SAMPLING AND ANALYSIS PLAN

VAPOR INTRUSION AND GROUNDWATER EXPLORATION
PACIFIC PARK/DUMPSITE
PACIFIC, WASHINGTON

Prepared for
River and Floodplain Management Section
King County Water and Land Resources Division

Prepared by
Herrera Environmental Consultants, Inc.

SAMPLING AND ANALYSIS PLAN

VAPOR INTRUSION AND GROUNDWATER EXPLORATION
PACIFIC PARK/DUMPSITE
PACIFIC, WASHINGTON

Prepared for
River and Floodplain Management Section
King County Water and Land Resources Division
201 South Jackson Street, Suite 600
Seattle, Washington 98467

Prepared by
Herrera Environmental Consultants, Inc.
2200 Sixth Avenue, Suite 1100
Seattle, Washington 98121
Telephone: 206-441-9080

August 3, 2022

CONTENTS

Executive Summary v

Introduction 1

- Objectives 4
- Site Background Conditions 6
  - Previous Investigations 6

Site Conditions 9

- Physical Setting 9
  - Site Geology 9
  - Site Hydrogeology 9

Project Personnel and Schedule 11

- Project Team and Responsibilities 11
- Project Schedule 11

Field Procedures 13

- Sampling Procedures 15
  - Pre-Drilling Activities 15
- Soil Vapor Sample Collection 15
  - Soil Vapor Probes 15
  - Sub-Slab Probes at Buildings 16
- Soil Sample Collection 17
  - Push-Probe Borings 17
  - Monitoring Well Borings 17
- Groundwater Sample Collection 18
- Decontamination Procedures 19
  - Decontamination of Soil Sampling Equipment 19
- Sample Handling 19
  - Sample Containers and Labeling 19
  - Sample Storage 21
  - Sample Shipment and Delivery 21
  - Chain of Custody 21
  - Sample Documentation 22

Disposal of Investigation-Derived Waste....22
    Disposal of Incidental Trash....22
    Disposal of Soil Cuttings and Investigation-Derived Water....22
Analytical Procedures....23
Quality Control Objectives and Procedures....25
  Field Quality Control Procedures....25
    Instrument Maintenance and Calibration....26
    Field Duplicates....27
    Filter Blank....27
    Trip Blank....27
  Laboratory Quality Control Procedures....27
    Method Blanks....27
    Control Standards....27
    Matrix Spikes....28
    Laboratory Duplicates....28
Data Assessment Procedures and Corrective Actions....29
  Completeness....29
  Methods....29
  Holding Times....30
  Detection Limits....30
  Blanks....30
  Duplicates....30
  Spiked Samples....31
Reporting....33
References....35

APPENDICES

Appendix A	Post-Run Tubing System and Vapor Pin Sampling Device Standard Operating Procedures
Appendix B	Instrumentation Calibration and Maintenance Documentation

TABLES

Table 1. Samples To Be Collected at Pacific Park/Dumpsite. 14

Table 2. Summary of Data Quality Objectives, Sample Containers, Preservation, and Holding Times for the Pacific Park/Dumpsite Environmental Evaluation. 20

Table 3. Analytical Methods and Applicable Criteria for Soil and Groundwater Samples Collected for the Pacific Park/Dumpsite Environmental Evaluation. 23

Table 4. Quality Assurance Requirements and Anticipated Number of Samples....26

FIGURES

Figure 1. Vicinity Map, Pacific City Park, Pacific, Washington. 2

Figure 2. Proposed Sampling Locations, and Groundwater Contour Map, Pacific City Park, Pacific, Washington. 3

EXECUTIVE SUMMARY

As part of King County's Pacific Right Bank Project, this sampling and analysis plan (SAP) describes the additional Remedial Investigation sampling activities to be performed in the vicinity of the Pacific Park/Dumpsite (Park). King County Water and Land Resources Division, a service provider to the Flood Control District, is working with the Washington State Department of Ecology (Ecology) through their Voluntary Cleanup Program (VCP) to assess the nature and extent of contamination from the Park. The work is being completed to support development and evaluation of alternatives for permanent flood protection along the right (west) bank of the White River.

An additional Remedial Investigation is needed to determine the extent and possible source of a vinyl chloride groundwater plume found at the Park and adjacent properties. The additional Remedial Investigation will also evaluate whether the groundwater plume is causing vapor intrusion and indoor air contamination at nearby residences. This SAP outlines soil, soil vapor, and groundwater sampling to be conducted west of King County's Park boundary to assess the nature and extent of vinyl chloride contamination and related contaminants of potential concern (COPCs).

The sampling effort will be conducted in phases. The first phase of sampling will install up to 8 temporary soil vapor probes and up to 8 push-probe soil borings outside of the apartment buildings located north and south of Fourth Avenue Southeast. The first phase of sampling will also drill three new groundwater monitoring wells on Pacific Avenue S. During construction of the wells, up to 2 soil samples will be collected from each boring. Four rounds of quarterly groundwater samples will be collected from each of the 12 existing and 3 new monitoring wells located on and near the Park.

If sampling results from the first phase of sampling demonstrates that contamination above screening levels may indicate a pathway for vapor intrusion at the apartment buildings, the second phase of sampling will be initiated. The second phase of sampling will collect up to 9 additional sub-slab soil vapor samples at the apartment buildings located north and south of Fourth Avenue Southeast.

Results from the additional sampling activities will be described in a Second Supplemental Remedial Investigation report. The Second Supplemental Remedial Investigation will add to the project's understanding of the nature and extent of contamination as outlined in a Remedial Investigation (January 2019) and Supplemental Remedial Investigation (June 2019). Results from the additional remedial investigation will inform alternatives for site cleanup activities outlined in a Feasibility Study (FS). Results of additional sampling activities will also inform whether additional investigations and/or early actions are needed to mitigate contamination from the dumpsite before a more permanent clean-up action can be implemented.

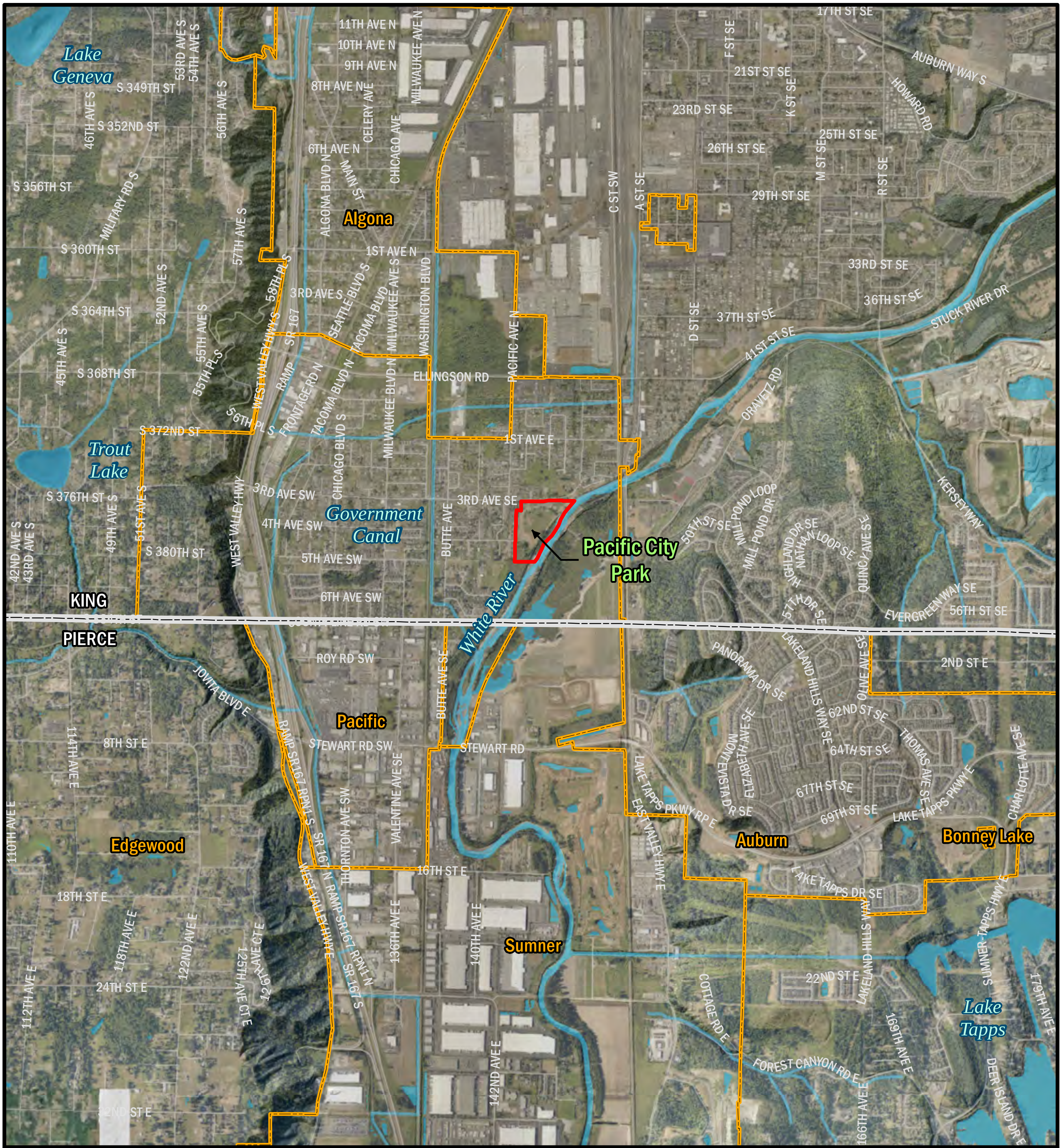
INTRODUCTION

This sampling and analysis plan (SAP) describes additional field investigation activities to be performed in the vicinity of the Pacific Park/Dumpsite (Park) located at 600 Third Avenue Southeast in Pacific, Washington (Figure 1). Vinyl chloride has been detected in groundwater monitoring wells at the Park and adjacent to the park on its' western boundary. Vinyl chloride is a common breakdown product released when solvents such as tetrachloroethylene (also known as PCE) and trichloroethylene (commonly referred to as TCE) undergo biodegradation. This SAP focuses on additional soil, soil vapor, and groundwater sampling to be conducted west of the Park boundary to assess the nature and extent of vinyl chloride and related contaminants of potential concern (COPCs) (if present) in these media.

Pacific Park comprises 21 acres located on the right (west) bank of the White River, which are part of a larger, 43-acre tax parcel that has been owned by King County since 1921 (Figure 2). The City of Pacific began leasing the 21 acres in 1969 for use as a park that opened in 1972 (S&W 2016). Before this time, it was used as an informal dumpsite that was used by the residents of the city, until it was closed to dumping in 1965. Previous investigations identified the presence of buried municipal waste at thicknesses of 2 to 12 feet across the Study Area. Pacific Park is closed for flood control purposes from approximately October through March each year.

From 2016 through 2020, a Remedial Investigation (RI), Supplemental Remedial Investigation (SRI), and subsequent investigations were completed at the Park to characterize the nature and extent of dumpsite refuse and associated contamination in soil, sediment, groundwater, surface water, and soil vapor (S&W 2016; Herrera 2017; Herrera 2019a, 2019b, 2019c, 2019d, 2019e; Herrera 2020). Herrera is preparing a Feasibility Study (FS) to help inform selection of a preferred remedial alternative for site cleanup activities. The work is being completed to support development and evaluation of alternatives for permanent flood protection along the right (west) bank of the White River.

During the RI, PCE and TCE were detected above Site Screening Levels (SSLs) in two soil samples (GP7-15 and GP10-15) near the central portion of the Site (Figure 2). PCE and TCE have not been detected above SSLs in groundwater. Laboratory analytical results for groundwater samples were initially compared to MTCA cleanup levels and then compared to SSLs for the groundwater to surface water pathway. For vinyl chloride, the SSL (0.02 ug/L) was lower than the laboratory's reporting limit (RL) and MTCA Method A CUL (0.2 ug/L). Therefore, Herrera requested that the laboratory review the data reports, specifically for vinyl chloride, to see if lower RLs could be provided. The laboratory was able to report lower RLs for those data that had been analyzed using Specific Ion Monitoring (SIM) by EPA Method EPA 8260C/SIM; for data not analyzed by the SIM method, the laboratory provided a theoretical calculated method detection limit (MDL).



Legend

- 🟥 Study area
- ▭ County boundary
- 🟧 City limits
- 🟦 Waterbody
- Stream (King County)
- Roads

Figure 1.
Vicinity Map, Pacific City Park,
Pacific, Washington.

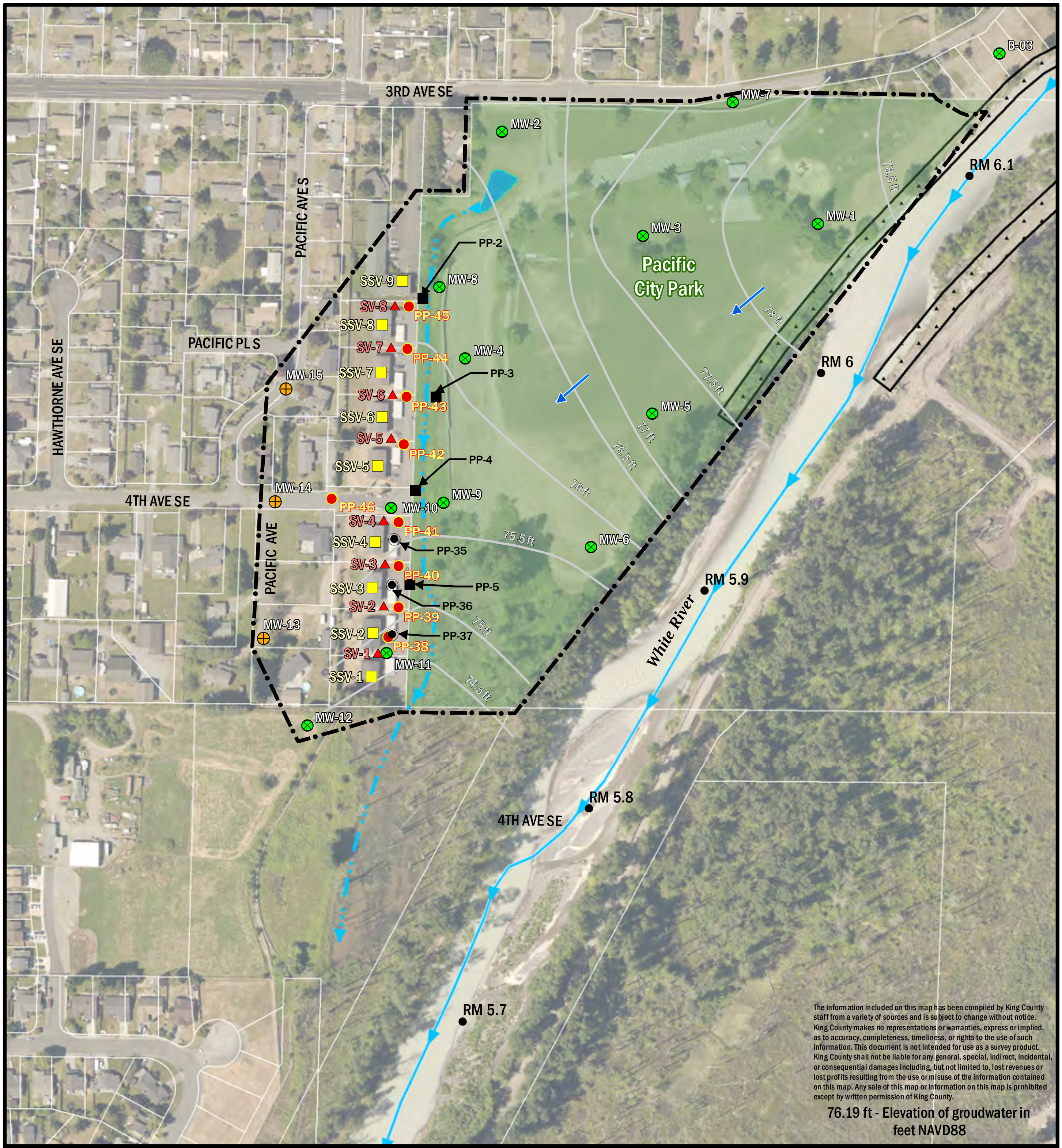
0 1,500 3,000 6,000
Feet

N

King County

Aerial: King County (2017)
Prepared for King County by Herrera

K:\Projects\Y2017\17-06520-000\Project\Report\Feasibility_Study\Fig1_GWVicinityMap_letter.mxd (3/4/2020)



76.19 ft - Elevation of groudwater in feet NAVD88

Legend

- Study Area
- Groundwater contour (Sept. 24, 2019)
- Estimated direction of groundwater flow
- Existing monitoring well
- Proposed monitoring well & soil sample location
- Probe location (Herrera, 12-2018)
- Probe location (Herrera 2017)
- Proposed soil sample location
- Proposed soil vapor monitoring location
- Proposed sub-slab vapor monitoring location
- River mile (10th)
- River
- Stormwater ditch
- Stormwater pond
- Concrete revetment
- Parcels

Figure 2.
Proposed Sampling Locations, and Groundwater Contour Map, Pacific City Park, Pacific, Washington.

0 150 300 600
Feet

N

King County

Aerial: King County (2017)
Prepared for King County by Herrera
Vertical datum: NAVD88

K:\Projects\Y2017\17-06520-000\Project\Report\Groundwater\water_level_contour_20190924.mxd (3/3/2022)

The re-evaluated date indicated that vinyl chloride was detected slightly above the SSL in groundwater samples from six monitoring wells (MW-3, MW-4, MW-8, MW-9, MW-10, and MW-11). Four of the wells are located within the Park and two of the wells (MW-10 and MW-11) are adjacent to the Park west of the boundary (Figure 2).

During the SRI, three push probe borings (GP-35, GP-36, and GP-37) were completed to evaluate soils at the apartment complex located adjacent to Fourth Avenue Southeast. Soil samples were also collected from the hollow-stem auger borings completed to install groundwater monitoring wells MW-10, MW-11, and MW-12. Fill soils from 4 to 7.5 feet thick were identified in the probes and borings, overlying native alluvial deposits and sand and gravel. The following COPCs were detected above SSLs in the soil samples:

- Gasoline-range petroleum hydrocarbons were detected in soil at boring MW-10, at a concentration of 110 milligrams/kilogram [mg/kg], which is slightly above the SSL of 100 mg/kg.

- The Model Toxics Control Act (MTCA) metals cadmium, lead and mercury were detected above SSLs in one or both soil samples collected from boring PP35.

- Total PCBs were detected above the SSL of 0.05 mg/kg in samples collected from borings MW-10 and PP35 at concentrations of 0.13 and 0.23 mg/kg, respectively.

- Concentrations of total cPAHs were detected above the SSL of 0.02 mg/kg in samples collected at five locations (MW-10, MW-11, PP35, PP36, and PP37) at concentrations ranging from 0.021 to 0.787 mg/kg.

The following sections describe the additional soil, soil vapor, and groundwater sampling to be conducted near the west Park boundary to meet the objectives outlined below.

OBJECTIVES

The specific objectives of the sampling described herein are as follows:

Groundwater

- Determine the approximate western extent of the vinyl chloride plume in groundwater by sampling existing monitoring wells and installing and sampling up to three additional monitoring wells (MW-13, MW-14, and MW-15) to the west of the Fourth Avenue Southeast apartments.

- Determine if concentrations of vinyl chloride or other COPCs in groundwater exceed SSLs west of the Park boundary.

- Confirm the direction of groundwater flow on the west side of the stormwater ditch, assumed to be toward the southeast and the stormwater ditch based on previous sampling events. The flow direction will be determined by creating a groundwater contour map based on static groundwater level measurements to be taken from wells MW-10 through MW-15).

- Determine if vinyl chloride in groundwater may be a risk to human exposure via volatilization through soils into the surrounding air or into building structures.

Proposed monitoring well locations may need to be adjusted based on property access agreements obtained by the County from landowners.

Soil

- Collect additional soil samples to determine if volatile organic compounds (VOCs) including vinyl chloride, and other COPCs are present at elevated concentrations above SSLs in the fill material placed by others during development of the apartments adjacent to Fourth Avenue Southeast. Samples will be collected from push probe borings adjacent to former push probe locations PP-35, PP-36, and PP-37 and MW-10 for VOC analysis.

