INNOVATIVE | EXPERIENCED | RESPONSIVE

Groundwater Sampling Work Plan

Rose Cleaners
Village of Mount Kisco, Westchester County, New York
NYSDEC Site No. 3-60-059

Submitted to:

LRB Cleaners
500 Lexington Avenue
Mt. Kisco, NY 10549

Submitted by:
EWMA
100 Misty Lane
Parsippany, NJ 07054-2741
973-560-1400

December 2018

Project No. 205548

Prepared by Jacob Strauss, PE
Senior Project Engineer

Reviewed by Donald Smith, PG
Director Project Manager

Table of Contents

Tables

Figures

Attachments

1. EWMA QA/QC Procedures
2. Field Sampling Procedures Plan
3. Field Instrument Calibration & Maintenance

1.0 INTRODUCTION

This Quality Assurance Project Plan (QAPP) is being prepared for the property known as Rose Cleaners, located at 500 Lexington Avenue, Mount Kisco, Westchester County, New York (subject property and site). The QAPP details the specific policies, organizations, objectives, functional activities and quality assurance/quality control (QA/QC) activities that will be implemented.

2.0 SCOPE OF PROJECT

This QAPP document applies to the proposed delineation of contaminated groundwater at the subject property where tetrachloroethylene and its daughter products were detected at levels exceeding the unrestricted groundwater standards used by the New York State Department of Environmental Conservation (NYSDEC). Groundwater samples will be collected from specific wells as approved by the NYSDEC.

In addition, surface water samples will be collected to evaluate if the contaminated groundwater is impacting the adjacent stream to the subject property. Figure 1 shows the general layout of the area and includes the monitoring well locations and proposed surface water sampling locations.

3.0 DATA QUALITY OBJECTIVES

The data collected will be consistent with the NYSDEC requirements. A Data Usability Summary Report (DUSR) will be generated and reviewed. Any problems with the data will be identified and resolved.

4.0 ANALYTICAL LABORATORY INFORMATION

Samples collected for analysis will be analyzed by the laboratory listed below.

Integrated Analytical Laboratories, LLC (IAL)
273 Franklin Road
Randolph, New Jersey 07869
NY Certified Lab # 11402

Eurofins Lancaster Laboratories Environmental (ELLE)
2425 New Holland Pike
Lancaster, Pennsylvania 17601
NY Certified Lab # 10670

5.0 PROJECT COORDINATION

5.1 Overall Project Coordination

Donald Smith, Director Project Manager
EWMA, LLC
100 Misty Lane, Parsippany, New Jersey 07054
973-560-1400
973-560-0400 (fax)

5.2 Sampling Coordination

Donald Smith, Director Project Manager
EWMA, LLC
100 Misty Lane, Parsippany, New Jersey 07054
973-560-1400
973-560-0400 (fax)

5.3 Laboratory Activities

Mike Leftin, Laboratory Director
Integrated Analytical Laboratories, LLC
273 Franklin Road, Randolph, New Jersey 07869
(973) 361-4252

Note: All laboratory activities will be coordinated through IAL. ELLE is a subcontractor to IAL.

6.0 ANALYTICAL METHODS/QA SUMMARY

The Analytical Methods/Quality Assurance Summary is included as Table 1.

7.0 SITE-SPECIFIC SAMPLING METHODS

Groundwater and soil samples will be collected following EWMA's Quality Assurance/Quality Control (QAQC) Guidance Document, which is included in Attachment 1 of this document. Sampling procedures deviating from the QA/QC are described in the site-specific Field Sampling Procedures Plan, which is included in Attachment 2.

8.0 FIELD INSTRUMENT CALIBRATION & MAINTENANCE

The Field Instrument Calibration & Maintenance procedure documents are included in Attachment 3. A copy of the equipment calibration log for the event is included in Attachment 3.

9.0 CHAIN OF CUSTODY PROCEDURES

9.1 Field Chain Of Custody

The field chain of custody (COC) will be generated by the analytical laboratory preparing the sample containers. The COC will accompany the sample containers during transportation to the field, sample collection, and transportation back to the lab. It will also be carried through during analysis along with a Laboratory Custody Chronicle. The COC will also identify the final disposal of the sample container. It will be signed and dated by persons handling and transporting the containers. A final copy of the COC will be included with the analytical data report generated for the samples.

