X DL). The spike concentration establishes the LOD and the concentration at which the LOD is verified.

The LOD is established during method validation and after major changes to the analytical system or procedure that affects sensitivity of analysis or how the procedure is performed.

An LOD study is not required for any component for which spiking solutions or quality control samples are not available. Additionally, an LOD study is not required if the laboratory does not report data below the LOQ.

The LOD must be verified on a quarterly basis. Each preparation method listed on the scope of accreditation must have quarterly LOD verifications; however, verification of all possible combinations of preparation and clean-up techniques is not required. Where LOD verifications are not performed on all combinations, the LOD verification is based on the worst-case combination (preparation method with all applicable cleanup steps).

The laboratory's procedure for LOD determination and verification is detailed in SOP ENV-SOP-GBAY-0106 *Determination of the LOD and LOQ*.

Section 5.4.5.3.4: Limit of Quantitation

For DoD/DOE, the LOQ is established for each analyte-matrix-method combination, including surrogates. When an LOD is determined or verified by the laboratory, the LOQ must be above the LOD [DL<LOD<LOQ].

At a minimum, the LOQ must be verified quarterly; however, verification of all possible combinations of preparation and clean-up techniques is not required. Where LOQ verifications are not performed

on all combinations, the LOQ verification on the worst-case combination (preparation method with all applicable cleanup steps).

The laboratory's procedure for LOQ determination and verification is detailed in laboratory SOP INSERT LOCAL SOP REFERENCE.

Section 5.4.7: Control of Data

The laboratory will assure LIMS passwords are changed at least once per year.

An audit of the LIMS will be incorporated into the laboratory's annual internal audit schedule.

The laboratory will have procedures in place to notify DoD/DOE customers of changes to LIMS software or hardware configurations that may impact the customer's integrity of electronic data

Section 5.9.1: Quality Control

For DoD/DOE, storage blanks are essential QC to monitor the storage of samples for volatile organic analysis (VOA). The SOP for storage of VOA samples must include a contamination monitoring program based on the performance of storage blanks. (See QSM 5.3.3)

Section 5.8.5: Sample Disposal

For DOE projects, the record of disposal must also include how the sample was disposed and the name of the person that performed the task.

Appendix E: Support Equipment Calibration

Mechanical Volumetric Pipette: In addition to the quarterly verification check, pipettes used for DoD/DOE projects are checked daily before use using the same procedure and criteria specified for the quarterly check.

Water Purification System: The performance of the water purification system is checked daily prior to use in accordance with SOP ENV-SOP-GBAY-0127 *Use and Maintenance of Water Purification Systems*.

Radiological Survey Equipment: The performance of the radiological survey equipment is checked daily prior to use in accordance with SOP ENV-SOP-GBAY-0158 *ECD Management*.

Additional: (DOE): Section 6.0 of the QSM outlines additional management system requirements for the management of hazardous and radioactive materials management and health and safety practices. The laboratory, if approved for DOE, will consult with the PAS Health and Safety Director to establish plans, policies and procedures that conform to these comprehensive specifications and incorporate these documents into the QMS.

ATTACHMENT 5
Permitted Sampling and Analysis Plan

APTIM

Groundwater Sampling Plan
Advanced Disposal Services Zion Landfill

August 2019

1.0 Introduction

This groundwater sampling plan addresses 35 IAC 811.318 and 35 IAC 812.317.

2.0 Coordination with Laboratory

The laboratory will supply coolers, cleaned and preserved containers, and chain-of-custody forms. They will be informed of the well/parameter combinations for which analyses are to be performed.

3.0 Equipment Preparation

Field equipment required for groundwater sampling will generally consist of the following:

- water level meter;
- pH/specific conductance/temperature meter(s);
- sample bottles and shipping containers;
- control box for dedicated sampling pumps;
- hardcopy and/or electronic field forms; and
- ice.

The field equipment will be cleaned and calibrated prior to the sampling event.

4.0 Monitoring Well Inspection

Monitoring wells will be inspected to identify the following:

- Cracks or discontinuities in the surface seal;
- Settlement of the surface seal;
- Well label and lock on protective cover; and
- Evidence of surface water intrusion into the well casing.

Conditions warranting repair will be recorded.

5.0 Water Level and Well Depth Measurements

Water levels will be measured at the monitoring wells and recorded. The depth below ground of wells that do not have a dedicated pump will be measured on an annual basis. The depth below ground of wells having a dedicated pump will be measured every five years or whenever it is pulled.

6.0 Groundwater Purging

Groundwater will be purged from each monitoring well prior to sampling such that the water level is not lowered to within the screen interval. Wells completed in poorly productive horizons will be purged until the water level is lowered to immediately above the well screen.

A total of three well volumes of groundwater will be purged from each well if possible. Less volume will be purged from wells in which the static water level lies close to or within the screen interval or that recharge slowly.

The temperature, pH, and specific conductance of groundwater will be monitored regularly during purging and the results recorded.

Groundwater purged from detection monitoring wells will be directed into the adjacent perimeter stormwater ditch or disposed of on the ground within the waste limits. Groundwater purged from wells undergoing assessment and/or corrective action will be containerized and disposed with leachate.

7.0 Groundwater Sampling

Groundwater will be sampled following purging. The pump rate will be slowed to approximately 100 ml/minute prior to sample collection. The groundwater level will not be lowered to within the screen interval during sampling. Field measurements for pH, specific conductance, and temperature will be performed and recorded. Samples will be containerized in order of volatility of the parameter as follows:

- Volatile organics;
- Semi-volatile organics (if necessary);
- Metals; and
- Inorganics.

Samples will be filtered with 0.45-micron in-line disposal cartridges as required. Samples for filtered parameters will be directed into the preserved bottle after passing through the cartridge.

8.0 Field Quality Control Samples

A trip blank will be analyzed for each cooler containing samples to be analyzed for volatile organics.

9.0 Sample Containers and Preservation

The samples will be containerized and preserved as specified by the method. Samples will be maintained at 4 degrees Celsius after collection as required.

10.0 Sample Shipment and Chain of Custody Procedures

Groundwater samples will be transported to the laboratory by field personnel or overnight courier in water-proof containers packed to prevent bottle breakage. Shipments to the laboratory will be accompanied by a chain-of-custody form.