- Additional soil samples will be collected from push probe borings to the north and west along Fourth Avenue Southeast, and from hollow stem auger borings completed for the new monitoring wells.

Proposed boring locations may need to be adjusted based on property access agreements obtained by the County from landowners.

Soil Vapor

- Collect soil vapor samples from temporary soil vapor probes installed to the west of the Fourth Avenue Southeast apartment buildings to determine if concentrations of vinyl chloride, PCE, and TCE in soil vapor exceed MTCA screening levels.

- Contingency: Collect sub-slab soil vapor samples at the Fourth Avenue Southeast and Megan’s Court apartment buildings to assess concentrations of vinyl chloride, PCE, and TCE, if warranted based on the soil vapor sampling conducted near these buildings.

- Determine if vinyl chloride is present in soils at concentrations above screening levels that may indicate a potential risk to human exposure.

Proposed soil vapor and sub-slab sample locations may need to be adjusted based on property access agreements obtained by the County from landowners.

SITE BACKGROUND CONDITIONS

Previous Investigations

This section describes previous environmental investigations that have been completed at the Site. No interim actions have been completed at the Site.

From 1985 to 2016, three investigations were completed at the Site to characterize potential contamination related to soil, groundwater, surface water, and landfill gas (also referred to soil vapor) to determine the approximate lateral and vertical extents of solid waste at the former dumpsite. The investigations included a 1985 abandoned landfill study, 2010 and 2011 stormwater sampling, and a 2016 Phase II Environmental Site Assessment (Seattle King County Department of Health 1985; King County 2015; S&W 2016).

In January 2019, Herrera Environmental Consultants, Inc. (Herrera) completed an RI report for the Site followed by an SRI to further evaluate the nature and extent of hazardous substances in soil and groundwater to the south-southwest of the Park, which was identified as a data gap in the RI (Herrera 2019a, 2019b). The SRI, conducted in December 2018, included installation and sampling of three additional groundwater monitoring wells, three soil borings, and collection of additional groundwater, soil, and surface water samples for laboratory analysis, along with soil vapor monitoring in the field.

In August 2019, the Washington State Department of Ecology (Ecology) issued an opinion letter for the Site and concluded that the RI met the MTCA requirements for characterizing the nature and extent of contamination sufficiently to establish cleanup standards and support evaluation of cleanup actions in a Feasibility Study (Ecology 2019).

Additional investigations performed at the Site after the RI and SRI reports were completed and submitted to Ecology include the following:

- March, June/July, and September 2019 monitoring events for groundwater, surface water and soil vapor. The results of these sampling events were provided to Ecology in separate technical memorandums (Herrera 2019c, 2019d, 2019e).
- Soil and sediment sampling conducted in December 2019 to enable the preparation of a site-specific TEE. The results of the sampling are summarized in the *Terrestrial Ecological Evaluation* section of this FS.

Herrera collected additional groundwater and surface water samples, and monitored soil vapor at the Site in March, June/July, and September 2019 (Herrera 2019c, 2019d, 2019e).

Groundwater

The results of the SRI and subsequent quarterly groundwater monitoring support the RI report conclusions, which indicate that the presence of the primary COPCs in soil generally correspond to the locations of historical placement of fill and solid waste. The COPCs detected in groundwater at the Site at concentrations above SSLs consist of vinyl chloride, metals (arsenic and lead), benzene, and total cPAHs.

Groundwater samples were collected from eight monitoring wells (MW-2, MW-4 through MW-6, and MW-9 through MW-12) and the samples were submitted for laboratory analysis of:

- Volatile organic compounds (VOCs) by EPA Method 8260C
- cPAHs by EPA Method 8270D/SIM
- Dissolved MTCA metals by EPA Methods 200.8/7470A
- Vinyl Chloride

In addition, samples from the three newer wells (MW-10 through MW-12) installed during the SRI were submitted for laboratory analysis of:

- Gasoline-range total petroleum hydrocarbons (TPH) by Ecology Method Northwest total petroleum hydrocarbons, gasoline-extended (NWTPH-Gx)
- Diesel-and oil-range TPH by Ecology Method NWTPH-Dx
- Vinyl Chloride

No concentrations of TPH or cPAHs were detected in groundwater above the SSLs in samples collected from any of the wells during the three sampling events. Of the five metals evaluated, only arsenic and lead were detected above the respective SSLs. To evaluate the arsenic detected, the SSL was adjusted upward for the FS to 8.0 micrograms per liter (µg/L), compared to the 3.3 µg/L SSL used during the RI in 2019. This adjustment is based on a recent study completed by Ecology that shows the natural background concentration of arsenic in groundwater in the Puget Sound Basin is 8.0 µg/L (Ecology 2021a). Dissolved arsenic was detected above the SSL of 8.0 µg/L in only three wells, MW-2, MW-4, and MW-12.

Although benzene was previously detected at a concentration above the SSL in one groundwater sample collected from a push probe boring adjacent to the west of the stormwater ditch in May 2017, it was not detected at concentrations above the SSL in groundwater samples collected from any monitoring wells thereafter.

Although vinyl chloride was not previously detected in soil samples during the RI above SSLs, the groundwater data with lower RLs and MDLs was re-evaluated and vinyl chloride was detected at low concentrations slightly above the SSL of 0.02 µg/L in groundwater samples from five monitoring wells (MW-3, MW-4, MW-9, MW-10, and MW-11). The elevated concentrations of PCE and TCE detected in soil samples GP7-15 and GP10-15 near the central portion of the Site may be contributing to the detections in groundwater. The vinyl chloride detected in wells MW-10 and MW-11 west of the stormwater ditch may be related to this same onsite source area or from contaminated fill material placed in the late 1980s by a private site developer during construction of the apartments along Fourth Avenue Southeast.

Groundwater conditions observed during the SRI monitoring and subsequent quarterly monitoring events were consistent with previous RI monitoring results. The direction of groundwater flow at the Site appears to be influenced by the stormwater drainage ditch located along the west side of the park. During the last groundwater monitoring event on September 24, 2019, groundwater flow was towards the southwest on the east side of the stormwater ditch and to the southeast on the west side of the stormwater ditch, indicating the ditch was drawing groundwater into it at that time.

Surface Water

Surface water analytical results for samples collected during the SRI and March and June/July 2019 monitoring events from the ditch and stormwater pond were compared to the groundwater SSLs protective of surface water. No concentrations of dissolved MTCA metals, cPAHs, VOCs, or polychlorinated biphenyls (PCBs) were detected in surface water above the SSLs in any of the samples. However, per Ecology recommendations, because there is a hydraulic connection between groundwater and surface water, concentrations of COPCs in groundwater were evaluated in wells adjacent to the ditch and stormwater pond. Based on the presence of vinyl chloride in groundwater samples collected from wells MW-4, MW-8, MW-9, and MW-10, it appears that vinyl chloride could be released to surface water.

Lube oil-range petroleum hydrocarbons were detected in two samples and the concentration detected in sample SW-4 (590 µg/L) slightly exceeded the SSL of 500 µg/L. This is likely attributed to runoff associated with vehicle traffic on Third Avenue Southeast or vehicles using the parking lot at the north side of the Site.

Soil Vapor

Consistent with monitoring performed during the RI and SRI, no methane (CH_4) or hydrogen sulfide (H_2S) was detected in soil vapor at monitoring wells MW-6, MW-9, MW-11, or MW-12 during the subsequent monitoring events in March, June, and September 2019.

SITE CONDITIONS

PHYSICAL SETTING

The current Site use includes a seasonal city park (it is closed each year in the wet season to reduce flood risks to surrounding residents and streets) and undeveloped natural areas along the White River. The Site consists of a relatively flat area with uplands and wetlands bounded by the White River to the east, a paved road (Third Avenue Southeast) to the north, and a surface water drainage ditch and multi-family residential properties located to the west (Figure 2).

Site Geology

The geology at the Site consists of fill overlying native Holocene alluvium to the maximum depth explored of approximately 62 feet bgs. Fill material was identified as soil with a disturbed appearance and from the presence of unnatural debris (dumpsite waste) such as glass shards and bottles, brick, cement, organics, wood, paper, rubber, and ceramic materials. The fill consists of fill soil and fill soil mixed with dumpsite waste. The fill soil consists of variable amounts of silt, sand, and gravel that generally directly overlies the Holocene alluvium deposits across the Site, and ranges in thickness from inches to 15 feet. The fill soil mixed with dumpsite waste is primarily located beneath the eastern portions of the Park, near the White River bank, and is up to 20 feet thick in the central and south-central portions of the Site. The dumpsite waste is typically covered by 1 to 4 feet of sandy, gravelly fill soil.

The fill is underlain by alluvial overbank deposits consisting mostly of poorly graded sand with gravel to sandy gravel interbedded with backwater lacustrine deposits consisting of silt with organics and interbeds of silty sand. The gradation of this fill soil is consistent with riverine deposits and is thus suspected to have been sourced from on or near the Site as a low-cost backfill material.

Site Hydrogeology

During the wet season, typically between October and March, the central and northern portions of the Site are frequently inundated by the surface expression of shallow groundwater and occasionally by river flood waters. In September 2015, groundwater depths ranged from 4 to 9 feet bgs (S&W 2016). During multiple monitoring events from 2017 to 2019, groundwater depths ranged from less than 0.5 foot to 8.5 feet bgs (Herrera 2019e). In summer 2021, despite hot dry conditions, large portions of the park remained ponded at the ground surface. In general, the depth to groundwater is greater in areas of higher relief, such as observed in explorations located on the existing levee and in terraced fill areas in the southern portion of the

Site. The groundwater flow direction suggests that the White River loses surface water to the upper alluvial aquifer, at least seasonally.

Shallow groundwater levels in the unconfined, upper alluvial aquifer were observed seasonally in monitoring wells located on the Site. Springtime groundwater flow near the middle and southwest corner of the Park has been observed to flow to the west and southwest. Near the northeast corner of the Park, groundwater flow is generally to the northwest.

King County created an animation of groundwater levels, based on hourly well measurements from October 2015 through October 2016. The direction of groundwater flow was typically to the southwest (parallel to river flow) for most of the year. When groundwater levels rise in winter with the river stage, the gradient increases and has a more westerly component, away from the river (Brummer 2017a, 2017b).

PROJECT PERSONNEL AND SCHEDULE

PROJECT TEAM AND RESPONSIBILITIES

Mark Ewbank: Project Manager, general project oversight and QA
Email: mewbank@herrerainc.com
Phone: 206-787-8266

George Iftner: Field investigation Task Manager and project geologist
Email: giftner@herrerainc.com
Phone: 206-787-8210

Gina Catarra: Lead data QA/QC manager
Email: gcatarra@herrerainc.com
Phone: 206-787-8223

Brianna Blaud: Field lead for groundwater sampling
Email: bblaud@herrerainc.com
Phone: 425-765-8126

David Baumeister: Laboratory analytical chemist at OnSite Environmental, Inc.
Email: dbaumeister@onsite-env.com
Phone: 425-883-3881

Brian O'Donnell: Project Manager at Cascade Drilling, Inc.
Email: bodonnell@cascade-env.com
Phone: 317-935-7622

Matt Langston: Laboratory Director at Fremont Analytical, Inc.
Email: mlangston@fremontanalytical.com
Phone: 206-352-3790

PROJECT SCHEDULE

The field sampling for soil, soil vapor, and groundwater is anticipated to be conducted over six non-consecutive days in April 2022:

- Day 1: Soil vapor probe sampling.
- Day 2: Soil sampling from direct push probes.

- Day 3: Soil sampling; installation and development of 3 groundwater monitoring wells.

- Days 4 and 5: The first round of quarterly groundwater sampling will be conducted at 15 wells (12 previously established wells and the 3 newly installed wells) approximately 2 to 4 days after the installation of the new wells, followed by three additional quarterly groundwater sampling events over the course of 1 year.

- Day 6: Contingency sub-slab soil vapor probe sampling, dependent on the results of the other soil, soil vapor, and groundwater monitoring.

FIELD PROCEDURES

Table 1 provides a summary of sample locations (see Figure 2), sample types, sample numbers, and analytical requirements for the following:

- Up to 8 temporary soil vapor probes (SV-1 through SV-9) will be installed using a push-probe drill rig to a maximum depth of 5 feet bgs within the vadose zone above the groundwater table. One sample will be collected from each soil vapor probe into a summa canister and Post-Run Tubing (PRT) system according to the standard operating procedure (SOP) in Appendix A.

- Up to 8 push-probe soil borings (pp-38 through PP-45) will be completed to 10 feet bgs. Two soil samples will be collected at each location, including one from the 0- to 5-foot depth interval or groundwater interface, and the second from the 5- to 10-foot interval.

- Three new groundwater monitoring wells (MW-13 through MW-15) will be installed to a depth of 15 feet bgs along the eastern boundary of the extended study area. Up to 2 soil samples will be collected from each boring, including one from the 0- to 5-foot depth interval or groundwater interface, and the second from the 5- to 15-foot interval.

- Four rounds of quarterly groundwater samples will be collected from each of the 15 monitoring wells located on the site.

- Contingent upon the soil vapor, soil, and groundwater analytical results, up to 9 additional sub-slab soil vapor samples (SSV-1 through SSV-9) may be collected at the apartment buildings located north and south of Fourth Avenue Southeast.

All boring and sampling locations off the King County property are contingent on signed access agreements from landowners. The boring locations have been selected to determine whether groundwater contamination identified on the Site during previous investigations has migrated off site and if there may be other sources of contamination offsite. The GPS coordinates of each probe boring location will be recorded.

Table 1. Samples To Be Collected at Pacific Park/Dumpsite.

Sampling Location	Sample Type	Maximum Number of Samples	Analytical Requirements
Soil vapor monitoring probes SV 1 through 8	Soil vapor	9: One from each of 8 probes, plus 1 field duplicate	VOCs (including PCE, TCE and related daughter products from decomposition)
Sub-slab Vapor Pin® probes SSV 1 through 9	Sub-slab soil vapor	10: One from each of 9 sub-slab locations, plus 1 field duplicate	VOCs (including PCE, TCE and related daughter products from decomposition)
Soil borings PP 38 through 45, and MW 13 through 15	Soil sample	23: Two samples from each of 11 borings, plus 1 field duplicate	VOCs (including halogenated VOCs and BTEX)
Groundwater monitoring wells MW 1 through 15	Groundwater sample	64: One from each of 15 wells x 4 events (60), plus 1 field duplicate per event	VOCs (including halogenated VOCs and BTEX)
Groundwater monitoring wells MW 4, and MW 8 through 15	Groundwater sample	40: One from each of 9 wells x 4 events (36), plus 1 field duplicate per event	Total and dissolved MTCA metals (As, Cd, Cr, Hg, Pb), and cPAHs

BTEX = benzene, toluene, ethylbenzene, and xylenes

cPAHs = Carcinogenic polycyclic aromatic hydrocarbons (to include naphthalene)

MTCA = Model Toxics Control Act

MW = monitoring well (groundwater)

PCE = perchloroethylene

SSV = sub-slab vapor

SV = soil vapor

TCE = tetrachloroethylene

TPH = total petroleum hydrocarbon

VOCs = volatile organic compounds

SAMPLING PROCEDURES

Pre-Drilling Activities

Prior to commencing drilling activities, Underground Utility Location Service (UULS) will be notified of the intent to drill the probes and wells. UULS will contact participating agencies or companies with underground utilities in the area. These utility companies will mark the locations of their utility lines and equipment along the property boundary. In addition, a private utility locate service will be retained to locate underground utilities at each proposed boring location. Drill site conditions will be photo documented prior to beginning drilling. Wooden blocks will be placed adjacent to concrete curbs in residential areas for access and to avoid damaging the curb. The drill rig will be positioned to avoid blocking access for homeowners, tenants, and emergency vehicles.

SOIL VAPOR SAMPLE COLLECTION

Soil Vapor Probes

Soil vapor samples will be collected using the PRT system according to the SOP in Appendix A. At each location a stainless-steel probe rod will be driven into the ground in the vadose zone above the groundwater table using a push-probe rig. After the desired depth has been reached, the expendable tip will be disengaged by pulling up on the probe rods, and a length of silicone tubing with threaded PRT adapter will be inserted down inside the rod and screwed into the expendable point holder. The tubing connection will be tested by gently pulling up on the tubing.

Granular hydrated bentonite chips will be sprinkled down into the borehole and allowed to set up for 1 hour to create a tight seal above the expendable sampling tip and between the silicone tubing and adjacent soil. Sampling will begin at the first probe installed and finish with the last probe installed.

Prior to sampling, the vapor probe will be purged using a peristaltic pump for approximately 3 minutes to remove a minimum of 3 volumes of air from the probe. After purging the vapor probe, a flow regulator that limits the flow rate to 200 milliliters (mL) per minute will be attached to the end of the silicone tubing above the ground surface, and a summa canister under vacuum (-30 inches of mercury) provided by Fremont Analytical will be attached to the end of the tubing. Before collecting the sample a helium shroud (i.e., a large bag) will be placed over the top of the borehole and tubing and summa canister and regulator, and helium will be pumped into the shroud. The purpose of the shroud is to ensure that ambient air isn’t entering the borehole or sample. The helium concentration will be measured with an MGD 2002 Helium Leak Detector.

Once the helium shroud is in place, a sample will be collected by opening the valve on the regulator to allow flow at 200 mL/min or less, then opening the valve on the summa canister. The pressure gauge on the summa canister will be monitored and the valve will be closed to end the sample collection when the pressure reaches -2 inches of mercury. Each summa canister will be labeled with the unique sample ID and the date and time of sample collection before being delivered to Fremont Analytical for laboratory analysis.

Sub-Slab Probes at Buildings

Depending on the results of soil vapor probe, soil, and groundwater sampling, contingency soil vapor monitoring beneath the concrete building slabs (i.e., sub-slab) may be performed at some or all of the apartment buildings north and south of Fourth Avenue Southeast, as depicted on Figure 2.

Sub-slab soil vapor samples will be collected at the outdoor stairwells in the middle of each of the apartment buildings according to the Vapor Pin® SOP included in Appendix A. To install the sampling device (e.g., a metal Vapor Pin®), a small diameter hole (5/8 inch) will be drilled with a hammer drill through the concrete building slab underneath the stairs. After cleaning out debris from the drilled hole with a bottle brush and vacuum, the Vapor Pin® with silicone sleeve will be pounded into place in the hole. The silicone sleeve creates an airtight seal between the vapor pin and the concrete.

After installation, the vapor pin will be allowed to sit undisturbed for 20 minutes after which a simple leak test will be performed. To run the test, a circular ring of plumber’s putty will be placed a few inches outside and around the vapor pin and approximately 1/4 cup of water will be poured into the putty dam. If the water in the putty dam does not disappear by leaking down through the concrete past the silicone sleeve then the seal is assumed to be tight.

To collect a sample, a short piece of Tygon™ tubing connected to Nylaflow tubing will be connected to the barbed fitting on top of the Vapor Pin®. A flow regulator that limits the flow rate to 200 mL/min will be connected to the tubing and a sub-slab soil vapor sample will be collected into a 1L summa canister under vacuum (-30 inches of mercury). The pressure gauge on the summa canister will be monitored and the valve will be closed to end the sample collection when the pressure reaches -2 inches of mercury. Each summa canister will be labeled with the unique sample ID and the date and time of sample collection before being delivered to Fremont Analytical for laboratory analysis.

Upon completion of the sampling, the vapor pin and all associated tubing will be removed and the hole in the slab will immediately be patched with concrete.

SOIL SAMPLE COLLECTION

Push-Probe Borings

Probe borings will be advanced using a probe-drive sampler attached to driven probe rods.

During drilling, discrete soil samples for soil classification, field screening, and chemical analysis will be collected continuously at 5-foot intervals using a probe-drive sampler 5 feet long by 2 inches outside diameter and lined with dedicated clear Lexan® liners. The sampler will be sealed with a piston stop pin while being pushed or driven to the desired sampling depth of 5 feet or 10 feet bgs. The piston stop pin will be retracted into the sampler while the sampler is pushed or driven to obtain a soil sample.

Following retrieval, the soil-filled Lexan® liner will be removed from the sampler and cut open to expose the soil core. Soil encountered during drilling will be visually inspected and classified in accordance with the Unified Soil Classification System (USCS; American Society for Testing and Materials [ASTM] D2488-09). A photoionization detector (PID) instrument (MiniRAE 3000 or similar unit) will also be used to screen soil for VOCs.