A blank copy of the Chain of Custody is included in Attachment 1.

9.2 Laboratory Chain Of Custody

The named analytical laboratory will generate an internal Laboratory Custody Chronicle in tracking the samples within the laboratory. As with the field COC, persons handling and transporting the samples will sign-off on the chronicle.

A final copy of the chronicle will be included with the analytical data report generated for the samples.

10.0 SAMPLE STORAGE PROCEDURES AT THE LABORATORY

The laboratory analyzing the samples will store the samples in a refrigerated and secured room.

11.0 LABORATORY DATA DELIVERABLE

In accordance with the NYSDEC ASP, Category B data deliverables and NYSDEC EQUIS electronic disk deliverables (EDDs) will be submitted for the groundwater samples collected from the sites. A DUSR will be prepared by an independent 3rd party data validator. The deliverables will be generated by the analytical laboratory named in Section 4.0, Analytical Laboratory Information, of this document.

Table 1: Analytical Methods/Quality Assurance Summary Table

Table 1 - Analytical Methods/Quality Assurance Summary Table

Sample ID	Matrix	Parameters	Sample Container & Volume	Sample Preservation	Holding Time	Analytical Method
MW-A to MW-L, MW-1, MW-2 to MW-9 to MW-11, HP-1, & BW-1	Groundwater	VOCs	2 - 40 ml glass vials	HCl	14 Days	EPA Method 8260B
HP-2, MW-D, & MW-H	Groundwater	1,4-dioxane	2 - 1 L amber bottles	None	7 days extract/ 40 days analyze	EPA Method 8270C SIM
HP-2, MW-D, & MW-H	Groundwater	PFAS	2 - 250 ml HDPE/polypropylene bottles	Trizma	14 days extract/ 28 days analyze	Modified EPA Method 537
HP-2, MW-D, & MW-H	Groundwater	CH4, ethane, ethene,	2 - 60 ml glass vials	HCl	14 days	RSK-175
HP-2, MW-D, & MW-H	Groundwater	VFAs	2 - 40 ml glass vials	None	7 days	Modified EPA Method 8015D
HP-2, MW-D, & MW-H	Groundwater	Bicarbonate alkalinity, CO2	1 - 500 ml glass bottle	None	14 days	SM2320B, SM4500CO2D
HP-2, MW-D, & MW-H	Groundwater	NO2, NO3	1 - 250 ml plastic or glass bottle	H2SO4	28 days	SM4500NO3 F
HP-2, MW-D, & MW-H	Groundwater	Chloride	1 -2 50 ml plastic or glass	None	28 days	SM4500Cl B, E
HP-2, MW-D, & MW-H	Groundwater	TOC	1 - 250 ml plastic or glass bottle	HCl or H2SO4	28 days	SM5310B, C, or D
HP-2, MW-D, & MW-H	Groundwater	Ferrous Iron, Ferric Iron	1 -250 ml plastic or glass bottle	None	24 hours	SM4500FE B
HP-2, MW-D, & MW-H	Groundwater	SO4	1 - 250 ml plastic or glass bottle	None	28 days	ASTM D516
HP-2, MW-D, & MW-H	Groundwater	dechlorinating bacteria/functional gene analysis	1 - 1 L poly bottle	None	24 hours	qPCR Taq Man assay
SW-1 to SW-4	Surface Water	VOCs	2 - 40 ml glass vials	HCl	14 Days	EPA Method 8260B
MW-DMS/MSD	Groundwater	VOCs	2 - 40 ml glass vials	HCl	14 days	EPA Method 8260B
MW-DMS/MSD	Groundwater	1,4-dioxane	2 - 1 L amber bottles	None	7 days extract/ 40 days analyze	EPA Method 8270C SIM
MW-DMS/MSD	Groundwater	PFAS	2 - 250 ml HDPE/polypropylene bottles	Trizma	14 days extract/ 28 days analyze	Modified EPA Method 537
FB-1	Groundwater	VOCs	2 - 40 ml glass vials	HCl	14 days	EPA Method 8260B