Soil samples will be prepared for chemical analysis by removing soil from the liner and placement directly into jars provided by the analytical laboratory. Each sample will be uniquely labeled denoting sample identification number and depth, date, and time sampled, and job number. Soil samples will then be placed into a chilled cooler for storage prior to delivery to the analytical laboratory.

Pre-weighed sample vials will be filled to comply with the 5035A method for sample collection for NWTPH-G analyses. These samples will be collected directly from the liner.

At the completion of sampling, all borings will be filled with hydrated granular bentonite chips, and borings within paved areas will be patched with asphalt. Borings if located in grass lawns, will be restored by replacing the sod circle removed at the start of the boring.

Monitoring Well Borings

The three new monitoring wells will be drilled, constructed, and developed using the same field methods described in the RI Report for the previous well installations at the Site. Each well will be completed at the ground surface with a flush-mounted steel monument sealed in concrete.

Soil samples will be collected from each boring using an 18-inch, split spoon sampler. The soil will be visually inspected for staining and classified in accordance with the Unified Soil Classification System (USCS; ASTM International [ASTM] D2488-09), and a PID instrument will be used to screen soil for VOCs. Sample collection intervals will be adjusted in the field depending on observations of potential soil contamination, such as odors, staining, sheen, or elevated PID readings. Following soil sample collection, a monitoring well will be installed in each boring.

GROUNDWATER SAMPLE COLLECTION

General procedures for collecting groundwater samples from monitoring wells will be as follows:

- Remove the well monument cover and inspect the condition of the well and surrounding area. Note observations in the field notebook or on the well sampling log. Unlock and remove the well casing plug.
- Using an electric water level indicator, measure the depth to groundwater to the nearest 0.01 foot. Record date, time, and measurements in the field notebook or on the well sampling log.
- Place clean 0.25-inch polyethylene tubing into the well opposite the center of the screened zone to draw water from the formation.
- Connect the tubing to the peristaltic pump and begin purging at a low flow rate, less than 1 liter per minute. Drawdown should not exceed 0.33 foot and should approximate the estimated well recovery rate.
- Purge one tubing volume of water from the well and then begin recording water quality indicator parameters, including pH, specific conductance, dissolved oxygen, and temperature at 5-minute intervals. The water level and flow rate should also be monitored at 5-minute intervals. Record all measurements on the well sampling log.
- When drawdown, flow rate, and the parameters have stabilized after three successive readings, the sample may be collected.
- Sample stabilization criteria are as follows: ±0.1 for pH, ±3 percent for specific conductance, and ±0.3 milligrams per liter for dissolved oxygen.
- If well stabilization does not occur, increase the flow rate to approximately 1 gallon per minute and purge three volumes of water from the well. Record field parameters after removing each volume of water. Sample collection may occur upon removing three volumes from the well, assuming the indicator parameters have stabilized. Sample collection may occur regardless of indicator parameter stabilization when five well volumes have been removed.
- Following purging, fill the laboratory approved sample containers using the peristaltic pump.
- Connect a 0.45-micron high-capacity water filter capsule to the polyethylene tubing prior to filling the sample container for **dissolved metals** analysis.
- Securely cap, label, and place sample containers into a chilled cooler for storage prior to delivery to the laboratory.
- Record the date and time of sample collection on the chain-of-custody form.
- Replace the well casing plug, lock, and well monument cover.

DECONTAMINATION PROCEDURES

Decontamination will be performed on all sampling equipment potentially exposed to contaminated soil between sampling locations. All sampling equipment will be decontaminated prior to entry in the field. Chemical-resistant gloves worn during sample collection will be changed between each location.

Decontamination of groundwater sampling equipment is only required for the water level indicator that follow the same decontamination of soil sampling equipment (below). Clean, dedicated polyethylene tubing will be used during groundwater sample collection.

Decontamination of Soil Sampling Equipment

The following decontamination procedure will be used for soil sampling equipment:

- Rinse with tap water
- Scrub with water and Liquinox detergent
- Rise with tap water
- Rinse with deionized water

SAMPLE HANDLING

All samples collected during this investigation will be handled according to the procedures described in this section.

Sample Containers and Labeling

Soil and water samples will be placed into containers supplied by the analytical laboratory and sample container labels will be completed at the time of collection using a permanent waterproof pen or marker. Sample labels will include the following information:

- Project name
- Sample identification
- Date and time of collection
- Initials of sampling personnel
- Analysis to be performed

Sample containers, preservation, and holding times are summarized in Table 2.

Table 2. Summary of Data Quality Objectives, Sample Containers, Preservation, and Holding Times for the Pacific Park/Dumpsite Environmental Evaluation.

Parameter	Units	Detection Limits	Accuracy	Precision	Method Number[a]	Bottle/ Preservative	Maximum Holding Time
Soil Vapor							
VOCs	μg/m^3	0.02 to 47[b]	70 to 130%	25%	TO-15	1L summa vacuum canister (at -30” Hg to start, and -5” to -2” Hg when filled)	30 days to analyze
Soil							
VOCs	μg/kg	1.0 to 5.0	52 to 132%	31%	8260C	1 x 40 mL GV 2 x 40 mL GV with stir bar Cool to 4°C	48 hours to preserve, 14 days to analyze
Groundwater							
VOCs	μg/L	0.02 to 5.0	52 to 132%	31%	8260C/SIM	3 x 40 mL GV/ HCl Cool to 4°C	14 days to analyze
MTCA metals[c]	μg/L	0.6 to 60	75 to 125%	20%	200.8/6010B/7470A	500 mL HDPE/ HNO$_3$, cool to 4°C	180 days 28 days (mercury)
cPAHs	μg/L	0.010 to 0.10	20 to 140%	50%	8720D-SIM	2 x 1L AG Cool to 4°C	7 days to extract, 40 days to analyze

[a] Method numbers and analytical methods are from USEPA 1986 (6010, 7470, 7471, 8082, 8270) and Ecology 1997 (NWTPH-HCID, NWTPH-Dx, NWTPH-Gx).

[b] Range of detection limits is designed by the air analytical laboratory to meet MTCA Method B screening levels for specific compounds listed in the CLARC data tables.

[c] MTCA metals include arsenic, cadmium, chromium, lead, and mercury.

AG = amber glass bottle
cPAHs = carcinogenic polycyclic aromatic hydrocarbons
GV = glass vial
HCl = hydrochloric acid
HDPE = high-density polyethylene
HG = mercury
HNO$_3$ = nitric acid
μg/m^3 = micrograms per cubic meter
μg/kg = micrograms per kilogram
μg/L = micrograms per liter
mg/L = milligrams per liter
MTCA = Model Toxics Control Act
NA = not applicable
NWTPH = Northwest total petroleum hydrocarbons
TPH = total petroleum hydrocarbons
TO = toxic organics
TPH = total petroleum hydrocarbons
VOCs = volatile organic compounds

Sample Storage

Immediately following sample collection, sample containers for soil and groundwater will be placed into a chilled cooler for storage prior to delivery to the analytical laboratory; soil vapor samples in summa canisters do not need to be chilled after being collected. Care shall be taken to ensure sample holding times are not exceeded during periods of storage. Sample containers may be placed into plastic bags to protect labels from moisture in the cooler, if necessary.

Sample Shipment and Delivery

Samples collected during this investigation will be delivered by Herrera to the analytical laboratories.

Chain of Custody

Following collection, sample information will be recorded on a chain-of-custody form. The purpose of this record is to account for the possession (or custody) of each sample from the time it is collected until laboratory testing and reporting is complete. The signature of each person in possession of the samples must be recorded on the chain-of-custody form. Information to be recorded on the chain-of-custody record will include the following:

- Project name and location
- Project number
- Names of project manager and sampling personnel
- Sample identification
- Date and time of collection
- Analysis requested (for each sample)
- Number of sample containers
- Initial and final vacuum pressure reading for summa canisters
- Signature, date, and time (for each person releasing or accepting sample custody)

Sample Documentation

Sampling activities will be documented in a dedicated field notebook. The notebook will be labeled with the project name, project identification number, dates of field activities, and the name and phone number of the project manager. All relevant activities will be recorded in the field notebook during the sample collection period. Entries into the field notebook will be made in permanent ink. Corrections will be made by placing a single line through the original entry and the initials of the person entering the correction. At a minimum, information in the field notebook will include:

- Date and atmospheric weather conditions
- Activities to be performed
- Name(s) of sampling personnel
- General condition of sampling area
- Start and stop times of work
- Any unusual events or occurrences
- Description of soil profile

DISPOSAL OF INVESTIGATION-DERIVED WASTE

Disposal of Incidental Trash

Incidental trash generated during this investigation (including discarded nitrile gloves, used Ziploc® bags, paper towels) will be placed in plastic trash bags and disposed of as solid waste.

Disposal of Soil Cuttings and Investigation-Derived Water

Soil cuttings will be placed into a 20-gallon or 55-gallon drum, depending on the volume of soil generated. Decontamination solutions, rinse water, and purge water will be placed into 55-gallon drums. Drums will be stored near the park entrance on Third Avenue Southeast, and disposal will be arranged pending analytical results.

ANALYTICAL PROCEDURES

The analytical methods listed in Table 3 will be performed by OnSite Environmental (for soil and groundwater) and Fremont Analytical (for soil vapor), both accredited Washington State Department of Ecology laboratories.

Table 3. Analytical Methods and Applicable Criteria for Soil and Groundwater Samples Collected for the Pacific Park/Dumpsite Environmental Evaluation.

Parameter	Method	Reporting Limit	Dangerous Waste Criterion[a]	MTCA Method A Criterion
Volatile Organic Compounds				
Benzene	EPA 8260C (soil) EPA 8260C/SIM (water)	1.0 μg/kg 0.20 μg/L	–	0.03 mg/kg[b] 5 μg/L[b]
cis-1,2-dichloroethylene (cis-DCE)	EPA 8260C (soil) EPA TO-15 (soil vapor) EPA 8260C/SIM (water)	1.0 μg/kg 1.59 μg/m^3 0.20 μg/L	–	160 mg/kg[b] 32 μg/m^3[c] 16 μg/L[b]
trans-1,2-dichloroethylene (trans-DCE)	EPA 8260C (soil) EPA TO-15 (soil vapor) EPA 8260C/SIM (water)	1.0 μg/kg 0.793 μg/m^3 0.20 μg/L	–	1,600 mg/kg[b] 1,300 μg/m^3[c] 160 μg/L[b]
Ethylbenzene	EPA 8260C (soil) EPA 8260C/SIM (water)	1.0 μg/kg 0.20 μg/L	–	6 mg/kg[b] 700 μg/L[b]
Methylene chloride	EPA 8260C (soil) EPA 8260C/SIM (water)	1.0 μg/kg 0.20 μg/L	–	0.02 mg/kg[b] 5 μg/L[b]
Methyl t-butyl ether (MTBE)	EPA 8260C (soil) EPA 8260C/SIM (water)	1.0 μg/kg 0.20 μg/L	–	0.1 mg/kg[b] 20 μg/L[b]
Naphthalenes	EPA 8260C (soil) EPA 8260C/SIM (water)	5.0 μg/kg 5.0 μg/L	–	5 mg/kg[b] 160 μg/L[b]
Tetrachloroethylene	EPA 8260C (soil) EPA TO-15 (soil vapor) EPA 8260C/SIM (water)	1.0 μg/kg 0.271 μg/m^3 0.20 μg/L	–	0.05 mg/kg[b] 1,300 μg/m^3[c] 5 μg/L[b]
Toluene	EPA 8260C (soil) EPA 8260C/SIM (water)	1.0 μg/kg 0.20 μg/L	–	7 mg/kg[b] 1,000 μg/L[b]
1,1,1-Trichloroethane	EPA 8260C (soil) EPA 8260C/SIM (water)	1.0 μg/kg 0.20 μg/L	–	0.03 mg/kg[b] 200 μg/L
Trichloroethylene	EPA 8260C (soil) EPA TO-15 (soil vapor) EPA 8260C/SIM (water)	1.0 μg/kg 0.215 μg/m^3 0.20 μg/L	–	0.03 mg/kg[b] 67 μg/m^3[c] 5 μg/L[b]

Table 3 (continued). Analytical Methods and Applicable Criteria for Soil and Groundwater Samples Collected for the Pacific Park/Dumpsite Environmental Evaluation.

Parameter	Method	Reporting Limit	Dangerous Waste Criterion[a]	MTCA Method A Criterion
Volatile Organic Compounds (continued)				
Vinyl chloride	EPA 8260C (soil) EPA TO-15 (soil vapor) EPA 8260C/SIM (water)	1.0 µg/kg 0.102 µg/m^3 0.020 µg/L[d]	–	0.67 mg/kg[b] 95 µg/m^3[c] 0.2 µg/L[b]
Xylenes	EPA 8260C (soil) EPA 8260C/SIM (water)	5.0 µg/kg 5.0 µg/L	–	9 mg/kg[b] 1,000 µg/L[b]
MTCA Metals				
Arsenic	EPA 200.8/6010B/ 7470A (water)	0.50 mg/L	5.0 mg/L	–
Cadmium		0.050 mg/L	1.0 mg/L	–
Chromium		0.33 mg/L	5.0 mg/L	–
Lead		0.15 mg/L	5.0 mg/L	–
Mercury		0.009 mg/L	0.2 mg/L	–
cPAHs				
Total cPAHs (TEQ)	EPA 8270D (water)	0.010 µg/L	–	0.1 µg/L[b]

[a] Washington State Dangerous Waste Regulations (WAC 173-303).

[b] Washington State Model Toxics Control Act (WAC 173-340), Method A soil cleanup level for unrestricted land uses or Method A cleanup level for groundwater.

[c] Washington State Model Toxics Control Act (WAC 173-340), Method C sub-slab soil gas (i.e., soil vapor) screening level.

[d] Lower reporting limit of 0.02 µg/L can be achieved if requested on chain-of-custody to analyze VOCs by using SIM (selected ion monitoring) method.

cPAHs = carcinogenic polycyclic aromatic hydrocarbons

EPA = Environmental Protection Agency

µg/L = micrograms per liter

mg/L = milligrams per liter

MTCA = Model Toxics Control Act

PAHs = polycyclic aromatic hydrocarbons

SIM = selected ion monitoring

TEQ = toxicity equivalency quotient

QUALITY CONTROL OBJECTIVES AND PROCEDURES

The overall quality assurance objective is to ensure that data of known and acceptable quality are provided. All measurements will be performed to yield consistent results that are representative of the media and conditions measured. Specific objectives and procedures for precision, accuracy, representativeness, completeness, and comparability are identified below and presented above in Table 2:

- **Precision:** Precision will be assessed using laboratory duplicates. One laboratory duplicate will be analyzed for each sample batch. Two levels of precision for duplicate analyses will be evaluated. For values that are greater than 5 times the reporting limit, the relative percent difference (RPD) of laboratory duplicates will be less than or equal to the values provided in Table 2. For values that are less than or equal to 5 times the reporting limit, duplicate values will be within ±2 times the reporting limit.

- **Accuracy:** Accuracy will be assessed with analyses of laboratory preparation blanks and matrix spikes. The values for blanks will not exceed the reporting limit. The percent recovery of matrix spikes is presented in Table 2.

- **Representativeness:** Sample representativeness will be ensured by employing consistent and standard sampling procedures.

- **Completeness:** A goal of 100 percent of the samples submitted to the laboratory and analyzed will be judged valid.

- **Comparability:** Data comparability will be ensured through the application of standard sampling procedures, analytical methods, units of measurement, and detection limits. The results will be tabulated in standard spreadsheets for comparison will regulatory standards and historical data.

FIELD QUALITY CONTROL PROCEDURES

Quality control procedures that will be implemented for field activities are described in the following subsections. The frequency and type of quality control samples to be collected in the field are also summarized in Table 4.

Table 4. Quality Assurance Requirements and Anticipated Number of Samples.

Parameter	Number of Samples	Laboratory Method Blanks[a]	Laboratory Control Standard[a]	Matrix Spike[a]	Lab Duplicates[a]	Field Duplicates	Trip Blank[b]
Soil Vapor at Probes and Sub-Slab Locations							
VOCs	17	1	1	NA	1	2	NA
Soil							
VOCs	22	1	1	1	1	1	NA
Groundwater							
VOCs	60	1	1	1	1[c]	4	1
MTCA total metals	36	1	1	1	1	4	NA
MTCA dissolved metals	36	1	1	1	1	4	NA
cPAHs	36	1	1	1	1	4	NA

[a] Laboratory quality assurance samples will be analyzed with each batch of samples submitted to the laboratory for analysis. A laboratory batch will consist of no more than 20 samples.

[b] One trip blank will be analyzed for VOCs.

[c] A matrix spike/matrix spike duplicate or laboratory control sample/laboratory control sample duplicate may be analyzed as a laboratory duplicate.

NA = not applicable

cPAHs = carcinogenic polycyclic aromatic hydrocarbons

MTCA = Model Toxics Control Act

TPH = total petroleum hydrocarbons

Instrument Maintenance and Calibration

Portable electronic field instruments will be used to screen soil and to measure groundwater parameters. The instrument manufacturers give direction for the maintenance and calibration of the instruments.

Soil Screening Instruments

The recommended calibration and maintenance procedures for the PID and sensors can be found in Appendix B of this SAP.

Groundwater Monitoring Instruments

A multimeter (YSI ProDSS) will be used to make measurements of water temperature, conductivity, pH, turbidity, and DO. The recommended calibration and maintenance procedures for this instrument and sensors can be found in Appendix B of this SAP.

Field Duplicates

One field duplicate will be collected for each matrix and analyzed for all parameters, as shown in Table 4. For groundwater samples, two successive grabs will be collected for each parameter.

Filter Blank

One filter blank will be collected in the field and analyzed for dissolved metals, as shown in Table 4. The filter blank will be collected using laboratory provided deionized and micro-filtered pure water that will be filtered in the field and submitted for laboratory analysis.

Trip Blank

One trip blank will be analyzed for VOCs, as shown in Table 4. The laboratory will provide a 40 mL vial with deionized and micro-filtered pure water that will be stored in the ice cooler with the samples and submitted for laboratory analysis along with the project samples.

LABORATORY QUALITY CONTROL PROCEDURES

Quality control procedures that will be implemented in the laboratory are described in the following subsections. The frequency and type of quality control samples to be analyzed by the laboratory are also summarized in Table 4.

Method Blanks

Method blanks consisting of deionized and micro-filtered pure water will be analyzed with every laboratory sample batch. A laboratory sample batch will consist of no more than 20 samples and may include samples from other projects. The total number of method blanks anticipated for this study is shown in Table 4 by parameter. Blank values will be presented in each laboratory report.

Control Standards

Control standards from each parameter will be analyzed by the laboratory with every sample batch. A laboratory sample batch will consist of no more than 20 samples and may include samples from other projects. The total number of control standards anticipated for this study is shown in Table 4 by parameter. Raw values and percent recovery (see formula in the *Data Assessment Procedures and Corrective Actions* section) for the control standards will be presented in each laboratory report.

Matrix Spikes

For applicable parameters, matrix spikes will be analyzed by the laboratory with every sample batch. A laboratory sample batch will consist of no more than 20 samples and may include samples from other projects. The total number of matrix spikes anticipated for this study is shown in Table 4 by parameter. Raw values and percent recovery (see formula in the *Data Assessment Procedures and Corrective Actions* section) for the matrix spikes will be presented in each laboratory report.

Laboratory Duplicates

Laboratory duplicate samples for each parameter will be analyzed for specifically labeled quality assurance samples submitted with every sample batch. This will represent no less than 20 percent of the project submitted samples. The total number of laboratory duplicates anticipated for this study is shown in Table 4 by parameter. Raw values and relative precent difference (see formula in the *Data Assessment Procedures and Corrective Actions* section) of the duplicate results will be presented in each laboratory report.

DATA ASSESSMENT PROCEDURES AND CORRECTIVE ACTIONS

Quality control problems and corrective actions will be summarized in quality assurance worksheets. Values associated with minor quality control problems will be considered estimates and flagged with a J. Values associated with major quality control problems will be rejected and flagged with an R. Estimated values may be used for evaluation purposes, while rejected values will not be used. This section describes the data assessment procedures for the following quality control elements:

- Completeness
- Methods
- Holding times
- Detection limits
- Blanks (laboratory, trip, and filter)
- Duplicates (laboratory and field)
- Matrix spikes
- Surrogate spikes (organic analyses only)

COMPLETENESS

Completeness will be assessed by comparing valid sample data with this quality assurance plan and chain-of-custody records. Completeness will be calculated by dividing the number of valid values by the total number of values. Samples may be reanalyzed if completeness is less than 100 percent.

METHODS

Analytical and field methods will be assessed by examination of the field notebook and laboratory reports for deviation from the quality assurance plan. Unacceptable deviations will result in rejected values.

HOLDING TIMES

The dates that analyses are performed will be reported by the laboratory. Holding times will be assessed by comparing analysis dates to sample collection dates. Values that exceed the maximum holding times allowed by the method will be flagged as estimates (J), whereas severe exceedances will results in rejected values (R).

DETECTION LIMITS

Detection limits will be reported in each laboratory report. If detection limits are elevated due to matrix interference, the laboratory will be requested to reanalyze the samples and/or revise the method, if time permits. Detection limits will be less than or equal to criteria listed in Table 3.

BLANKS

Blanks (including method, trip and filter blanks), composed of deionized distilled water prepared as a sample, will be analyzed and the results reported in each laboratory report. If a blank value exceeds the detection limit, associated sample values that are less than 5 times the blank value will be flagged as estimates (J).

DUPLICATES

Precision of laboratory duplicate results will be presented in each laboratory report and checked by the project chemist. Precision of laboratory duplicate results will be calculated according to the following equation:

$$RPD = \frac{(C_{1-}\,C_2)x\ 100\%}{(C_1 + C_2)/\ 2}$$

Where: RPD = relative percent difference

C1 = larger of two values

C2 = smaller of two values

Laboratory duplicate results exceeding the objectives will be noted in the quality assurance worksheets and associated values will be flagged as estimates (J). If the objectives are severely exceeded (e.g., more than twice the objective), associated values will be rejected (R).

SPIKED SAMPLES

Matrix spike and surrogate spike results will be presented in the laboratory reports and checked by the project chemist. The percent recoveries for matrix and surrogate spikes will be calculated using the following equations:

$$\%R = \frac{(S - U)}{C_{sa}}\, x\ 100\%$$

Where: %R = Percent recovery

S = Measured concentration in spike sample

U = Measured concentration in unspiked sample

Csa = Actual concentration of spike added

If the analyte is not detected in the unspiked sample, then a value of zero will be used in the equation.

REPORTING

Herrera will prepare a second Supplemental Remedial Investigation Report (SRI) for the project that includes the following:

1. A summary of the investigation methods and results in text, data tables, and figures, including a groundwater contour map.
2. An updated Conceptual Site Model and assumptions regarding the nature and extent of contamination.
3. Any problems and associated corrective actions taken will be reported. Specific quality assurance information to be noted in the report includes:
    - Changes in the sampling and quality assurance plan
    - Significant quality assurance problems and recommended solutions
    - Data quality assessment in terms of precision, accuracy, representativeness, completeness, comparability, and detection limits
    - Discussion of whether the quality assurance objectives were met and the resulting impact on decision making
    - Limitations on use of the measurement data

The SRI results and conclusions will be incorporated into a third draft FS as previously scoped.

REFERENCES

Brummer, Chris. 2017a. Personal communication with Bruce Carpenter, Herrera Environmental Consultants, Inc., and Chris Brummer, King County Water and Land Resources Division, provided draft hand drawn water level contour map for the Site using October 2015 groundwater elevations. February 10.

Brummer, Chris. 2017b. Personal communication with Bruce Carpenter, Herrera Environmental Consultants, Inc., and Chris Brummer, King County Water and Land Resources Division, provided animated groundwater level hydrograph, based on groundwater levels from October 2015 through October 2016. February 22.

Ecology. 2007. Model Toxics Control Act Statute and Regulation—Model Toxics Control Act, Chapter 70.105D RCW; Uniform Environmental Covenants Act, Chapter 64.70 RCW; and MTCA Cleanup Regulation, Chapter 173-340 WAC. Washington State Department of Ecology, Toxics Cleanup Program. Publication Number 94-06. Revised November.

Ecology. 2019. Opinion Pursuant to WAC 173-340-515(5) on Remedial Action for Pacific City Park. Issued by the Washington State Department of Ecology. Olympia, Washington. August 26.

Herrera. 2019a. Remedial Investigation Report, Pacific City Park. Prepared for the River and Floodplain Management Section, King County Water and Land Resources Division by Herrera Environmental Consultants, Inc., Seattle, Washington. January 4.

Herrera. 2019b. Supplemental Remedial Investigation Report, Pacific City Park. Prepared for the River and Floodplain Management Section, King County Water and Land Resources Division by Herrera Environmental Consultants, Inc., Seattle, Washington. June 4.

Herrera. 2019c. March 2019 Monitoring Report, Pacific City Park. Prepared for the River and Floodplain Management Section, King County Water and Land Resources Division by Herrera Environmental Consultants, Inc., Seattle, Washington. June 10.

Herrera. 2019d. June/July 2019 Monitoring Report, Pacific City Park. Prepared for the River and Floodplain Management Section, King County Water and Land Resources Division by Herrera Environmental Consultants, Inc., Seattle, Washington. October 1.

Herrera. 2019e. September 2019 Monitoring Report, Pacific City Park. Prepared for the River and Floodplain Management Section, King County Water and Land Resources Division by Herrera Environmental Consultants, Inc., Seattle, Washington. December 10.

Herrera. 2020. Terrestrial Ecological Evaluation—Sampling and Analysis Plan. Prepared for the River and Floodplain Management Section, King County Water and Land Resources Division by Herrera Environmental Consultants, Inc., Seattle, Washington. April 10.

King County. 2015. Stormwater Quality Sampling Results from the Pacific Right Bank Wetland. Memorandum prepared by King County on February 18.

S&W. 2016. Pacific Park Phase II Environmental Site Assessment for the Pacific Right Bank Levee, Pacific, Washington. Prepared by Shannon and Wilson, Seattle, Washington, for King County River and Floodplain Management Section, Water and Land Resources Division. May.

Seattle-King County Department of Public Health. 1985. Abandoned landfill study in King County: Report prepared by Seattle-King County Department of Public Health, April 30.

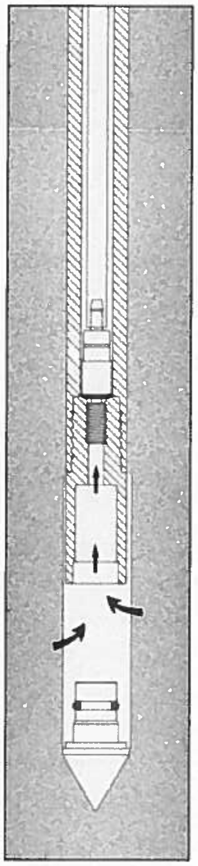
APPENDIX A

Post-Run Tubing System and Vapor Pin Sampling Device Standard Operating Procedures

Soil Gas Sampling – PRT System Operation

from Geoprobe Systems®

www.geoprobe.com
1-800-436-7762



Soil Gas Sampling using the Post-Run Tubing (PRT) System.

Soil Gas Sampling — PRT System Operation

Basics

Using the Post-Run Tubing System, one can drive probe rods to the desired sampling depth, then insert and seal an internal tubing for soil gas sampling. The usual Geoprobe probe rods and driving accessories and the following tools are required:

- PRT Expendable Point Holder
- PRT Adapter
- Selected PRT Tubing

Preparation

1. Clean all parts prior to use. Install O-rings on the PRT Expendable Point Holder and the PRT adapter.

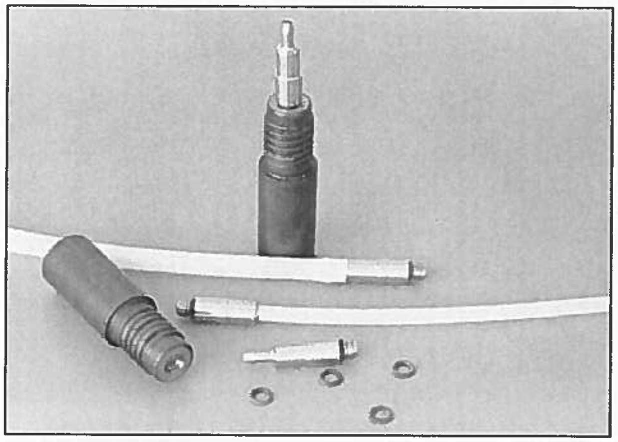
2. Inspect the probe rods and clear them of all obstructions.

3. TEST FIT the adapter with the PRT fitting on the expendable point holder to assure that the threads are compatible and fit together smoothly.

   NOTE: PRT fittings are left-hand threaded.

4. Push the adapter into the end of the selected tubing. Tape may be used on the outside of the adapter and tubing to prevent the tubing from spinning freely around the adapter during connection – especially when using Teflon tubing **(Figure 1)**.

   REMEMBER: The sample will not contact the outside of the tubing or adapter.



PRT SYSTEM PARTS
PRT Expendable Point Holder, PRT Adapters, Tubing, and O-rings.

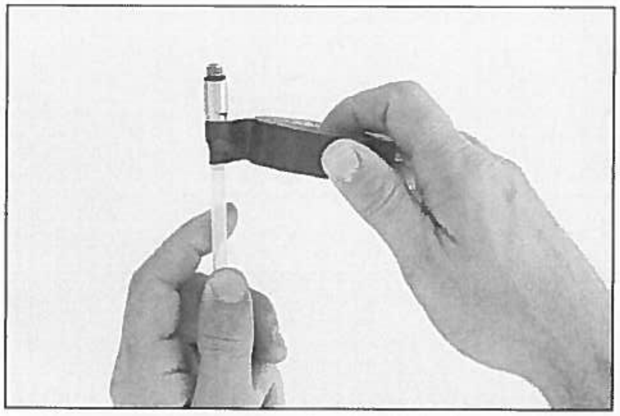


Figure 1. Securing adapter to tubing with tape. NOTE: Tape does not contact soil gas sample.

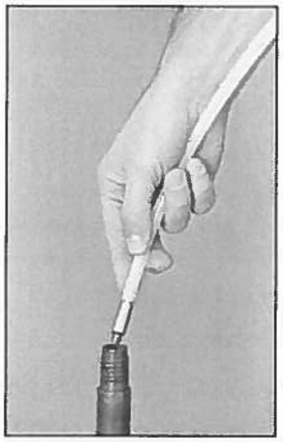


Figure 2. Insertion of tubing and PRT adapter.

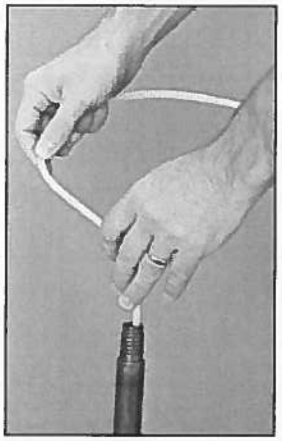
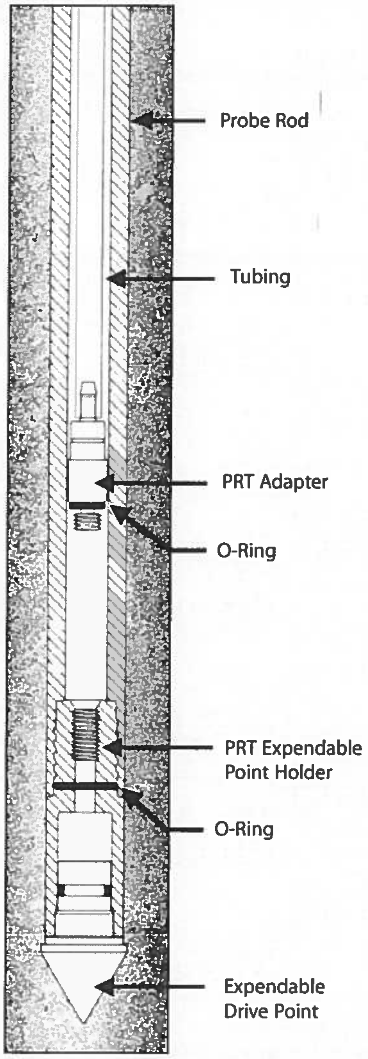


Figure 3. Engaging threads by rotating tubing.

Geoprobe® Systems

Soil Gas Sampling — PRT System Operation



A cross section of probe rods driven to depth and then retracted to allow for soil gas sampling. The PRT adapter and tubing are now fed through the rods and rotated to form a vacuum-tight connection at the point holder. The result is a continuous run of tubing from the sample level to the surface.

Probing

Drive the PRT tip configuration into the ground. Connect probe rods as necessary to reach the desired depth. After depth has been reached, disengage the expendable point by pulling up on the probe rods. Remove the pull cap from the top probe rod, and position the Geoprobe unit to allow room to work.

Connection

1. Insert the adapter end of the tubing down the inside diameter of the probe rods **(Figure 2)**.

2. Feed the tubing down the rod bore until it hits bottom on the expendable point holder. Allow about 2 ft. (610 mm) of tubing to extend out of the hole before cutting it.

3. Grasp the excess tubing and apply some downward pressure while turning it in a counterclockwise motion to engage the adapter threads with the expendable point holder **(Figure 3)**.

4. Pull up lightly on the tubing to test engagement of the. threads. (Failure of adapter to thread could mean that intrusion of soil may have occurred during driving of probe rods or disengagement of drive point.)

Sampling

1. Connect the outer end of the tubing to the Silicone Tubing Adapter and vacuum hose (or other sampling apparatus).

2. Follow the appropriate sampling procedure for collecting a soil gas sample **(Figure 1)**.

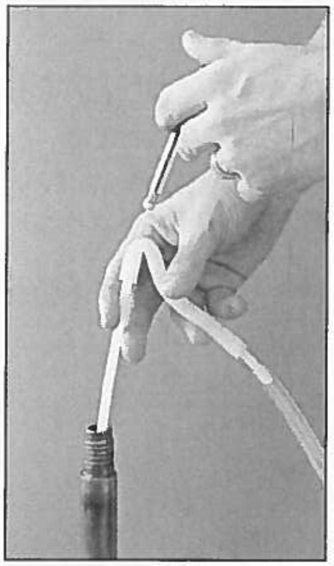


Figure 1. Taking a soil gas sample for direct injection into a GC with the PRT system.

Removal

1. After collecting a sample, disconnect the tubing from the vacuum hose or sampling system.

2. Pull up firmly on the tubing until it releases from the adapter at the bottom of the hole. (Taped tubing requires a stronger pull.)

3. Remove the tubing from the probe rods. Dispose of polyethylene tubing or decontaminate Teflon tubing as protocol dictates.

4. Retrieve the probe rods from the ground and recover the expendable point holder with the attached PRT adapter.

5. Inspect the O-ring at the base of the PRT adapter to verify that proper sealing was achieved during sampling. The O-ring should be compressed. This seal can be tested by capping the open end of the point holder applying vacuum to the PRT adapter.

6. Prepare for the next sample.

Standard Operating Procedure Installation and Extraction of the Vapor Pin® Sampling Device

Updated January 28, 2021

Scope:

This standard operating procedure describes the installation and extraction of the VAPOR PIN® sampling device for use in sub-slab soil-gas sampling.

Purpose:

The purpose of this procedure is to assure good quality control in field operations and uniformity between field personnel in the use of the VAPOR PIN® sampling device for the collection of sub-slab soil-gas samples or pressure readings.

Equipment Needed:

- Assembled VAPOR PIN® sampling device [VAPOR PIN® sampling device and silicone sleeve (Figure 1)]; Because of sharp edges, gloves are recommended for sleeve installation;
- Hammer drill;
- 5/8-inch (16mm) diameter hammer bit (hole **must** be 5/8-inch (16mm) diameter to ensure seal. It is recommended that you use the drill guide). (Hilti™ TE-YX 5/8" x 22" (400 mm) #00206514 or equivalent);
- 1½-inch (38mm) diameter hammer bit (Hilti™ TE-YX 1½" x 23" #00293032 or equivalent) for flush mount applications;
- ¾-inch (19mm) diameter bottle brush;
- Wet/Dry vacuum with HEPA filter (optional);
- VAPOR PIN® sampling device installation/extraction tool;
- Dead blow hammer;
- VAPOR PIN® sampling device flush mount cover, if desired;
- VAPOR PIN® sampling device drilling guide, if desired;
- VAPOR PIN® sampling device protective cap; and
- VOC-free hole patching material (hydraulic cement) and putty knife or trowel for repairing the hole following the extraction of the VAPOR PIN® sampling device.

Figure 1. Assembled VAPOR PIN® sampling device

Installation Procedure:

1) Check for buried obstacles (pipes, electrical lines, etc.) prior to proceeding.

2) Set up wet/dry vacuum to collect drill cuttings.

3) If a flush mount installation is required, drill a 1½-inch (38mm) diameter hole at least 1¾-inches (45mm) into the slab. Use of a VAPOR PIN® sampling device drilling guide is recommended.

4) Drill a 5/8-inch (16mm) diameter hole through the slab and approximately 1-inch (25mm) into the underlying soil to form a void. Hole **must** be 5/8-inch (16mm) in diameter to ensure seal. It is recommended that you use the drill guide.
5) Remove the drill bit, brush the hole with the bottle brush, and remove the loose cuttings with the vacuum.

6) Place the lower end of VAPOR PIN® sampling device assembly into the drilled hole. Place the small hole located in the handle of the installation/extraction tool over the vapor pin to protect the barb fitting, and tap the vapor pin into place using a dead blow hammer (Figure 2). Make sure the installation/extraction tool is aligned parallel to the vapor pin to avoid damaging the barb fitting.

Figure 2. Installing the VAPOR PIN®

During installation, the silicone sleeve will form a slight bulge between the slab and the VAPOR PIN® sampling device shoulder. Place the protective cap on VAPOR PIN® sampling device to prevent vapor loss prior to sampling (Figure 3).

Figure 3. Installed VAPOR PIN® sampling device

7) For flush mount installations, cover the vapor pin with a flush mount cover, using either the plastic cover or the optional stainless-steel Secure Cover (Figure 4).

Figure 4. Secure Cover Installed

8) Allow 20 minutes or more (consult applicable guidance for your situation) for the sub-slab soil-gas conditions to re-equilibrate prior to sampling.

9) Remove protective cap and connect sample tubing to the barb fitting of the VAPOR PIN® sampling device. This connection can be made using a short

piece of Tygon™ tubing to join the VAPOR PIN® sampling device with the Nylaflow tubing (Figure 5). Put the Nylaflow tubing as close to the VAPOR PIN® sampling device as possible to minimize contact between soil gas and Tygon™ tubing.

Figure 5. VAPOR PIN® sampling device sample connection

10) Conduct leak tests in accordance with applicable guidance. If the method of leak testing is not specified, an alternative can be the use of a water dam and vacuum pump, as described in SOP Leak Testing the VAPOR PIN® sampling device via Mechanical Means (Figure 6). For flush-mount installations, distilled water can be poured directly into the 1 1/2 inch (38mm) hole.

Figure 6. Water dam used for leak detection

11) Collect sub-slab soil gas sample or pressure reading. When finished, replace the protective cap and flush mount cover until the next event. If the sampling is complete, extract the VAPOR PIN® sampling device.

Extraction Procedure:

1) Remove the protective cap, and thread the installation/extraction tool onto the barrel of the VAPOR PIN® sampling device (Figure 7). Turn the tool clockwise continuously, don't stop turning, the VAPOR PIN® sampling device will feed into the bottom of the installation/extraction tool and will extract from the hole like a wine cork, DO NOT PULL.

2) Fill the void with hydraulic cement and smooth with a trowel or putty knife.

Figure 7. Removing the VAPOR PIN® sampling device

- Prior to reuse, remove the silicone sleeve and protective cap and discard. Decontaminate the VAPOR PIN®

sampling device in a hot water and Alconox® wash, then heat in an oven to a temperature of 265° F (130° C) for 15 to 30 minutes. For both steps, **STAINLESS – ½ hour, BRASS 8 minutes**

3) Replacement parts and supplies are available online.

APPENDIX B

Instrumentation Calibration and Maintenance Documentation

MiniRAE 3000
ppbRAE 3000

Basic Operation
Pocket Reference

PN: 059-4030-000-D
Rev. B August 2010

Read Before Operating

This Pocket Reference is intended as a quick guide to basic use and calibration of your instrument. It does not cover advanced features. Information on advanced features and other operation modes is included in the User's Guide.