Table 1 - Analytical Methods/Quality Assurance Summary Table

Sample ID	Matrix	Parameters	Sample Container & Volume	Sample Preservation	Holding Time	Analytical Method
FB-2	Groundwater	1,4-dioxane	2 - 1 L amber bottles	None	7 days extract/ 40 days analyze	EPA Method 8270C SIM
FB-2	Groundwater	PFAS	2 - 250 ml HDPE/polypropylene bottles	Trizma	14 days extract/ 28 days analyze	Modified EPA Method 537
DUP-1	Groundwater	VOCs	2 - 40 ml glass vials	HCl	14 days	EPA Method 8260B
DUP-2	Groundwater	1,4-dioxane	2 - 1 L amber bottles	None	7 days extract/ 40 days analyze	EPA Method 8270C SIM
DUP-2	Groundwater	PFAS	2 - 250 ml HDPE/polypropylene bottles	Trizma	14 days extract/ 28 days analyze	Modified EPA Method 537
TB	Groundwater	VOCs	2 - 40 ml glass vials	HCl	14 days	EPA Method 8260B

BW - Bedrock Well
CH4 - methane
Cl - chloride
CO2 - carbon dioxide
DUP - Duplicate
EPA - Environmental Protection Agency
FB - Field blank/equipment blank
HCl - Hydrochloric Acid
HP
MW-Monitoring Well
NA - Not available/not applicable
NO2 - nitrite
NO3 - nitrate
PFAS - Per- and Polyfluoroalkyl Substances
QA - Quality Assurance
SO4 - sulfate
TB - Trip blank
TOC - total organic carbon
VFAs - volatile fatty acids
VOCs - Volatile Organic Compounds

Figure 1: GENERAL SITE PLAN

N

302
304
306
308
310
312
314
316
318
328

MW-11
MW-9
MW-10
MW-8
MW-7
MW-6
MW-5
MW-4
MW-3
MW-2
MW-1
MW-D
MW-C
MW-B
MW-A
MW-E
MW-I
MW-J
MW-L
MW-F
MW-G
MW-H
MW-K
HP-1
HP-2
BW-1
SW-1
SW-2
SW-3
SW-4

SOURCE

1) THE 2016 DIGITAL ORTHOPHOTOGRAPHY, THE 2-FOOT ELEVATION CONTOURS, THE MUNICIPAL TAX PARCELS AND STREAMS WERE OBTAINED FROM WESTCHESTER COUNTY GEOGRAPHIC INFORMATION SYSTEMS

2) SURVEYED MONTIORING WELL LOCATIONS OBTAINED FROM DPK SURVEY PERFORMED ON OCTOBER 29, 2018

3) MONITORING WELL LOCATIONS NOT SURVEYED WERE OBTAINED FROM MAPS PREPARED BY BEI

Legend

- Proposed Surface Water Samples

Monitoring Wells

- Overburden (Single Screen)
- Overburden (Multi-Screen)
- Monitoring Wells (Not Surveyed)
- Site Boundary
- Streams
- Elevation Contours
- Westchester County Parcels

Document Path: G:\Job Data\209000\209288\Figure 1_General Site Plan_Portrait.mxd

0 25 50 100 Feet

EWMA
INNOVATIVE | EXPERIENCED | RESPONSIVE
100 MISTY LANE
P.O. BOX 5430
PARSIPPANY, NEW JERSEY

DATE: 9/7/2017

PROJECT # 209288

DRAWN BY: BOB DENBLEYKER
CHECKED BY: DONALD SMITH

GENERAL SITE PLAN

ROSE CLEANERS
500 LEXINGTON AVENUE
MOUNT KISCO, NEW YORK

FIGURE 1

Attachment 1: EWMA QA/QC PROCEDURES

In order to assure the validity of the chemical test results for soil and water samples collected during the sampling program, the following QA/QC Program will be strictly adhered to:

QUALITY CONTROL

A.1 SamplingEquipment:

1. Drill Rig w stainless steel split spoons
2. PPE (disposable tyveks, gloves, etc.)
3. 6 mil. plastic sheeting, plastic bags and ties
4. Calculator, wristwatch, timer
5. Calibrated bucket for purge water measurement
6. Paper towels
7. Dedicated polyethylene tubing (submersible pump)
8. Dedicated teflon-line polyethelene tubing (for low-flow purge)
9. Plastic electrician ties or stainless steel clamps
10. Disposable fiber brushes
11. Stainless steel trays and bowls
12. Distilled and deionized water
13. Liquinox soap/tap water mixture
14. Pesticide grade acetone
15. 10% nitric acid (trace metal or higher grade HNO_3)
16. Sample containers and preservatives
17. Trip blanks
18. Cooler and ice packs
19. Bound field log book, labels and permanent markers
20. Chain of custody forms and seals
21. Grunfos Redi-Flow 2-inch diameter submersible pump with a variable speed control box
22. Stainless steel scoops or dedicated polyethylene scoops

A.2 Monitoring Equipment:

1. Rae Systems Inc. Mini RAE Plus Photoionization Detector
2. Horiba U-10 Water Quality Checker (pH, temperature, DO, turbidity, conductivity)
3. Solinst Model 121 sonic, product/water interface probe
4. Solinst Model 100/101 sonic water interface probe

A.3 General Equipment:

1. Spade shovels
2. Square shovels
3. Manual post hole digger
4. Johnson bar or breaker bar
5. Gas powered generator
6. Masonry hammer
7. DC to AC power converter (in vans)

(All general equipment with the exception of the gas generator, is decontaminated prior to field use)

B. Non-Aqueous Sampling Equipment Decontamination:

A decontamination pad will be established to conduct all cleaning. The pad will be equipped with provisions for the containment of wash solutions. All equipment such as drill rigs, backhoes and other mobile equipment will be cleaned prior to site use. The frequency of subsequent cleanings while on-site will be dependent upon how the equipment is actually used in relation to how the samples are obtained. All rinsate will either be drummed for off-site disposal or will be filtered of solids and run through the on-site ground water treatment system. All filtered solids will be containerized, classified and disposed in accordance with all applicable regulations.

All non-aqueous sampling equipment will be cleaned and decontaminated by the following procedures:

1. Oil, grit, rust and soil shall be removed with a brush.
2. Liquinox detergent and tap water scrub wash.
3. Generous tap water rinse.
4. Distilled and deionized water rinse (ASTM Type II).

All drilling, boring and excavation equipment will be steam cleaned using a portable steam wash unit. The decontamination procedure will be repeated if visual inspection indicates the initial decontamination procedure was unsuccessful in thoroughly cleaning the equipment.

In cases were visual contamination persists, or gross contamination is suspected, the sampling equipment will be cleaned and decontaminated by the following procedures:

1. Oil, grit, rust and soil shall be removed with a brush.
2. Liquinox detergent and tap water wash.
3. Generous tap water rinse.
4. Distilled and deionized water rinse (ASTM Type II).
5. 10% nitric acid rinse (trace metal or higher grade HNO_3 diluted with distilled and deionized (ASTM Type II) H_20).*
6. Distilled and deionized water rinse (ASTM Type II)*.
7. Pesticide grade acetone rinse.**
8. Total air dry.**
9. Distilled and deionized water rinse(ASTM Type II).**

* Only if sample is to be analyzed for metals.
** Only if sample is to be analyzed for organics.

C. Aqueous Sampling Equipment Decontamination

All submersible pumps will be cleaned and flushed prior to and between each use. The pump casing, hose and cables will be cleaned with laboratory grade glassware detergent wash and tap water rinse. This will be followed by a 20-gallon flush of portable water through the pump (for 4" pumps). Should the pumps be of a smaller diameter, the recommended number of gallons required for flushing will be proportionately reduced (i.e. 3" – 15 gallons, 2" – 10 gallons).

Any additional aqueous sampling equipment will be cleaned and decontaminated by the following procedures:

1. Liquinox detergent and tap water wash.
2. Generous tap water rinse.
3. Distilled and deionized water rinse (ASTM Type II).
4. 10% nitric acid rinse (trace metal or higher grade HNO_3 diluted with distilled and deionized (ASTM Type II) H_20).*
5. Distilled and deionized water rinse (ASTM Type II)*.
6. Pesticide grade acetone rinse.**
7. Total air dry.**
8. Distilled and deionized water rinse(ASTM Type II).**

* Only if sample is to be analyzed for metals.
** Only if sample is to be analyzed for organics.

D. Sample Collection:

The sampling containers and equipment, if practical, will be transported to the site separately from gasoline and generators. No sampling equipment shall come in contact directly with the ground surface but will be placed on 6. mil. plastic sheeting. Clean, disposable, surgical grade latex or nitrile gloves will be worn during the sampling event. Gloves will be changed between each sample point and immediately before obtaining the sample.

All field monitoring equipment will be calibrated in accordance with the manufacturer's specifications.

1. Soil: Samples will be retrieved using either a, stainless steel spatula or disposable polyethylene scoops. Samples to be analyzed for volatile organic compounds will be collected from a minimum depth of eighteen to twenty-four inches when sampling the surface soils, or will be collected from a discrete 0-6" interval from the sampling equipment.

When utilizing a split spoon sampler, the split spoon should be opened upon retrieval, its contents logged and then the samples shall be transferred into the sample containers using a decontaminated stainless steel spatula or dedecated disposaable polyethylene trowel. A field log shall be generated.

If general air monitoring of the soil core is required, a knife or spatula will be utilized to make a cross sectional slice of the soil core or to score a longitudinal line the length of the core deep enough to expose a porous surface. The probe of the monitoring device will be placed into the opened area a maximum of 1 inch from the exposed soil, but will not touch the sample.

If field screening of headspace is required to determine the appropriate interval from which to collect the sample, the sample collected for screening will be collected after all other parameters are secured. The headspace sample will be placed in an airtight container (either a clear glass sample jar or zip lock bag). The sample will be warmed to induce volatilization and the container will then be opened just enough to permit the entry of the monitoring probe.

2. Water: Ground water samples from monitoring wells, sumps or temporary points will be retrieved utilizing laboratory decontaminated dedicated disposable Teflon or polyethylene bailers. The bailers are slowly lowered into the well by hand being careful not to aerate the ground water to be sampled. The bailer is lowered using a Teflon coated stainless steel leader. Prior to sampling monitoring wells, static water levels will be measured and a minimum of three

times the volume of the well shall be purged, when possible. Slow recharge wells will be purged as conditions allow and will be allow to recover for a period not to exceed 24 hours prior to sampling. Detailed well purge guides (including field readings of DO, specific conductance, and pH) will be generated for each well. Unless specific site conditions warrant (see below), samples shall be collected no later than two hours after purging the well.

Prior to sampling, the monitoring wells will be purged. Wells less than 25' deep will be purged utilizing a peristaltic pump. Wells greater than 25' deep will be purged utilizing a submersible pump. A purge log will be kept for each well.

Purging with a peristaltic pump will be accomplished by inserting dedicated polyethylene tubing into the well. The other end of the tubing will be attached to flexible silicon tubing that has been threaded around the rotor.

Purging with a submersible pump will be accomplished by carefully lowering the pump, discharge hose, electrical cable and security cable into the well. The cables will be bundled together with plastic electrician ties or stainless steel clamps. As EWMA utilizes a control box, a gate valve at the end of the purge line is not required. If a portable generator is utilized to power the pump it will be placed downwind and at some distance from the well. The pump will be equipped with a check valve and will be decontaminated between well locations. Care will be taken not to let the dump draw from the bottom of the well to minimize the impact of silts and sands on the pump.

If a flow through cell is utilized to monitor the water quality, the wells will be purged utilizing the low-flow purging technique (< 0.5 L/min). The pump-intake will be located in the middle or slightly above the middle of the screened interval. The well will be purged until stabilization of parameters indicates that formation water has been accessed. The order of stabilization will be pH, temperature and specific conductance, followed by dissolved oxygen and turbidity. Measurements will be recorded every five minutes. Stabilization will be deemed complete after all parameters have stabilized for three successive readings. The following subset of parameters will be utilized to determines stabilization: pH, conductivity and DO. Three successive readings should be within ±0.1 for pH, ±3% for conductivity and ±10% for DO. Drawdown will not exceed 0.3'.

Upon stabilization, sampling will be initiated using the same device used for purging. Volatile and gas sensitive parameters will be sampled first. The samples will be placed into laboratory prepared sample containers. The appropriate preservatives will be placed into the sample containers prior to departure from the lab to reduce the chances of improperly preserving the sample bottles or introducing field contaminants into the sample bottles. After the container has been filled, the cap will be screwed on tightly to prevent the container from leaking. A sample label will be filled out and the samples will be stored at 4°C.