The User's Guide must be carefully read by all individuals who have or will have the responsibility of using, maintaining, or servicing this product. The product will perform as designed only if it is used, maintained, and serviced in accordance with the manufacturer's instructions. The user should understand how to set the correct parameters and interpret the obtained results.

CAUTION!

To reduce the risk of electric shock, turn the power off before removing the instrument cover. Disconnect the battery before removing sensor module for service. Never operate the instrument when the cover is removed. Remove instrument cover and sensor module only in an area known to be non-hazardous.

WARNINGS

STATIC HAZARD: Clean only with damp cloth.
For safety reasons, this equipment must be operated and serviced by qualified personnel only. Read and understand the User's Guide completely before operating or servicing.

Use only RAE Systems battery packs, part numbers 059-3051-000, 059-3052-000, and 059-3054-000. This instrument has not been tested in an explosive gas/air atmosphere having an oxygen concentration greater than 21%. Substitution of components may impair intrinsic safety. Recharge batteries only in non-hazardous locations.

Do not mix old and new batteries or batteries from different manufacturers.

The calibration of all newly purchased RAE Systems instruments should be tested by exposing the sensor(s) to known concentration calibration gas before the instrument is put into service.

MiniRAE 3000/ppbRAE 3000 Pocket Reference

For maximum safety, the accuracy of the instrument should be checked by exposing it to a known concentration calibration gas before each day's use.

Do not use USB/PC communication in hazardous locations.

Intrinsic Safety: US and Canada: Class I, Division 1,
Groups A,B, C, D
Europe: ATEX (0575 Ex II 2G Ex ia
IIC/IIB T4 Gb)
KEMA 07 ATEX 0127
Complies with EN60079-0:2009,
EN60079-11:2007
IECEx CSA 10.0005 Ex ia IIC/IIB T4 Gb
Complies with IEC 60079-0:2007,
IEC 60079-11:2006
(IIC: 059-3051-000 Li-ion bat pack or
059-3054-000 NiMH bat pack;
IIB: 059-3052-000 alkaline bat pack)

Special Notes

⚠ When the instrument is taken out of the transport case and turned on for the first time, there may be some residual organic or inorganic vapor trapped inside the detector chamber. The initial PID sensor reading may indicate a few ppm. Enter an area known to be free of any organic vapor and turn on the instrument. After running for several minutes, the residual vapor in the detector chamber will be cleared and the reading should return to zero.

⚠ The battery of the instrument discharges slowly even if it is turned off. If the instrument has not been charged for 5 to 7 days, the battery voltage will be low. Therefore, it is a good practice to always charge the instrument before using it. It is also recommended to fully charge the instrument for *at least 10 hours* before first use. Refer to the User Guide’s section on battery charging for more information on battery charging and replacement.

MiniRAE 3000/ppbRAE 3000 Pocket Reference

Contents

Charging The Battery 6
Charging A Spare Rechargeable Battery 8
Pump Status & Calibration Status 10
User Interface... 12
Display... 15
Operating The Instrument... 16
   Turning The Instrument On.. 17
   Turning The Instrument Off... 18
   Operating The Built-In Flashlight 18
Basic User Mode/Hygiene Mode 19
Entering Calibration.. 21
Standard Two-Point Calibration (Zero & Span).............. 23
   Zero (Fresh Air) Calibration.. 25
   Span Calibration.. 28
   Exiting Two-Point Calibration 32
Alarm Signal Summary 33
Preset Alarm Limits & Calibration................................. 35
Sampling Pump... 36
Ordering Replacement Parts 37
Special Servicing Note 38
Troubleshooting.. 38
Technical Support... Back cover

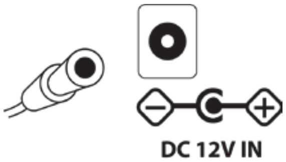
Charging The Battery

Always fully charge the battery before using the instrument. The instrument's Li-ion battery is charged by placing the instrument in its cradle. Contacts on the bottom of the instrument meet the cradle's contacts, transferring power without other connections.

Note: Before setting the instrument into its charging cradle, visually inspect the contacts to make sure they are clean. If they are not, wipe them with a soft cloth. Do not use solvents or cleaners.

Follow this procedure to charge the instrument:

1. Plug the AC/DC adapter's barrel connector into the instrument's cradle.



2. Plug the AC/DC adapter into the wall outlet.
3. Place the instrument into the cradle, press down, and lean it back. It locks in place and the LED in the cradle glow

The instrument begins charging automatically. The “Primary” LED in the cradle blinks green to indicate charging. During charging, the diagonal lines in the battery icon on the instrument’s display are animated and you see the message “Charging...”

When the instrument’s battery is fully charged, the battery icon is no longer animated and shows a full battery. The message “Fully charged!” is shown. The cradle’s LED glows continuously green.

Note: If you see the “Battery Charging Error” icon (a battery outline with an exclamation mark inside), check that the instrument or rechargeable battery has been set into the cradle properly. If you still receive the message, check the Troubleshooting section of this guide.

Charging A Spare Rechargeable Battery

A rechargeable Li-ion battery can be charged when it is not inside the monitor. The charging cradle is designed to accommodate both types of charging. Contacts on the bottom of the battery meet the contacts on the cradle, transferring power without other connections, and a spring-loaded capture holds the battery in place during charging.

1. Plug the AC/DC adapter into the monitor's cradle.
2. Place the battery into the cradle, with the gold-plated contacts on top of the six matching charging pins.
3. Plug the AC/DC adapter into the wall outlet.

The battery begins charging automatically. During charging, the Secondary LED in the cradle blinks green. When charging is complete, it glows steady green.

Release the battery from the cradle by pulling it back toward the rear of the cradle and tilting it out of its slot.

Note: If you need to replace the Li-ion battery pack, replacements are available from RAE Systems. The part number is 059-3051-000.

Note: An Alkaline Battery Adapter (part number 059-3052-000), which uses four AA alkaline batteries (Duracell MN1500), may be substituted for the Li-Ion battery.

WARNING!

To reduce the risk of ignition of hazardous atmospheres, recharge and replace batteries only in areas known to be non-hazardous. Remove and replace batteries only in areas known to be non-hazardous.

Low Voltage Warning

When the battery's charge falls below a preset voltage, the instrument warns you by beeping once and flashing once every minute, and the "empty battery" icon blinks on and off once per second. Turn off the instrument within 10 minutes and either recharge the battery by placing the instrument in its cradle, or replace the battery with a fresh one with a full charge.

Pump Status

During operation, make sure the probe inlet and the gas outlet are free of obstructions. Obstructions can cause premature wear on the pump, false readings, or pump stalling. During normal operation, the pump icon alternately shows inflow and outflow as shown here:

During duty cycling (PID lamp cleaning), the display shows these icons in alternation:

If there is a pump failure or obstruction that disrupts the pump, you will see this icon blinking on and off:

If you see this blinking icon, consult the Troubleshooting section in the User's Guide.

Calibration Status

The instrument displays this icon if it requires calibration:

Calibration is required (and indicated by this icon) if:

- The lamp type has been changed (for example, from 10.6 eV to 9.8 eV).
- The sensor has been replaced.
- It has been 30 days or more since the instrument was last calibrated.
- If you have changed the calibration gas type without recalibrating the instrument.

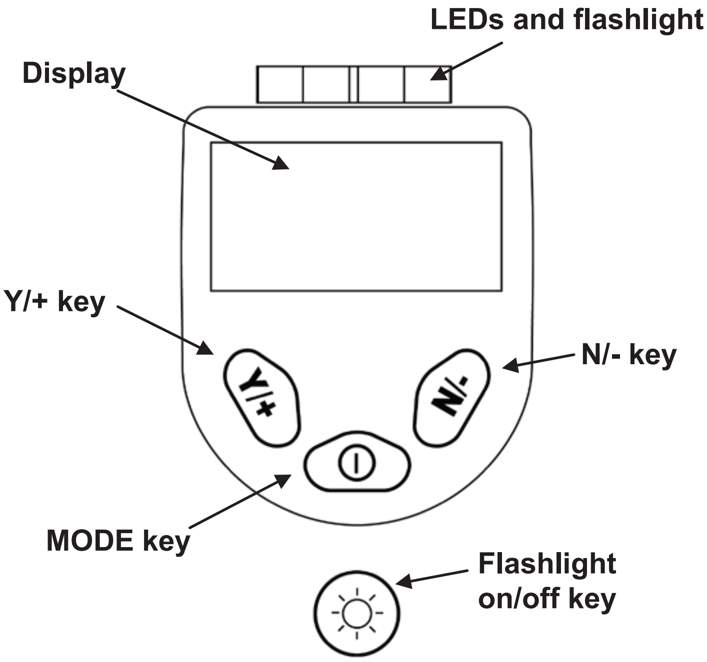
User Interface

The instrument's user interface consists of the display, LEDs, an alarm transducer, and four keys. The keys are:

Y/+
MODE
N/-
Flashlight on/off

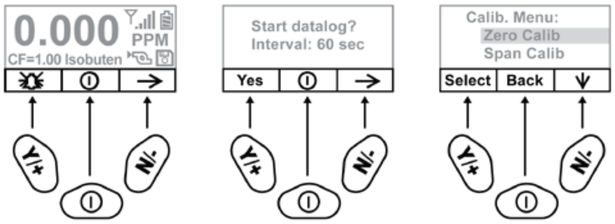
The LCD display provides visual feedback that includes time, battery condition, and other functions.

In addition to their labeled functions, the keys labeled Y/+, MODE, and N/- act as "soft keys" that control different parameters and make different selections within the instrument's menus. From menu to menu, each key controls a different parameter or makes a different selection.


LEDs and flashlight
Display
Y/+ key
Y/+
N/-
N/- key
MODE key
Flashlight on/off key

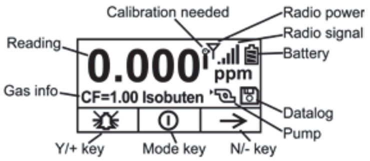
Three panes along the bottom of the display are "mapped" to the keys. These change as menus change, but at all times the left pane corresponds to the [Y/+] key, the center pane corresponds to the [MODE] key, and the right pane corresponds to the [N/-] key. Here are three examples of different menus with the relationships of the keys clearly shown:

RELATIONSHIP OF BUTTONS TO CONTROL FUNCTIONS



Display

The display shows the following information:



Graph	Graphic representation of concentration plotted over time
Gas info*	Tells the Correction Factor and type of calibration gas
Reading	Concentration of gas as measured
Calibration needed	Indicates that calibration should be performed
Radio power	Indicates whether radio connection is on or off
Radio signal	Indicates signal strength in 5-bar bargraph
Battery	Indicates battery level in 3 bars
Pump	Indicates that pump is working
Datalog	Indicates whether datalog is on or off
Y/+	Y/+ key's function for this screen
MODE	MODE key's function for this screen
N/-	N/- key's function for this screen

Operating The Instrument

The instrument is designed as a broadband VOC gas monitor and datalogger for work in hazardous environments. It gives real-time measurements and activates alarm signals whenever the exposure exceeds preset limits. Prior to factory shipment, the instrument is preset with default alarm limits and the sensor is pre-calibrated with standard calibration gas. However, you should test the instrument and verify the calibration before the first use. After the instrument is fully charged and calibrated, it is ready for immediate operation.

Turning The Instrument On

1. With the instrument turned off, press and hold [MODE].
2. When the display turns on, release the [MODE] key.

The instrument is now operating and performs self tests. If any tests (including sensor and memory tests fail), refer to the Troubleshooting section of the User's Guide.

Note: In Basic User/Hygiene Mode (the default setting), the instrument stops after self-testing, and asks whether to perform a zero air (fresh air) calibration. You can start this calibration, quit, or abort the calibration while the instrument is undergoing calibration. When the zero calibration is done, you see screen telling you that the zero calibration is complete, along with its value. After calibration (or after you abort the calibration), the instrument then shows a numerical reading screen with icons. This indicates that the instrument is fully functional and ready to use.

Turning The Instrument Off

1. Press and hold the Mode key for 3 seconds. A 5-second countdown to shutoff begins.
2. Once the countdown stops, the instrument is off. Release the Mode key.
3. When you see “Unit off...” release your finger from the [MODE] key. The instrument is now off.

Note: You must hold your finger on the key for the entire shutoff process. If you remove your finger from the key during the countdown, the shutoff operation is canceled and the instrument continues normal operation.

Operating The Built-In Flashlight

The instrument has a built-in flashlight that helps you point the probe in dark places. Press the flashlight key to turn it on. Press it again to turn it off.

Note: Using the flashlight for extended periods shortens the battery’s operating time before it needs recharging.

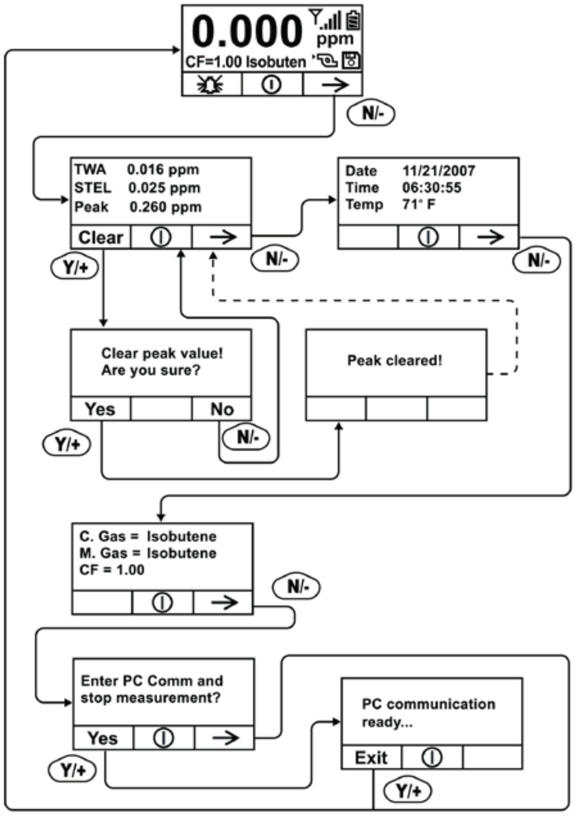
Basic User Mode/Hygiene Mode (Default Settings)

The instrument is programmed to operate in Basic User Mode/Hygiene Mode as its default. This gives you the most commonly needed features while requiring the fewest parameter adjustments.

Pressing [N/-] steps you from one screen to the next, and eventually return to the main display. If you do not press a key within 60 seconds after entering a display, the instrument reverts to its main display.

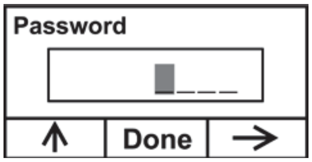
Note: While viewing any of these screens, you can shut off your instrument by pressing [MODE].

Note: Whenever you see the alarm icon in the lower left pane, you can press [Y/+] to test the alarms.


0.000
ppm
CF=1.00 Isobuten
N/-
TWA 0.016 ppm
STEL 0.025 ppm
Peak 0.260 ppm
Clear
Y/+
N/-
Date 11/21/2007
Time 06:30:55
Temp 71° F
N/-
Clear peak value!
Are you sure?
Yes
No
Y/+
N/-
Peak cleared!
C. Gas = Isobutene
M. Gas = Isobutene
CF = 1.00
N/-
Enter PC Comm and
stop measurement?
Yes
Y/+
PC communication
ready...
Exit
Y/+

Entering Calibration

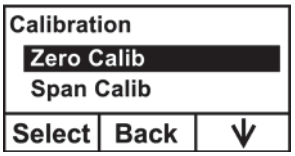
1. Press and hold [MODE] and [N/-] until you see the Password screen.



2. In Basic User Mode, you do not need a password to perform calibrations. Instead of inputting a password, enter calibration by pressing [MODE].

   Note: If you inadvertently press [Y/+] and change any of the numbers, simply press [MODE] and you will be directed to the calibration menu.

The Calibration screen is now visible with Zero Calibration highlighted.



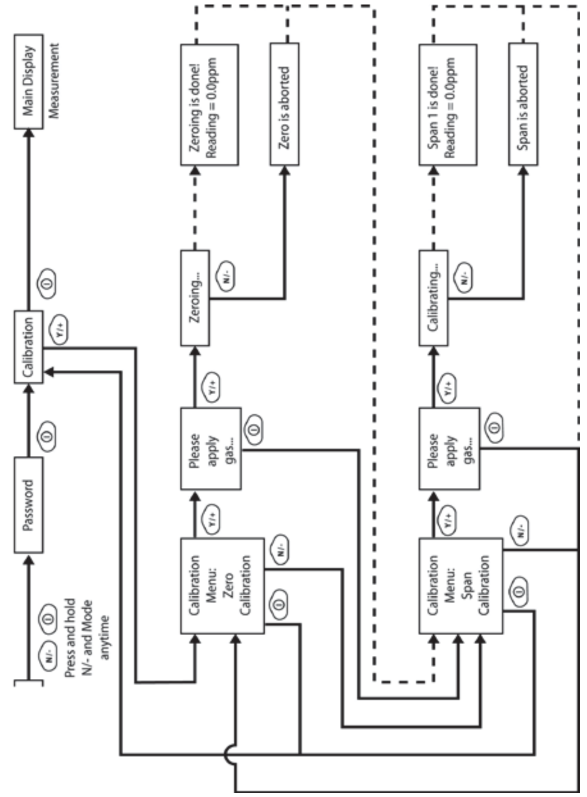
These are your options:

- Press [Y/+] to select the highlighted calibration (Zero Calib or Span Calib).
- Press [MODE] to exit calibration and return to the main display and resume measurement.
- Press [N/-] to toggle the highlighted calibration type.

Standard Two-Point Calibration (Zero & Span)

The following diagram shows the instrument's calibrations in Basic/Hygiene mode.

Note: In the diagram, a dashed line indicates automatic change to another screen.


Main Display
Measurement
Password
Calibration
Press and hold
N/- and Mode
anytime
N/-
Y/+
Calibration
Menu:
Zero
Calibration
Please
apply
gas...
Zeroing...
Zeroing is done!
Reading = 0.0ppm
Zero is aborted
Calibration
Menu:
Span
Calibration
Please
apply
gas...
Calibrating...
Span 1 is done!
Reading = 0.0ppm
Span is aborted

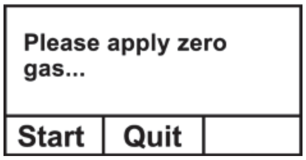
Zero (Fresh Air) Calibration

This procedure determines the zero point of the sensor calibration curve. To perform a fresh air calibration, use the calibration adapter to connect the instrument to a "fresh" air source such as from a cylinder or Tedlar bag (optional accessory). The "fresh" air is clean, dry air without organic impurities and an oxygen value of 20.9%. If such an air cylinder is not available, any clean ambient air without detectable contaminants or a charcoal filter can be used.

At the Zero Calibration menu, you can proceed to perform a Zero calibration or bypass Zero calibration and perform a Span calibration. You may also go back to the initial Calibration menu if you want to exit calibration.

- Press [Y/+] to start calibration.
- Press [MODE] to quit and return to the main calibration display.

If you have pressed [Y/+] to enter Zero calibration, then you will see this message:



Please apply zero gas...

1. Turn on your Zero calibration gas.
2. Press [Y/+] to start calibration.

   Note: At this point, you may press [MODE] if you decide that you do not want to initiate calibration. This will take you directly to the Calibration menu, highlighted for Span calibration.

3. Zero calibration starts and displays this message:

   Zeroing...

During the zeroing process, the instrument performs the Zero calibration automatically and does not require any actions on your part.

Note: To abort the zeroing process at any time and proceed to Span calibration, press [N/-] at any time while zeroing is being performed. You will see a confirmation message that says “Zero is aborted!” and then the Span calibration menu appears.

When Zero calibration is complete, you see this message:

> Zeroing is done!
> Reading = 0.000 ppm

The instrument will then show the Calibration menu on its display, with Span Calib hightlighted.

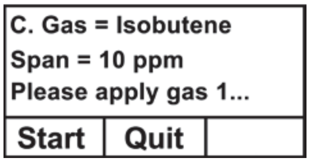
Span Calibration

This procedure determines the second point of the sensor calibration curve for the sensor. A cylinder of standard reference gas (span gas) fitted with a 500 cc/min. flow-limiting regulator or a flow-matching regulator is the simplest way to perform this procedure. Choose the 500 cc/min. regulator only if the flow rate matches or slightly exceeds the flow rate of the instrument pump. Alternatively, the span gas can first be filled into a Tedlar bag or delivered through a demand-flow regulator. Connect the calibration adapter to the inlet port of the instrument, and connect the tubing to the regulator or Tedlar bag.