E. Sample Handling:

All samples shall be preserved in the field immediately after collection and submitted to the laboratory as soon as possible and no later than 48 hours after sample collection.

All samples will be preserved in accordance with the preservation requirements. Site-specific sample preservative requirements will be summarized in the Technical Overview section of the report which accompanies this document.

1. Soil: Samples will be removed from the sampling equipment with sterilized and disposable wooden, polyethylene or reusable stainless steel spatulas. In no case will the soil sample come in contact with the field personnel or any foreign objects. Samples analyzed for volatile organics will be removed from the sampling equipment using a dedicated, graduated small diameter-syringe. All samples will be transferred into glassware supplied by the testing laboratory. Upon transferal to the containers, the samples will be placed into coolers packed with ice and kept chilled at four degrees Centigrade, in dark storage until they reach the testing laboratory.

2. Water: All water samples will be transferred to laboratory supplied glassware. Care shall be taken to insure that no air bubbles are present in the VOA sample bottles after filling. Upon transfer to the appropriate containers, the samples will be placed into coolers packed with ice and kept chilled until they reach the testing laboratory.

F. *Chain of Custody:*

Chain of custody will be initiated by the field team and maintained through sample analysis and reporting of results. Each transfer of sample custody will be recorded on the custody record, and upon transfer to the laboratory the sampling team will maintain a copy.

QUALITY ASSURANCE

A. *Trip and Field Blanks (Non-Aqueous Matrix):*

Field and Trip blanks will not be generated for the non-aqueous matrix unless specifically requested.

Field blanks will be generated by passing demonstrated analyte free water provided by the laboratory through the dedicated or field decontaminated sampling device(s) and into an identical empty set of bottles.

Field blanks will be preserved in the same manner as samples. For sampling events lasting more than one day, field blanks will be generated at a rate of 10% of the total number of samples collected throughout the event. For one-day sampling events, only one field blank will be generated.

B. *Trip and Field Blanks (Aqueous Matrix):*

Trip blanks will accompany each set of laboratory supplied glassware. The trip blank sample bottles will be filled at the laboratory with laboratory demonstrate analyte free water. The trip blank samples will accompany the laboratory prepared bottles into the field and back to the laboratory. The trip blanks will not be opened and will be analyzed for volatile organic parameters (at a minimum).

Field Blanks will only be generated when specifically requested. Field blanks will be generated by passing demonstrated analyte free water provided by the laboratory through the dedicated or field decontaminated sampling device(s) and into an identical empty set of bottles.

Field blanks will be preserved in the same manner as samples. Field blanks will be analyzed for all the same parameters as samples collected that day.

C. *Duplicate Samples:*

If requested, duplicate samples will be included for each matrix at a minimum rate of one for every twenty samples (5% of total). Site specific duplicate frequencies will be addressed in the Technical Overview section of the accompanying report. The duplicate sample will be tested for all of the parameters proposed within each area of concern. Each duplicate sample will be given a unique sample number to insure that the testing laboratory is unaware of the internal check.

Aqueous matrix duplicates will be obtained by alternately filling sample containers from the same sampling device for each parameter. Samples for volatile organic analysis from monitoring wells will be filled from the same bailer full of water whenever possible and be the first set of containers filled.

Nonaqueous matrix duplicates from a soil or sediment matrix requires homogenization of the sample prior to filling the sample containers. Enough sample will be collected to facilitate the generation of two equal samples. The sample will be placed in a properly decontaminated stainless steel bowl and mixed with a decontaminated stainless steel instrument. The sample will be mixed to the point at which a consistent physical appearance is achieved. Once mixed, the sample will be divided into half and then placed into the containers by alternately scooping the material from each half. Volatile organic samples must always be taken from discrete locations or intervals without compositing or mixing.

D. *Sample Documentation:*

All information pertaining to the sampling event will be recorded in ink in a bound field notebook with consecutively numbered pages. This shall include, but not be limited to date and time of sampling, weather conditions, people on site, maps of sample locations and sample numbers, sampling equipment utilized, listing of any significant events.