Another alternative is to use a regulator with >500 cc/min flow but allow the excess flow to escape through a T or an open tube. In the latter method, the span gas flows out through an open tube slightly wider than the probe, and the probe is inserted into the calibration tube. At the Span Calibration menu, you perform a Span calibration. You may also go back to the Zero calibration menu or to the initial Calibration menu if you want to exit calibration.

- Press [Y/+] to enter Span calibration.
- Press [N/-] to skip Span calibration and return to Zero calibration.
- Press [MODE] to exit Span calibration and return to the top calibration menu.

If you have pressed [Y/+] to enter Span calibration, then you will see the name of your Span gas (the default is isobutylene) and the span value in parts per million (ppm). You will also see this message that prompts you:



C. Gas = Isobutene
Span = 10 ppm
Please apply gas 1...

1. Turn on your span calibration gas.
2. Press [Y/+] to initiate calibration.

   Note: You may press [MODE] if you decide that you do not want to initiate calibration. This will abort the span calibration and take you directly to the Calibration menu for Zero calibration.

3. Span calibration starts and displays this message:

Calibrating...

During the Span calibration process, there is a 30-second countdown and the instrument performs the Span calibration automatically. It requires no actions on your part.

Note: If you want to abort the Span calibration process, press [N/-] at any time during the process. You will see a confirmation message that says “Span is aborted!” and then the Zero calibration menu appears. You can then proceed to perform a Zero calibration, perform a Span calibration, or exit to the topmost Calibration menu.

When Span calibration is complete, you see this message:

Span 1 is done!
Reading = 100.0 ppm

The instrument then exits Span calibration and shows the Zero calibration menu on its display.

Note: The reading should be very close to the span gas value.

Exiting Two-Point Calibration

When you are done performing calibrations, press [MODE], which corresponds with “Back” on the display. You will see the following message:

Updating settings…

The instrument updates its settings and then returns to the main display. It begins or resumes monitoring.

Alarm Signal Summary

If the measured gas concentration exceeds any of the preset limits, the buzzer and red flashing LED are activated immediately to warn you of the alarm condition. The instrument also alarms if one of the following conditions occurs: battery voltage falls below a preset voltage level, failure of the UV lamp, or pump stall.

Message	**Condition**	**Alarm Signal**
HIGH	Gas exceeds “High Alarm” limit	3 beeps/flashes per second*
OVR	Gas exceeds measurement range	3 beeps/flashes per second
MAX	Gas exceeds electronics’ maximum range	3 beeps/flashes per second
LOW	Gas exceeds “Low Alarm” limit	2 beeps/flashes per second*
TWA	Gas exceeds “TWA” limit	1 Beep/flash per second*

STEL	Gas exceeds "STEL" limit	1 Beep/flash per second*
Pump icon flashes	Pump failure	3 beeps/flashes per second
Lamp	PID lamp failure	3 beeps/flashes per second plus "Lamp" message on display
Battery icon flashes	Low battery	1 flash per minute, 1 beep per minute plus battery icon flashes on display
CAL	Calibration failed, or needs calibration	1 beep/flash per second
NEG	Gas reading measures less than number stored in calibration	1 beep/flash per second

* Hygiene mode only. In Search mode, the number of beeps per second (1 to 7) depends upon the concentration of the sampled gas.

Preset Alarm Limits & Calibration

The instrument is factory calibrated with standard calibration gas, and is programmed with default alarm limits.

Cal Gas (Isobutylene)	**Cal Span**	**unit**	**Low**	**High**	**TWA**	**STEL**
ppbRAE 3000	10	ppm	10	25	10	25
MiniRAE 3000	100	ppm	50	100	10	25

Sampling Pump

When approaching the end of the specified lifetime of the pump, it will consume higher amount of energy and reduce its sample draw capability significantly. When this occurs, it is necessary to replace or rebuild the pump. When checking the pump flow, make sure that the inlet connector is tight and the inlet tubing is in good condition. Connect a flow meter to the gas inlet probe. The flow rate should be above 450 cc/min when there is no air leakage.

If the pump is not working properly, refer the instrument to qualified service personnel for further testing and, if necessary, pump repair or replacement.

Ordering Replacement Parts

If you need replacement parts, contact your local RAE Systems distributor. A list is available online:

http://www.raesystems.com

In the U.S., you can order sensors, replacement batteries, and other accessories online at:

http://istore.raesystems.com/

Special Servicing Note

If the instrument needs to be serviced, contact either:

1. The RAE Systems distributor from whom the instrument was purchased; they will return the instrument on your behalf.
2. The RAE Systems Technical Service Department. Before returning the instrument for service or repair, obtain a Returned Material Authorization (RMA) number for proper tracking of your equipment. This number needs to be on all documentation and posted on the outside of the box in which the instrument is returned for service or upgrade. Packages without RMA Numbers will be refused at the factory.

Troubleshooting

Refer to the User’s Guide for troubleshooting details.

RAE Systems by Honeywell
3775 N. First St.
San Jose, CA 95134-1708 USA

Web: www.raesystems.com

Technical Support

To contact RAE Systems Technical Support Team:

Monday through Friday, 7:00AM to 5:00PM Pacific (US) Time

Phone (toll-free): +1 888-723-4800
Phone: +1 408-952-8461
Email: tech@raesystems.com

PN: 059-4030-000-D
Rev. B August 2010

ProDSS Calibration Guide

a xylem brand

Contents

Introduction 3
Calibration Worksheet 3
Temperature 6
  - Calibration Tips 6
  - Troubleshooting Tips 6
Conductivity 6
  - Calibration Tips 6
  - Troubleshooting Tips 7
pH 8
  - pH Calibration Tips 8
  - pH Troubleshooting Tips 9
ORP 11
  - ORP Calibration Tips 11
  - ORP Troubleshooting Tips 11
Dissolved Oxygen 12
  - DO Calibration Tips 12
  - DO Troubleshooting Tips 13
Turbidity 14
  - Turbidity Calibration Tips 14
  - Turbidity Troubleshooting Tips 15
Depth 17
  - Depth Calibration Tips 17
  - Depth Troubleshooting Tips 17
Ammonium 18
  - Ammonium Calibration Tips 18
  - Ammonium Troubleshooting Tips 20
Nitrate 20
  - Nitrate Calibration Tips 20
  - Nitrate Troubleshooting Tips 22
Chloride 22
  - Chloride Calibration Tips 23
  - Chloride Troubleshooting Tips 24
Installing and Uninstalling Sensors 25
  - General Precautions 25
Cleaning a Sensor Port 26
Verifying Sensor Accuracy and Calibration 26
Resetting a Sensor to Factory Default 26

Introduction

This guide provides helpful instructions, tips and troubleshooting suggestions for calibrating a ProDSS instrument. For more detailed information on calibration and information on how to setup and operate a ProDSS, please refer to the ProDSS User Manual.

Calibration Worksheet

The Calibration Worksheet on the following pages is provided for your convenience. This can help document your calibration and track the performance of your sensors. Please follow the detailed calibration procedures in the ProDSS manual or your facility's standard operating procedure (SOP) to ensure all calibrations are as accurate and as consistent as possible.

Refer to the YSI Solution Expiration Dates document to ensure your calibration solutions are fresh. In addition to using fresh standards, never accept out-of-range or questionable calibration results.

Calibration Date ____________________ ***Technician:*** __________________

Handheld Serial Number: ___________ ***Handheld Software Version:*** _________

Cable Serial Number: _______________

Temperature

Reading when sensor is dry and in room temp air: ________ *Accurate?* ***Y*** ***N***

Conductivity

Reading when sensor is dry and in room temp air: ________ *Acceptable value is less than* ***1 µS/cm***

Actual Reading in solution before calibration is accepted: ________

Reading in calibration solution after calibration is completed: __________

Conductivity Cell Constant in GLP record after calibration:* ________

Acceptable range for ProDSS conductivity/temperature sensors (626902) is ***4.5*** *to* ***6.5***

Acceptable range for integral (i.e. built-in) sensors on ODO/CT assemblies is ***4.4*** *to* ***6.4***

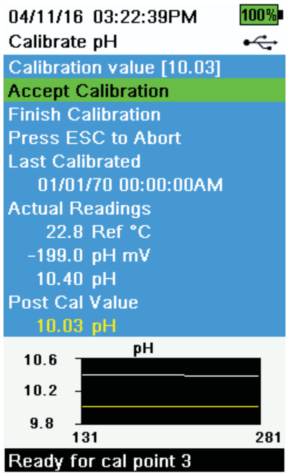
Optical Dissolved Oxygen

Barometric pressure: __________

Actual Reading before DO% calibration is accepted: __________

Reading in DO% calibration environment after calibration is completed: __________

ODO gain in GLP record after calibration: ________ *Acceptable range is* ***0.75*** *to* ***1.50***



04/11/16 03:22:39PM 100%
Calibrate pH
Calibration value [10.03]
Accept Calibration
Finish Calibration
Press ESC to Abort
Last Calibrated
01/01/70 00:00:00AM
Actual Readings
22.8 Ref °C
-199.0 pH mV
10.40 pH
Post Cal Value
10.03 pH
Ready for cal point 3

pH

		Actual Readings during calibration		
Buffer	Calibration Value	pH	pH mV**	Acceptable pH mV in buffer
7				-50 mV to 50 mV
4				+165 to +180 from pH 7 buffer mV value
10				-165 to -180 from pH 7 buffer mV value

pH slope in GLP record after calibration: __________ *Acceptable range is ~* ***55*** *to* ***60*** *pH/mV*
(Ideal is 59.16 mV/pH)

ORP

Actual Reading in solution before calibration is accepted: ________

Reading in calibration solution after calibration is completed: ________

ORP Cal Offset in GLP record after calibration: ________ *Acceptable range is* ***-100*** *to* ***50***

**GLP stands for Good Laboratory Practice file. This calibration record contains important information about the calibration result.*

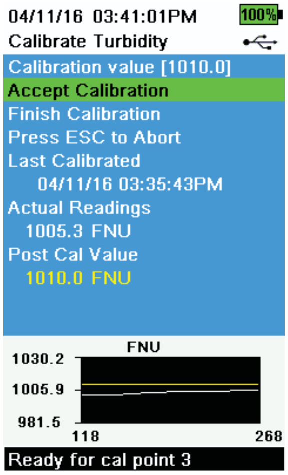
***The pH mV at the time of calibration (Sensor Value) can also be seen in the final pH GLP record.*

Turbidity

Calibration value (FNU)*	Actual Reading during calibration
0	
12.4*	
124*	
1010	

*Acceptable range for **Actual Reading** during calibration of the first point is **-10** to **10** FNU*

***Note:** The turbidity sensor can be calibrated to 3 points. Either 12.4 or 124 FNU standard can be used for the second point, but not both. Other calibration values can be used when calibrating.*


04/11/16 03:41:01PM

Calibrate Turbidity

Calibration value [1010.0]

Last Calibrated 04/11/16 03:35:43PM

Actual Readings 1005.3 FNU

Post Cal Value 1010.0 FNU

Ready for cal point 3

Depth (Completed in Air)

Actual Reading before calibration is accepted:__________

Reading in air after calibration is completed:___________

Ammonium

	Actual Readings during calibration		
Concentration** (i.e. Calibration Value)	mg/L	mV***	Acceptable mV when the sensor is new
1st point: 1 mg/L			-20 mV to 20 mV
2nd point: 100 mg/L			+90 to +130 from mV value in 1 mg/L standard

Nitrate

	Actual Readings during calibration		
Concentration** (i.e. Calibration Value)	mg/L	mV***	Acceptable mV when the sensor is new
1st point: 1 mg/L			180 mV to 220 mV
2nd point: 100 mg/L			-90 to -130 from mV value in 1 mg/L standard

Chloride

	Actual Readings during calibration		
Concentration** (i.e. Calibration Value)	mg/L	mV***	Acceptable mV when the sensor is new
1st point: 10 mg/L			205 mV to 245 mV
2nd point: 1,000 mg/L			-80 to -130 from mV value in 10 mg/L standard

***Other standard concentrations can be used. A 2 point calibration without chilling a third calibration solution is extremely accurate and is the preferred method. However, if there is a large temperature variation during sampling, a chilled third calibration point is recommended.*

****The mV at the time of calibration (Sensor Value) for each point can also be seen in the GLP record after a calibration is complete.*

Temperature

Calibration Tips

Before calibrating any other ProDSS sensor, verify the temperature sensor is reading accurately by comparing it to a traceable thermometer or other known reference in a water bath.

With the exception of the turbidity and TSS, accurate temperature compensation is required for all parameters, so temperature accuracy should be verified and recorded each time the ProDSS is calibrated. Be sure to consider the specification tolerances of both the ProDSS temperature sensor and the thermometer when comparing the measurements.

The ProDSS temperature sensor cannot be calibrated nor should calibration be required.

Troubleshooting Tips

If the temperature sensor is not reading accurately, ensure that it is clean and free of debris. The conductivity cleaning brush and warm water with mild detergent can be used to scrub the temperature sensor if needed. Alternatively, you can use a toothbrush to clean the sensor.

ProDSS 4 port cables feature a replaceable conductivity/temperature sensor (626902), while all other ProDSS cables have integral (i.e. built-in) temperature sensors. If using a ProDSS 4 port cable and your temperature sensor is not reading accurately even after cleaning, remove the conductivity/temperature sensor from the cable and inspect the sensor port and sensor connector for any damage or moisture. Please follow the section on Cleaning a Sensor Port if needed.

Conductivity

The conductivity calibration should be verified every day the instrument is used. However, the conductivity sensor is very stable and may hold its calibration for several weeks.

Calibration Tips

1. It is not necessary to calibrate conductivity, specific conductance and salinity. Calibrating one of these parameters will simultaneously calibrate the others. YSI recommends calibrating specific conductance (temperature compensated conductivity) for greatest ease and accuracy.
2. Ensure the conductivity sensor is clean and dry before performing a specific conductance calibration.
3. Always use fresh, traceable conductivity calibration solution when calibrating the conductivity sensor.
    a. The shelf life of conductivity solution is one month after being opened. This is due to potential changes in the value of the solution caused by evaporation which can occur after opening the bottle. Be sure to write the open date on the bottle so you know that you are using good calibration solution.

   b. Never calibrate with a conductivity solution that is less than 1.0 mS/cm. You are setting the slope on a linear device so a good, strong conductivity signal will give you the best performance. Use 1.0 mS/cm for fresh water, 10 mS/cm for brackish to estuarine water and 50 mS/cm for salt water. Please note that 1.0 mS (millisiemens) = 1000 uS (microsiemens).

4. Pre-rinse the cal cup and sensors with a small amount of calibration standard or rinse standard and discard.
5. The calibration solution must cover the top vent holes of the conductivity sensor. If the entire sensor is not in solution, the instrument will read approximately half the expected value.
   a. If using a ProDSS 4 port cable, the top vent hole is located on the side of the combination conductivity/temperature sensor (i.e. 626902 sensor). Filling the ProDSS calibration cup to line 2 (i.e. the top line) when the cup is empty will ensure the vent hole is covered.

   or

   b. If using the ODO/CT assembly, ensure the vent holes at the top of the sensor are completely immersed and the solution level is at least 1/2 inch higher than these top vent holes.
6. After placing the sensor into the solution, gently move the sensor up and down to remove any air bubbles that may be trapped in the conductivity sensor.
7. If calibrating Specific Conductance, enter the value of the conductivity solution as it is listed for 25 °C. Make sure you are entering the correct units. 1 mS = 1,000 uS.
8. If you receive a warning message stating that the calibration is questionable, do not continue with the calibration. Instead, select 'No' and investigate what is causing the questionable results. If you accept a questionable calibration, your conductivity readings (and your DO mg/L readings) will be erroneous. Typical causes for this error message include: incorrect entries (entering 1000 uS/cm instead of 1.0 mS/cm), not using enough solution to cover the vent holes, air bubbles trapped in the sensor, calibrating in conductivity instead of specific conductance, dirty conductivity electrodes, and/or bad calibration solution.
9. After accepting a good calibration, navigate to the GLP file and check the conductivity cell constant for the calibration. The cell constant should be 5.0 to 6.0 for highest accuracy (4.9 to 5.9 on ODO/CT probe and cable assemblies). However, 4.5 to 6.5 is the acceptable range (4.4 to 6.4 on ODO/CT cables).

Troubleshooting Tips

If you get an error message during calibration, be sure that you are:

1. Entering the correct calibration value (1 mS/cm = 1000 uS/cm).
2. Calibrating in Specific Conductance mode.
3. Using enough solution to cover the vent holes on the sensor.
4. Dislodging any air bubbles that could be trapped in the sensor.
5. Using a fresh, traceable conductivity calibration solution.

If you are following the above recommendations and still receiving an error message, check the conductivity sensor to make sure it is clean. A clean conductivity sensor should read less than 1 uS/cm in dry air. If your sensor is dry and giving you a reading higher than 1 uS/cm in air, it should be cleaned.

Any significant jump or change in the conductivity cell constant from one calibration to the next usually indicates a problem with the calibration and/or sensor. If you are sure that your calibration standard is good and your calibration process is correct, then your sensor may need to be cleaned.

Cleaning the Conductivity Sensor

The openings that allow sample access to the conductivity electrodes should be cleaned regularly. The small cleaning brush included with each new conductivity sensor and cable is intended for this purpose. Dip the brush in clean water and insert it into each hole 10 to 12 times. In the event that deposits have formed on the electrodes, it may be necessary to use a mild detergent (laboratory grade soap or bathroom foaming tile cleaner) with the brush. Rinse thoroughly with clean water, then check the response and accuracy of the conductivity sensor with calibration solution.

Cables with user-replaceable sensors

If using a 4 port cable and your conductivity sensor is not calibrating or is reading > 1 uS/cm in dry air after being cleaned, remove the conductivity/temperature sensor from the cable and inspect the sensor port and sensor connector for any damage or moisture. Please follow the section on Cleaning a Sensor Port if needed.

Cables with integral (i.e. built-in) sensors

If your conductivity sensor is not calibrating or is reading > 1 uS/cm in dry air after performing a sensor cleaning, contact your local YSI Representative or a YSI Authorized Service Center.

pH

The pH calibration should be verified every day the instrument is used. However, a new pH sensor may be capable of holding its calibration for several days.

pH Calibration Tips

1. The pH sensor can be calibrated with up to three calibration points.
2. Calibration can be accomplished in any buffer order.
3. pH 7 buffer should be used regardless of how many calibration points you use; however, it does not have to be the first point.
4. In most cases, a two-point calibration is all that is required (4 and 7 or 7 and 10). You can bracket the expected in-situ pH values. Use a three-point calibration with 4, 7 and 10 if the in-situ pH values are unknown or if you expect the in-situ values to be on both sides of the pH scale.

5. Rinse the sensors and cal cup with a small amount of pH buffer. Fill the cup so that the pH sensor tip and the temperature sensor are submerged in buffer.
6. Calibration values will not have to be entered if using a USA (4, 7, 10) or a NIST (4.01, 6.86, 9.18) buffer set, as the ProDSS will automatically recognize these buffers and will compensate the calibration value for temperature. The buffer set can be changed in the pH Sensor Setup menu.
7. Record the pH millivolts for each calibration point. The acceptable mV outputs for each buffer are shown below.

   pH 7 mV value = 0 mV +/- 50 mV
   pH 4 mV value = +165 to +180 from pH 7 buffer mV value
   pH 10 mV value = -165 to -180 from pH 7 buffer mV value

   - A value of +50 or -50 mVs in buffer 7 does not indicate a bad sensor.
   - The mV span between pH 4 and 7 and 7 and 10 mV values should be ≈ 165 to 180 mV. 177 is the ideal distance. The slope can be 55 to 60 mV per pH unit with an ideal of 59 mV per pH unit.
   - If the mV span between pH 4 and 7 or 7 and 10 drops below 160, clean the sensor and try to recalibrate.
8. Wait for the measurement to stabilize in each buffer and then press Enter to accept each calibration point.
9. Rinse the sensor and cal cup with a small amount of the next buffer between calibration points.
10. If you want to finish calibration after 1 or 2 points, select **Finish Calibration**. Otherwise, the calibration will automatically be completed after accepting the third point in a 3 point calibration.
11. If you receive a warning message stating that the calibration is questionable, do not continue with the calibration. Instead, select 'No' and investigate what is causing the questionable results. If you accept a questionable calibration, your pH readings will be erroneous. Typical causes for this error message include: incorrect buffer set selected, a dirty sensor, or bad buffer solution.
12. After accepting a good calibration, navigate to the GLP file and check the pH Slope and Slope % of ideal. A good slope should be between 55 and 60 mVs while the ideal is 59 mV. If the slope drops below 53, the sensor should be reconditioned and recalibrated.

pH Troubleshooting Tips

Typical working life for pH sensors is approximately 12-24 months depending on usage, storage and maintenance. Proper storage and maintenance generally extends the sensor's working life.