MONITORING WELL PURGE GUIDE / LOW FLOW SAMPLING

Site Name:
Site Location:
EWMA Project No:
Client Code:
Technician:
Date / Time:
Weather:

Well Identification		Water Quality Parameters					
MW -		TIME	pH	Cond.	Turb.	Dis. O2	Temp.
Casing Height (feet)*							
Depth to Water (initial, feet)**							
Depth to Product (feet)**							
Product Thickness (inches)							
Depth to Water (final, feet)**							
Total Depth of Well (feet)**							
PID (initial)							
PID (final)							
Mount Type Flush/Stick-up							
Sample Depth T (1/3) 1/2) (2/3) B							
Sampling Device							
Tubing Type							
Screen Length (feet)							
Well Diameter (inches)							
Sheen							
Odor			**Samples taken**				
Comments:							

MW -		TIME	pH	Cond.	Turb.	Dis. O2	Temp.
Casing Height (feet)*							
Depth to Water (initial, feet)**							
Depth to Product (feet)**							
Product Thickness (inches)							
Depth to Water (final, feet)**							
Total Depth of Well (feet)**							
PID (initial)							
PID (final)							
Mount Type Flush/Stick-up							
Sample Depth T (1/3) 1/2) (2/3) B							
Sampling Device							
Tubing Type							
Screen Length (feet)							
Well Diameter (inches)							
Sheen							
Odor			**Samples taken**				
Comments:							

notes:
Samples were taken at the **bold** time interval.
* - negative casing height indicates a flush mount below ground surface.
** - measured from the top of the casing
NA - parameter not available
ND - not detected

Phone # (973) 361-4252
Fax # (973) 989-5288

INTEGRATED ANALYTICAL LABORATORIES
CHAIN OF CUSTODY

273 Franklin Rd
Randolph, NJ 07869

CLIENT & PROJECT

Name:	
Address:	
Telephone #:	
Fax #:	
Project Name:	
Project Manager:	
Reference ID#: PO#:	

REPORTING & BILLING

Fax to:
Fax #:
EMail to:
Report to:
Address:
Invoice to:
Address:

Turnaround Time

Conditional / TPHC

24 hr* 48 hr 72 hr 1 wk NA Other:

Verbal/Fax

24 hr* 48 hr* 72 hr* 1 wk* 2 wk Other:

Hard Copy

72 hr* 1 wk* 2 wk* 3 wk Other:

*Prior to sample arrival, Lab notification is required.

Report Format

Results Only

Reduced

Regulatory

SRP Disk**: dbf or wk1

Special Requirements:

ANALYTICAL PARAMETERS / PRESERVATIVES

** Circle format required

1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6	Preservatives
										1. HCL 3. HNO_3
										2. NaOH 4. H_2SO_4
										5. MeOH 6. Other

COOLER TEMP. °C

SAMPLE INFORMATION

SAMPLE MATRIX
W - Waste SL - Sludge A - Aqueous
O - Oil X - Other S - Soil
GW - Groundwater SOL - Solid

Sample ID	Sample Depth (in Feet)	Sampling Date	Sampling Time	am	pm	Matrix	# of Containers	Lab ID	Comments/Area of Concern

Please print legibly and fill out completely. Samples cannot be processed and the turnaround time will not start until any ambiguities have been resolved.

Concentrations Expected

LOW MED HIGH

Known Hazard: yes no

Describe:

CUSTODY LOG

Signature/Company	Date	Time	Signature/Company
Relinquished by:			Received by:
Relinquished by:			Received by:
Relinquished by:			Received by:
Relinquished by:			Received by:
Relinquished by:			Received by:

Comments:

Lab Case #

PAGE: OF

LAB COPIES - WHITE & YELLOW: CLIENT COPY - PINK

Environmental Waste Management Associates, LLC
P.O. Box 5430, Parsippany, NJ 07054
Tel: (973) 560-1400 Fax: (973) 560-0400

EWMA Job #:	Boring Location:
Boring #:	
Installation Date:	
Site Name:	
Site Location:	
Completion Date:	
Geologist:	Drilling Co.:
Driller:	Drill Rig:
Bit: / Hammer Wt: / Drop: / Total Depth:	
Sampler Type:	G.W. Encountered:
	G.W. Stabilized:

BORING LOCATION SKETCH (N.T.S.)