Clean and recondition the sensor if a slow response in the field has been reported or if it takes more than 90 seconds to stabilize in pH buffer.

If you get an error message during a pH calibration, check the following:

1. Ensure the pH buffers are good and not expired.
2. The correct buffer set is enabled.
3. Check for damage to the glass bulb or the electrode body.
4. Ensure the sensor module is installed correctly, especially if it has recently been replaced.
5. If you continue to get error messages during calibration, clean and recondition the sensor.

Cleaning and Reconditioning the pH, ORP or pH/ORP Sensor

If the pH or pH/ORP sensor has been allowed to dry out or has been stored in distilled or deionized water for an extended period of time, soak the sensor in buffer 4 overnight to try and restore functionality.

Cleaning is required whenever deposits or contaminants appear on the glass and/or platinum surfaces or when the sensor's response slows. The cleaning can be chemical and/or mechanical. Removing the sensor from the cable may make cleaning easier. Initially, moisten a soft clean cloth, lens cleaning tissue or cotton swab to remove all foreign material from the glass bulb and/or platinum button. Then use a moistened cotton swab to carefully remove any material that may be blocking the reference electrode junction of the sensor.

CAUTION: When using a cotton swab, be careful NOT to wedge the swab between the guard and the glass sensor. If necessary, remove cotton from the swab tip, so that the cotton can reach all parts of the sensor tip without stress. You can also use a pipe cleaner for this cleaning if more convenient.

If good pH and/or ORP response is not restored, perform the following additional procedure:

1. Soak the sensor for 10-15 minutes in clean water containing a few drops of commercial dishwashing liquid.
2. Rinse the sensor in clean water, wipe with a cotton swab moistened with clean water, and then re-rinse with clean water.

If good pH and/or ORP response is still not restored or if hard deposits have built up on the electrode, perform the following additional procedure:

1. Soak the sensor for ~3 minutes in one molar (1 M) hydrochloric acid (HCl). This reagent can be purchased from most lab supply distributors. Be sure to follow the safety instructions included with the acid. Vinegar can also be used, but will require a longer period of soaking.
2. Rinse the sensor in clean water, wipe with a cotton swab moistened with clean water (not DI water), and then re-rinse with clean water. To be certain that all traces of the acid are removed from the sensor crevices, soak the sensor in clean tap water for about an hour with occasional stirring.

If biological contamination of the reference junction is suspected or if good response is not restored by the above procedures, perform the following additional cleaning step:

CAUTION: Do not mix the acid from the previous step with the chlorine bleach in the following step. A toxic gaseous product can form from the reaction between the acid and the chlorine bleach. Be certain to copiously rinse the sink and drain system of acid after its disposal and before the disposal of chlorine bleach.

1. Soak the sensor for approximately 1 hour in a 1:1 dilution of commercially available chlorine bleach.
2. Rinse the sensor with clean water and then soak for at least 1 hour in clean tap water with occasional stirring to remove residual bleach from the junction. (If possible, soak the sensor for a period of time longer than 1 hour in order to be certain that all traces of chlorine bleach are removed.) Then re-rinse the sensor with clean water and retest.

Prior to reinstalling the sensor, dry the port and sensor connector with compressed air. If you suspect port contamination, follow the instructions in the Cleaning a Sensor Port section of this document before reinstalling the sensor.

If your pH sensor is still not calibrating after performing a sensor cleaning, contact your local YSI Representative or a YSI Authorized Service Center.

ORP

The ORP calibration should be verified every day the instrument is used. However, a new ORP sensor may be capable of holding its calibration for several days.

ORP Calibration Tips

1. If using a pH/ORP combination sensor, calibrate pH first to ensure it is working.
2. Rinse the sensors and cal cup with a small amount of ORP calibration solution. Fill the cup so that the ORP sensor tip and the temperature sensor are submerged in solution.
3. If using YSI Zobell calibration solution, the ProDSS will automatically adjust the calibration value based on temperature. Otherwise, the Calibration value can be manually adjusted.
4. Wait for the readings to stabilize and then press Enter to accept the calibration.
5. If you receive a warning message stating that the calibration is questionable, do not continue with the calibration. Instead, select 'No' and investigate what is causing the questionable results. If you accept a questionable calibration, your ORP readings will be erroneous. Typical causes for this error message include a dirty sensor or bad calibration solution.

ORP Troubleshooting Tips

Typical working life for ORP sensors is approximately 12-24 months depending on usage, storage and maintenance. Proper storage and maintenance generally extends the sensor's working life.

Clean and recondition the sensor if the sensor exhibits a slow response in Zobell solution, i.e. it takes more than 90 seconds to stabilize when placed in Zobell.

If you get error messages during an ORP calibration, check the following:

1. Ensure the ORP calibration solution is good and not expired.
2. If you continue to get error messages during calibration, clean and recondition the sensor per the instructions in the pH Troubleshooting section of this document. If you suspect port contamination, follow the instructions in the Cleaning a Sensor Port section before reinstalling the sensor.
3. If you continue to have problems, you can check the offset of the ORP sensor by performing a factory reset to the ORP sensor. After resetting the sensor, compare the ORP mV readings in Zobell solution to the calibration value. The difference between values should be less than 100 mVs. If the difference is 80 mVs or higher, consider replacing the sensor as it is nearing the end of its life span.

Dissolved Oxygen

The dissolved oxygen sensor should be calibrated every day the instrument is used. It is not necessary to calibrate in both % and mg/L or ppm. Calibrating in % will simultaneously calibrate mg/L and ppm and vice versa.

DO Calibration Tips

1. The ProDSS optical DO sensor can be calibrated in air-saturated water, water-saturated air or against a Winkler Titration. You can perform a 1 or 2 point DO calibration. A 2 point calibration includes 1 point in a zero oxygen environment and the 2nd point at full saturation.
2. For both ease of use and accuracy, YSI recommends that you perform a 1 point calibration in water-saturated air.
3. Make sure that there is a good optical DO sensor cap installed. The cap should not be scratched or excessively dirty. Caps should be changed as needed (15-18 month expected life for caps with a 1 year warranty).
4. To perform a 1 point calibration in water-saturated air, place the sensor in a 100% humid environment. This can be accomplished several ways:
    a. For the ProDSS 4 port cables, place a small amount of water in the calibration/storage cup and place it over the sensors and sensor guard. ***Partially*** tighten the locking ring on the calibration cup to the bulkhead. The goal is to have air exchange between inside and outside the calibration cup.
    b. For the ProDSS ODO/CT (627150) or ProODO (626250) cables, moisten the sponge in the gray calibration sleeve with a small amount of clean water and place it over the sensor guard.
5. The sponge and calibration sleeve/cup should be clean since bacterial growth may consume oxygen and interfere with the calibration. Be sure the sensor is in air, not water, and that there are not any water droplets on the sensor cap or temperature sensor.

6. After entering the % calibration mode, wait approximately 5 to 10 minutes for the storage container to become completely saturated.
7. Salinity affects the ability of water to hold oxygen and is used by the instrument to calculate DO mg/L (ppm). The Salinity value displayed near the top of the DO calibration screen is either the salinity correction value entered in the Sensor menu or the Salinity value as measured by the conductivity sensor in use. If you are using a conductivity sensor, ensure that it is calibrated and reading correctly in order to obtain accurate DO mg/L (ppm) measurements. If you are not using a conductivity sensor, the Salinity correction value should be the salinity of the water you will be testing. Press the Probe key, highlight Salinity, and press Enter to modify this setting if necessary. The salinity of fresh water is typically 0-0.5 ppt and seawater is typically 35 ppt.
8. If you receive a warning message stating that the calibration is questionable, do not continue with the calibration. Instead, select 'No' and investigate what is causing the questionable results. If you accept a questionable calibration, your DO readings will be erroneous. Typical causes of a calibration error message include a dirty and/or bad sensor cap or a sensor that needs reconditioned.

DO Troubleshooting Tips

1. Ensure the ProDSS barometer is reading accurately. The DO % Saturation calibration uses the instrument's barometric pressure reading for the DO % calibration. If the barometer is not reading accurately, the calibration will be erroneous. The barometer should be reading true barometric pressure. If you suspect the barometer reading is incorrect, calibrate the barometer and then recalibrate the DO sensor. Laboratory barometer readings are usually "true" (uncorrected) values of air pressure and can be used "as is" for barometer calibration. Weather service readings are usually not "true", i.e., they are corrected to sea level, and therefore cannot be used until they are "uncorrected". An approximate formula for this "uncorrection" is: True BP in mmHg = Corrected BP in mmHg – [2.5 * (Local Altitude in ft. above sea level/100)]
2. Clean the ODO sensor cap and rehydrate it if needed.
3. If you have changed the sensor cap, ensure the sensor cap coefficients have correctly been entered. These can be seen under Sensor Setup on the handheld, or within KorDSS.
4. If you suspect port contamination, remove the sensor and follow the instructions in the Cleaning a Sensor Port section.
5. If you continue to have trouble calibrating the DO sensor, contact your local YSI Representative or a YSI Authorized Service Center.

ODO Sensor Cap Replacement

The sensor cap should be replaced about once per year for those with a 1 year warranty, but the cap may last longer. It should also be replaced if it is cracked or damaged.

The instructions for replacing the sensor cap on ProDSS ODO sensors (626900) are different than the instructions for integral (i.e. built-in) ODO sensors on ODO/CT (627150) and ProODO (626250) cable assemblies, so ensure the correct directions are being followed when replacing the sensor cap. Each replacement ODO sensor cap is shipped in a humidified container and the package should not be opened until immediately before sensor cap replacement.

The instruction sheet shipped with the replacement ODO sensor cap includes the calibration coefficients specific to your sensor cap. Make sure to save this instruction sheet in case you need to reload the calibration coefficients. ***These coefficients must be entered whenever the sensor cap has been replaced.*** Coefficients can be entered using the ProDSS handheld (under ODO Sensor Setup) or KorDSS (under the Instrument and Sensors tab).

Cleaning the ODO Sensor Cap

The sensor cap should be kept clean since some types of fouling may consume oxygen which could affect the dissolved oxygen measurements. To clean the sensor cap, gently wipe away any fouling with a lens cleaning tissue that has been moistened with water.

Caution: Do not use organic solvents to clean the sensor cap. Using an organic solvent to clean the sensor cap may cause permanent damage to the cap. For example, alcohol will dissolve the outer paint layer and other organic solvents will likely dissolve the dye in the cap.

Rehydrating the ODO Sensor Cap

To prevent sensor drift, always store the ODO sensor in a wet or water-saturated air environment. If the ODO sensor has accidentally been left dry for longer than 8 hours, it must be rehydrated.

If rehydration is necessary, soak the ODO sensor cap in warm (room temperature) tap water for approximately 24 hours. After the soak, calibrate the sensor.

Turbidity

The turbidity calibration should be verified every day the instrument is used. However, the turbidity sensor is very stable and may hold its calibration for several weeks.

Turbidity Calibration Tips

1. For proper calibration, you must use standards that have been prepared according to details in Standard Methods for the Treatment of Water and Wastewater (Section 2130 B). Standards from other vendors are NOT approved, and their use will likely result in a bad calibration and incorrect field readings. Acceptable standards include:
    - AMCO-AEPA standards prepared specifically for the ProDSS turbidity sensor manufactured by YSI (i.e. YSI turbidity standards)
    - Formazin prepared according to Standard Methods, especially for calibration points greater than 1010
    - Dilutions of 4000 FNU (NTU) formazin concentrate purchased from Hach
    - Hach StablCal™ standards in various FNU (NTU) denominations
2. It is important to use the same type of standard for all calibration points (i.e. do not mix formazin and AMCO-AEPA standard for different points in a multi-point calibration).
3. The ProDSS turbidity sensor can be calibrated by using up to three calibration points by using the following limits:

- 1st calibration point: 0-1 FNU (NTU) (see Preventing Negative Turbidity Readings).
- 2nd calibration point: 5-200 FNU (NTU)
- 3rd calibration point: 400-4200 FNU (NTU)

4. DI water can be used for the first calibration point (see Preventing Negative Turbidity Readings)
5. The ProDSS calibration cup and sensor guard ***must*** be used (and correctly installed!) when calibrating. The sensor guard must be installed when taking any measurements.
6. The sensor guard has a metal bottom that is painted black. Ensure the inside surface (i.e. the surface that faces the sensor tip) is not significantly scratched. This surface needs to be black to eliminate any stray light reflection. Also ensure the sensor guard and calibration cup are free of any reflective material.
7. Pour standard slowly down the side of the calibration container so you do not aerate the sample. This will reduce the possibility of air bubbles becoming trapped on the surface of the sensor.
8. Slowly place the turbidity sensor into the calibration cup when the cup is tilted at a 45 degree angle, as this will help prevent air bubbles from being caught on the sensor surface.
9. Wait for the turbidity measurement to stabilize in each standard and then press Enter to accept each calibration point.
10. Rinse the sensor and cal cup with a small amount of the next standard between calibration points.
11. If you want to finish calibration after accepting 1 or 2 points, select **Finish Calibration**. Otherwise, the calibration will automatically be completed after accepting the third point in a 3 point calibration.
12. If you receive a warning message stating that the calibration is questionable, do not continue with the calibration. Instead, select 'No' and investigate what is causing the questionable results. If you accept a questionable calibration, your turbidity readings will be erroneous. Typical causes for this error message include a dirty sensor or bad standard solution.

Turbidity Troubleshooting Tips

The ProDSS turbidity sensor has a two year warranty and there are no replaceable components (e.g. no optical sensor cap). Proper storage and maintenance will help extend the sensor's life.

If you get error messages during a turbidity calibration, check the following:

1. Ensure the standard solutions are good and not expired.
2. The calibration environment (e.g. calibration cup, sensor guard, and sensors) should be clean. See Preventing Negative Turbidity Readings if having issues with negative turbidity readings.
3. There should not be any reflective material on the sensor guard and calibration cup. The metal sensor guard bottom (inside; faces the sensors) should be free of any scratches.
4. If you suspect port contamination, remove the sensor and follow the instructions in the Cleaning a Sensor Port section.
5. If you continue to have trouble calibrating the turbidity sensor, contact your local YSI Representative or a YSI Authorized Service Center.

Cleaning the Turbidity Sensor

Clean the sensing window with a non-abrasive, lint-free cloth. This should be done carefully to prevent scratches. If necessary, use mild soapy water.

Preventing Negative Turbidity Readings

A negative turbidity reading is almost always connected to the 'zero' standard. Despite best practices, it is sometimes impossible to clean the sensors, calibration cup, and sensor guard to a point where the 'zero' standard will not be contaminated by some small amount.

A brand new instrument can contaminate a zero standard to ~0.1 FNU, even in a lab environment. Cleaned but used ProDSS sensors, calibration cup, and sensor guard can contaminate a zero standard to almost 1.0 FNU.

As an example, if a Calibration Value of zero is entered, but the actual reading in the 'zero' standard is 0.6 FNU, then a ProDSS turbidity sensor in a 0.3 FNU environment will display a measurement of -0.3 FNU.

Since the 'zero' calibration environment may not be 0 FNU due to contaminated standard, dirty sensors, dirty calibration cup, and/or dirty sensor guard, a Calibration Value from 0 to 1 FNU can be entered.

The following tips can help eliminate negative turbidity readings:

1. Use a calibration cup and sensor guard that is exclusively used for calibration. Calibration cups and sensor guards can easily become contaminated over time, especially if the instrument is used to measure in dirty samples and/or field conditions.
2. In cases where the equipment is properly cleaned and serviced, the level of contamination of the zero turbidity standard is quite small. Typically the average contaminant level ranges from 0.2 to 0.8 NTU. Knowing this, you can pick a number between these points (0.5) and enter this as the first calibration point.
3. Calibrating turbidity is best done in a lab environment; calibrations in the field can result in errors.
4. The only true way to determine if your zero standard is being contaminated is to analyze the zero solution with a laboratory turbidimeter.

Depth

The depth calibration is very easy to perform and should be completed every time the instrument is used to take depth measurements.

Depth Calibration Tips

1. Input a Depth Offset, Altitude, or Latitude under Sensor Setup if desired. Entering a value for these is not required to complete a calibration.
    a. **Depth offset**: Depth offset can be used if referencing water elevation against a known datum. If a depth offset is entered (in meters), the output value will shift by the value of the offset. The most common offset entered is 0.272 meters, as this is the distance from the depth sensor on 4 port cables to the sensor tips.
    b. **Altitude** and **Latitude**: To compensate for atmospheric pressure based on elevation and gravitational pull, enter the local altitude in meters relative to sea level and latitude in degrees where the ProDSS is sampling. This will ensure highest accuracy, although the altitude and latitude effects are relatively small. ***Varying altitudes*** cause approximately 90 mm change from sea level to 8000 m. A 100 m change causes 1.08 mm of change to the readings. ***Varying latitudes*** cause a 200 mm change in depth from equator to pole.
2. Ensure the depth sensor is clean and in air, not immersed in any solution.
3. For highest accuracy, keep the bulkhead still and in one position while calibrating. The holes on the side of the depth sensor should not be covered.
4. The Calibration Value will be set at zero even if a depth offset is entered. There is no need to change this as long as you're calibrating in air.
5. Wait for the depth measurement to stabilize and then press Enter to accept the calibration. Only a 1 point calibration can be completed.
6. If you receive a warning message stating that the calibration is questionable, do not continue with the calibration. Instead, select 'No' and investigate what is causing the questionable results. If you accept a questionable calibration, your depth readings will be erroneous. Typical causes of a calibration error message include dirty ports on the side of the depth sensor, not waiting for stable measurements before accepting the calibration, moisture in the depth ports, and/or covering the depth ports with your hand during calibration.

Depth Troubleshooting Tips

The YSI ProDSS depth sensor measures virtually vented depth. This type of measurement allows for real time compensation for atmospheric pressure using the instrument's internal barometer. A major advantage to this type of depth sensor is there is no vented cable, tube or desiccant to worry about. Some troubleshooting tips include:

1. The ports on the side of the depth sensor should not be covered during calibration and should be free of any debris. These ports can be cleaned with the syringe included with the maintenance kit. When cleaning, fill the syringe with clean water and gently force water into one of the ports. Flush until clean water flows from the opposite depth port.

2. A sensor guard weight installed at the end of the sensor guard can help keep the bulkhead stable when sampling at depth. Up to 5 lbs of YSI stackable sensor guard weights can be installed.
3. Enable Vertical Position under Depth Display to view the real-time position of the depth sensor in the water column. This is helpful in profiling applications to ensure the depth sensor is lowered to the desired depth without waiting for the depth data to stabilize.

Ammonium

The ammonium sensor should be calibrated every day the instrument is used. The ammonium sensor should only be used in fresh water (salinity < 2 ppt) and to depths of 55 feet (17 meters) of water.

Ammonia is calculated from the ammonium, temperature and pH readings. pH greatly affects the ammonia calculation. Therefore, for highest accuracy in the ammonia calculation, be sure to use a pH sensor in conjunction with an ammonium sensor during measurements. If a pH sensor is not in use, the instrument will assume the sample is neutral (pH 7) for the calculation.

Ammonium Calibration Tips

1. Exposure to the high ionic content of pH buffers can cause a significant, but temporary, drift in the ammonium sensor. Therefore, if calibrating a pH sensor, either:
    a. Remove the ammonium sensor from the cable bulkhead and plug the port. After pH calibration is complete, reinstall the ammonium sensor and proceed with its calibration with no stabilization delay.

    or

    b. Calibrate pH first, immersing both sensors in the pH buffers. After calibrating pH, place the sensors in 100 mg/L ammonium standard and monitor the reading. Usually, the reading starts low and may take awhile to reach a stable value. When it does, proceed with the calibration. This may take several hours.
2. The ammonium sensor can be calibrated with up to three calibration points. For highest accuracy, perform a two point calibration with 1 and 100 mg/L standards within 10 °C of your sample temperature.
3. Rinse the sensors and cal cup with a small amount of ammonium solution (1 mg/L for the first point and 100 mg/L for the second point). Fill the cup so that the ammonium sensor tip and the temperature sensor are submerged in solution. Ensure the conductivity sensor is also submerged in the calibration solution. The salinity reading from the conductivity sensor is used in the algorithm for the ammonium measurement.
4. After entering the calibration screen, change the calibration value if necessary.
5. Record the NH_4 millivolts for each calibration point. The acceptable mV outputs for each calibration solution are shown below.
    - NH_4 1 mg/L = 0 mV +/- 20 mV (new sensor only)
    - NH_4 100 mg/L = 90 to 130 mV from 1 mg/L mV value
    - The mV span between 1 mg/L and 100 mg/L values should be ≈ 90 to 130 mV. The slope should be 45 to 65 mV per decade.

6. Wait for the ammonium and temperature readings to stabilize in each calibration solution and then press Enter to accept each calibration point.
7. Rinse the sensor and cal cup between calibration points with a small amount of the next standard.
8. After pressing Enter to accept the second calibration point, highlight **Finish Calibration** and press Enter to complete the calibration. Otherwise, you can continue calibrating with a third calibration point (see the ProDSS User Manual for more information on a chilled third calibration point).
9. If you receive a warning message stating that the calibration is questionable, do not continue with the calibration. Instead, select 'No' and investigate what is causing the questionable results. If you accept a questionable calibration, your ammonium and ammonia readings will be erroneous. Typical causes for this error message include a dirty sensor or bad standard solution.

Preparing Ammonium Calibration Solutions

We recommend using YSI calibration solutions whenever possible. However, qualified users can save cost by following the following recipes for 1 and 100 mg/L standards. Other concentrations can be made by altering the amount of ammonium chloride. All other ingredient concentrations should remain unchanged. It is important to note that some of these chemicals are hazardous and therefore, the standards should only be prepared by qualified chemists in laboratories where proper safety precautions are possible. It is the responsibility of the user to obtain and study the MSDS for each chemical and to follow the required instructions with regard to handling and disposal of these materials.

You will need: solid Ammonium Chloride or a certified 100 mg/L NH_4^+-N standard solution from a supplier, Lithium Acetate Dihydrate, concentrated hydrochloric acid, high purity water, a good quality analytical balance, a 1000 mL volumetric flask, accurate volumetric measuring devices for 100 mL and 10 mL of solution, and a 1000 mL glass or plastic storage vessels. (*Caution*: Hydrochloric acid is highly corrosive and toxic and should therefore be handled with extreme care in a well-ventilated fume hood. The user could also add the equivalent amount of a less-hazardous, more dilute sample of the acid if preferred.)

100 mg/L Standard: Accurately weigh 0.3817 g of ammonium chloride and transfer quantitatively into a 1000 mL volumetric flask. Add 2.6 g of lithium acetate dihydrate to the flask. Add approximately 500 mL of distilled or deionized water to the flask, swirl to dissolve all of the reagents and then dilute to the volumetric mark with distilled or deionized water. Mix well by repeated inversion and then transfer the 100 mg/L standard to a storage bottle. Add 3 drops of concentrated hydrochloric acid to the bottle, then seal and agitate to assure homogeneity. Alternatively, 100 mL of certified 100 mg/L NH_4^+-N standard can be used in place of the solid ammonium chloride.

1 mg/L Standard: Accurately measure 10.0 mL of the above 100 mg/L standard solution into a 1000 mL volumetric flask. Add 2.6 g of lithium acetate dihydrate to the flask. Add approximately 500 mL of distilled or deionized water, swirl to dissolve the solid reagents and then dilute to the volumetric mark with water. Mix well by repeated inversion and then transfer the 1 mg/L standard to a storage bottle. Add 3 drops of concentrated hydrochloric acid to the bottle, then seal and agitate to assure homogeneity.

Ammonium Troubleshooting Tips

Typical working life for ammonium sensors is approximately 3-6 months depending on use, storage and maintenance. Proper storage and maintenance generally extends the sensor's working life.

If you get error messages during an ammonium calibration, check the following:

1. Ensure the ammonium solutions are good and not expired.
2. Clean the sensor.
3. If you continue to get error messages during calibration, soak the sensor in 100 mg/L ammonium standard for several hours or overnight.
4. If you suspect port contamination, follow the instructions in the Cleaning a Sensor Port section.
5. If you continue to have trouble calibrating the ammonium sensor, contact your local YSI Representative or a YSI Authorized Service Center.

Cleaning the Ammonium Sensor

The ammonium sensor uses a PVC membrane. As always, when handling a sensor, care should be taken to avoid damaging the membrane. After extensive use, the membranes may become coated with a deposit or scoured with fine scratches which may cause a slow or reduced response (low slope) or unstable readings. Deposits may be removed with a fine jet of deionized water or rinsing in alcohol followed by soaking in 100 mg/L ammonium calibration standard.

The sensor may require soaking in the high ammonium calibration solution to recover its performance. Soak in 100 mg/L for several hours or overnight.

Nitrate

The nitrate sensor should be calibrated every day the instrument is used. The nitrate sensor should only be used in fresh water (salinity < 2 ppt) and to depths of 55 feet (17 meters) of water.

Nitrate Calibration Tips

1. Exposure to the high ionic content of pH buffers can cause a significant, but temporary, drift in the nitrate sensor. Therefore, if calibrating a pH sensor, either:
    a. Remove the nitrate sensor from the cable bulkhead and plug the port. After pH calibration is complete, reinstall the nitrate sensor and proceed with its calibration with no stabilization delay.

    or

    b. Calibrate pH first, immersing both sensors in the pH buffers. After calibrating pH, place the sensors in 100 mg/L nitrate standard and monitor the reading. Usually, the reading starts low and may take awhile to reach a stable value. When it does, proceed with the calibration. This may take several hours.
2. The nitrate sensor can be calibrated with up to three calibration points. For highest accuracy, perform a two point calibration with 1 and 100 mg/L standards within 10 °C of your sample temperature.

3. Rinse the sensors and cal cup with a small amount of nitrate solution (1 mg/L for the first point and 100 mg/L for the second point). Fill the cup so that the nitrate sensor tip and the temperature sensor are submerged in solution. Ensure the conductivity sensor is also submerged in the calibration solution. The salinity reading from the conductivity sensor is used in the algorithm for the nitrate measurement.
4. After entering the calibration screen, change the calibration value if necessary.
5. Record the NO_3^- millivolts for each calibration point. The acceptable mV outputs for each calibration solution are shown below.
    - NO_3^- 1 mg/L = 200 mV +/- 20 mV (new sensor only)
    - NO_3^- 100 mg/L = -90 to -130 mV from 1 mg/L mV value
    - The mV span between 1 mg/L and 100 mg/L values should be ≈ 90 to 130 mV. The slope should be -45 to -65 mV per decade.
6. Wait for the nitrate and temperature readings to stabilize in each calibration solution and then press Enter to accept each calibration point.
7. Rinse the sensor and cal cup between calibration points with a small amount of the next standard.
8. After pressing Enter to accept the second calibration point, highlight **Finish Calibration** and press Enter to complete the calibration. Otherwise, you can continue calibrating with a third calibration point (see the ProDSS User Manual for more information on a chilled third calibration point).
9. If you receive a warning message stating that the calibration is questionable, do not continue with the calibration. Instead, select 'No' and investigate what is causing the questionable results. If you accept a questionable calibration, your nitrate readings will be erroneous. Typical causes for this error message include a dirty sensor or bad standard solution.

Preparing Nitrate Calibration Solution

We recommend using YSI calibration solutions whenever possible. However, qualified users can save cost by following the following recipes for 1 and 100 mg/L nitrate standards. Other concentrations can be made by altering the amount of potassium nitrate. All other concentrations should remain unchanged. It is important to note that some of these chemicals are hazardous and therefore, the standards should only be prepared by qualified chemists in laboratories where proper safety precautions are possible. It is the responsibility of the user to obtain and study the MSDS for each chemical and to follow the required instructions with regard to handling and disposal of these materials.

You will need: Solid Potassium Nitrate or a certified 1000 mg/L NO_3^--N from a supplier, Magnesium Sulfate, high purity water, good quality analytical balance, 1000 mL volumetric flask, accurate volumetric measuring devices for 100 mL, 10 mL and 1 mL of solution, and 1000 mL glass or plastic storage vessels.

<u>100 mg/L standard:</u> Accurately weigh 0.7222 g of anhydrous potassium nitrate and transfer quantitatively into a 1000 mL volumetric flask. Add 1.0 g of anhydrous magnesium sulfate to the flask. Add approximately 500 mL of water to the flask, swirl to dissolve all of the reagents, and then dilute to the volumetric mark with distilled or deionized water. Mix well by repeated

inversion and then transfer the 100 mg/L standard to a storage bottle. Rinse the flask extensively with water prior to its use in the preparation of the 1 mg/L standard. Alternatively, 100 mL of certified 1000 mg/L NO_3^--N standard can be used in place of the solid potassium nitrate.

1 mg/L standard: Accurately measure 10.0 mL of the above 100 mg/L standard solution into a 1000 mL volumetric flask. Add 1.0 g of anhydrous magnesium sulfate to the flask. Add approximately 500 mL of distilled or deionized water, swirl to dissolve the solid reagents, and then dilute to the volumetric mark with water. Mix well by repeated inversion and then transfer the 1 mg/L standard to a storage bottle.

Recipes are given for 1 and 100 mg/L. Other concentrations can be made by altering the amount of potassium nitrate. All other concentrations should remain unchanged.

Nitrate Troubleshooting Tips

Typical working life for nitrate sensors is approximately 3-6 months depending on use, storage and maintenance. Proper storage and maintenance generally extends the sensor's working life.

If you get error messages during a nitrate calibration, check the following:

1. Ensure the nitrate solutions are good and not expired
2. Clean the sensor.
3. If you continue to get error messages during calibration, soak the sensor in 100 mg/L nitrate standard for several hours or overnight.
4. If you suspect port contamination, follow the instructions in the Cleaning a Sensor Port section.
5. If you continue to have trouble calibrating the nitrate sensor, contact your local YSI Representative or a YSI Authorized Service Center.

Cleaning and Reconditioning the Nitrate Sensor

The nitrate sensor uses a PVC membrane. As always, when handling a sensor, care should be taken to avoid damaging the membrane. After extensive use the membranes may become coated with a deposit or scoured with fine scratches which may cause a slow or reduced response (low slope) or unstable readings. Deposits may be removed with a fine jet of deionized water or rinsing in alcohol followed by soaking in 100 mg/L nitrate calibration standard.

The sensor may require soaking in the high nitrate calibration solution to recover its performance. Soak in 100 mg/L for several hours or overnight.

Chloride

The chloride sensor should be calibrated every day the instrument is used. The chloride sensor should only be used in fresh water (salinity < 2 ppt) and to depths of 55 feet (17 meters) of water.

Chloride Calibration Tips

1. Exposure to the high ionic content of pH buffers can cause a significant, but temporary, drift in the chloride sensor. Therefore, if calibrating a pH sensor, either:
    a. Remove the chloride sensor from the cable bulkhead and plug the port. After pH calibration is complete, reinstall the chloride sensor and proceed with its calibration with no stabilization delay.

    or

    b. Calibrate pH first, immersing both sensors in the pH buffers. After calibrating pH, place the sensors in 1,000 mg/L chloride standard and monitor the reading. Usually, the reading starts low and may take awhile to reach a stable value. When it does, proceed with the calibration. This may take several hours.
2. The chloride sensor can be calibrated with up to three calibration points. For highest accuracy, perform a two point calibration with 10 and 1000 mg/L standards within 10 °C of your sample temperature.
3. Rinse the sensors and cal cup with a small amount of chloride solution (10 mg/L for the first point and 1,000 mg/L for the second point). Fill the cup so that the chloride sensor tip and the temperature sensor are submerged in solution. Ensure the conductivity sensor is also submerged in the calibration solution. The salinity reading from the conductivity sensor is used in the algorithm for the chloride measurement.
4. After entering the calibration screen, change the calibration value if necessary.
5. Record the Cl millivolts for each calibration point. The acceptable mV outputs for each calibration solution are shown below.
    - Cl 10 mg/L = 225 mV +/- 20 mV (new sensor only)
    - Cl 1,000 mg/L = -80 to -130 mV from 10 mg/L mV value
    - The mV span between 10 mg/L and 1000 mg/L values should be ≈ 80 to 130 mV. The slope should be -40 to -65 mV per decade.
6. Wait for the chloride and temperature readings to stabilize in each calibration solution and then press Enter to accept each calibration point.
7. Rinse the sensor and cal cup between calibration points with a small amount of the next buffer.
8. After pressing Enter to accept the second calibration point, highlight **Finish Calibration** and press Enter to complete the calibration. Otherwise, you can continue calibrating with a third calibration point (see the ProDSS User Manual for more information on a chilled third calibration point).
9. If you receive a warning message stating that the calibration is questionable, do not continue with the calibration. Instead, select ‘No’ and investigate what is causing the questionable results. If you accept a questionable calibration, your chloride readings will be erroneous. Typical causes for this error message include a dirty sensor or bad standard solution.

Preparing Chloride Standards

The following recipes are provided for preparation of 10 and 1000 mg/L chloride reagents.

It is important to note that some of the chemicals required for these solutions could be hazardous under some conditions. It is the responsibility of the user to obtain and study the MSDS for each chemical and to follow the required instructions with regard to handling and disposal of these chemicals.

You will need: Solid sodium chloride or a certified 1000 mg/L chloride solution from a supplier, magnesium sulfate, high purity water, a good quality analytical balance, 1000 mL volumetric flask, an accurate 10 mL measuring devices, and 1000 mL glass or plastic storage vessels.

1000 mg/L standard: Accurately weigh 1.655 grams of anhydrous sodium chloride and transfer into a 1000 mL volumetric flask. Add 0.5 grams of anhydrous magnesium sulfate to the flask. Add 500 mL of distilled or deionized water to the flask, swirl to dissolve all of the reagents, and then dilute to the volumetric mark with water. Mix well by repeated inversion and then transfer the 1000 mg/L standard to a storage bottle. Rinse the flask extensively with water prior to its use in the preparation of the 10 mg/L standard. Alternatively, simply add 0.5 grams of magnesium sulfate to a liter of a 1000 mg/L chloride standard from a certified supplier.
10 mg/L standard: Accurately measure 10 mL of the above 1000 mg/L standard solution into a 1000 mL volumetric flask. Add 0.5 grams of anhydrous magnesium sulfate to the flask. Add 500 mL of distilled or deionized water, swirl to dissolve the solid reagents, and then dilute to the volumetric mark with water. Mix well by repeated inversion and then transfer the 10 mg/L standard to a storage bottle.

Chloride Troubleshooting Tips

Typical working life for chloride sensors is approximately 3-6 months depending on use, storage and maintenance. Proper storage and maintenance generally extends the sensor’s working life.

If you get error messages during a chloride calibration, check the following:

1. Ensure the chloride solutions are good and not expired
2. Clean the sensor.
3. If you continue to get error messages during calibration, soak the sensor in 1000 mg/L chloride standard for several hours or overnight.
4. If you suspect port contamination, follow the instructions in the Cleaning a Sensor Port section.
5. If you continue to have trouble calibrating the chloride sensor, contact your local YSI Representative or a YSI Authorized Service Center.

Cleaning and Reconditioning the Chloride Sensor

The chloride sensor is considered a pellet membrane ISE. As always, when handling sensors, care should be taken to avoid damaging the membrane. This sensor can be regenerated by washing with alcohol and/or gently polishing with fine emery paper in a circular motion to remove any deposits or discoloration, then thoroughly washing with deionized water to remove any debris.

The sensor may require soaking in the high chloride calibration solution to recover its performance. Soak in 1000 mg/L for several hours or overnight.

Installing and Uninstalling Sensors

General Precautions

It is important that the entire sensor connector and cable connector be dry when installing, removing or replacing sensors. This will prevent water from entering the port. Once a sensor is removed, examine the connector inside the port. If any moisture is present, use compressed air to completely dry the connector or place directly in front of a steady flow of fresh air. If you suspect port contamination, follow the port cleaning procedures listed under Cleaning a Sensor Port.

Remove sensors with the sensor tips facing the ground to help prevent water from entering the port upon removal.

The instrument utilizes o-rings as seals to prevent water from entering the sensor ports. When the sensors are removed, the o-rings that provide the seal should be carefully inspected for contamination (e.g. debris, grit, etc.) and cleaned if necessary.

If no dirt or damage to the o-rings is evident, wipe the o-rings with a lint free cloth or lens cloth to remove the old o-ring grease. Then, lightly apply new o-ring grease (provided in the maintenance kit) to the o-rings without removing them from their groove. If there is any indication of damage, the o-ring should be replaced with an identical o-ring. At the time of o-ring replacement, the entire o-ring assembly should be cleaned.

Do not over-grease the o-rings. The purpose of the o-ring grease it to keep the o-ring in good condition. Excess grease may collect grit particles that can compromise the seal. Excess grease can also cause the waterproofing capabilities of the o-ring to diminish, potentially causing leaks. If excess grease is present, remove it using a lens cloth or lint-free cloth.

To remove the o-rings:
Use a small, flat-bladed screwdriver or similar blunt-tipped tool to remove the o-ring from its groove. Do not use a sharp object to remove the o-rings. Using a sharp object could damage the o-ring groove which would allow water to enter the port resulting in permanent damage to the port and sensor. Check the o-ring and the groove for any excess grease or contamination. If contamination is evident, clean the o-ring and the portion of the titanium sensor where the o-ring fits with lens cleaning tissue or equivalent lint-free cloth. Alcohol can be used to clean the titanium sensor, but use only water and mild detergent on the o-ring itself. Using alcohol on o-rings may cause a loss of elasticity and may promote cracking. Also, inspect the o-rings for nicks and imperfections.

Before re-installing the o-rings, make sure to use a clean workspace, clean hands, and avoid contact with anything that may leave fibers on the o-ring or grooves. Even a very small amount of contamination (hair, grit, etc.) may cause a leak.

To re-install the o-rings:

Place a small amount of o-ring grease between your thumb and index finger. Draw the o-ring through the grease while pressing the fingers together to place a very light covering of grease to the o-ring. Place the o-ring into its groove making sure that it does not twist or roll. Do not excessively stretch the o-ring during installation.

Use your grease-coated finger to once again lightly go over the mating surface of the o-ring.

Do not over-grease the o-rings. The excess grease may collect grit particles that can compromise the seal. Excess grease can also cause the waterproofing capabilities of the o-ring to diminish, potentially causing leaks. If excess grease is present, remove it using a lens cloth or lint-free cloth.

Cleaning a Sensor Port

If you suspect port contamination, you can clean the port on the cable by filling the port with Isopropyl Alcohol for 30 seconds and then dumping it out. Next, allow the port to air dry completely or blow it out with compressed air. Installing a sensor into a port that is not completely dry is likely to cause erratic and erroneous readings.

If the connector is corroded, contact your local YSI Representative or a YSI Authorized Service Center.

Verifying Sensor Accuracy and Calibration

Sensor accuracy and calibration can be verified by immersing a sensor into calibration solution or YSI Confidence Solution®. Compare the readings on the ProDSS display to the value of the solution. If the readings have drifted more than the accuracy specification of the sensor, perform a calibration before taking field measurements.

YSI Confidence Solution can be used to check the accuracy and calibration of the conductivity, pH and ORP sensors. However, to maintain the highest accuracy of the instrument, it should not be used to perform a calibration.

Resetting a Sensor to Factory Default

Occasionally, it may be necessary to reset the instrument to its factory calibration default values. To reset the calibration values, press the Cal key, highlight Restore Default Cal and press Enter. Highlight the parameter you wish to reset to default and press Enter. Next, you will be asked to confirm the operation. Highlight Yes and press Enter to confirm.

YSI
1700/1725 Brannum Lane
Yellow Springs, Ohio 45387
+1 937.767.7241
800.765.4974 (US)
info@ysi.com
YSI.com

W89 0117

visit ysi.com/ProDSS

a xylem brand