DEPTH (FT.)	SAMPLE ID AND DEPTH	PID/FID/OUA (METER UNITS)	BLOWS/6.0"	RECOVERY (INCHES)	SOIL TYPE	SOIL/GEOLOGIC DESCRIPTION	DEPTH (FT.)
1							1
2							2
3							3
4							4
5							5
6							6
7							7
8							8
9							9
10							10
11							11
12							12
13							13
14							14
15							15
16							16
17							17
18							18
19							19
20							20
21							21
22							22
23							23
24							24

Unified Soil Classification System (USCS)
(As modified/amended by ASTM (D2488-98) for field classification)

				Group Symbol
Fines < 50%	GRAVEL %gravel≥ %sand	≤5% fines	Well-graded	GW
			Poorly-graded	GP
		10% fines	Well-graded, fines=ML or MH	GW-GM
			Well-graded, fines=CL or CH	GW-GC
			Poorly-graded, fines=ML or MH	GP-GM
			Poorly-graded, fines=CL or CH	GP-GC
		≥15% fines	fines=ML or MH	GM
			fines=CL or CH	GC
	SAND %sand≥ %gravel	≤5% fines	Well-graded	SW
			Poorly-graded	SP
		10% fines	Well-graded, fines=ML or MH	SW-SM
			Well-graded, fines=CL or CH	SW-SC
			Poorly-graded, fines=ML or MH	SP-SM
			Poorly-graded, fines=CL or CH	SP-SC
		≥15% fines	fines=ML or MH	SM
			fines=CL or CH	SC

Note: Percentages are based on estimating amounts of fines, sand and gravel to the nearest 5%.

Fines > 50%	Dry Strength – medium to high Dilatency – none to slow Toughness – medium Plasticity – medium	CL
	Dry Strength – none to low Dilatency – slow to rapid Toughness – low or thread cannot be formed Plasticity – low or non-plastic	ML
	Dry Strength – high to very high Dilatency – none Toughness – high Plasticity – high	CH
	Dry Strength – low to medium Dilatency – none to slow Toughness – low to medium Plasticity – low to medium	MH
	Soil contains enough organic particles to influence soil properties. Usually dark brown to black color, organic odor.	OL/ OH
	Fibrous texture or spongy feel – organic odor	Pt

Grain Size Chart

Classification	Range of Grain Sizes	
	U.S. Standard Sieve Size	Grain Size In Millimeters
Boulders	> 12"	> 305
Cobbles	12" – 3"	305 – 76
Gravel	3" – #4	76 – 4.75
coarse	3" – 3/4"	76 – 19.0
fine	3/4" – #4	19.0 – 4.75
Sand	#4 – #200	4.75 – 0.075
coarse	#4 – #10	4.75 – 2.00
medium	#10 – #40	2.00 – 0.425
fine	#40 – #200	0.425 – 0.075
Silt and Clay	Passes #200	< 0.075

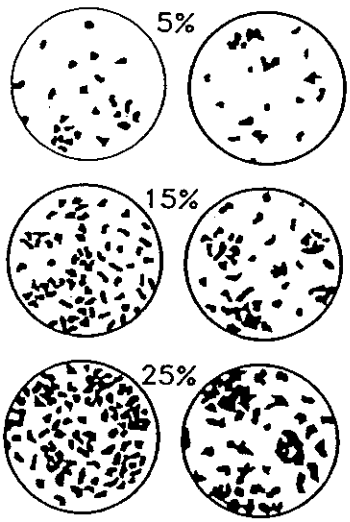
Relative Density (SPT)

Sands and Gravels	Blows/Foot
Very Loose	0–4
Loose	5–10
Medium Dense	11–30
Dense	31–50
Very Dense	> 50

Consistency (SPT)

Silts and Clays	Blows/Foot
Very Soft	0–2
Soft	3–4
Medium Stiff	5–8
Stiff	9–16
Very Stiff	17–32
Hard	> 32

Clast/Matrix Proportion



SOIL DESCRIPTIONS FORMAT

- Soil Color (matrix)
- Primary component (GRAVEL, SAND, SILT, CLAY,) with range (f, f–m, f–c, etc.)
- Secondary components, with soil fraction descriptors (in decreasing order)
- Moisture condition: dry, moist, wet.
- Relative density or consistency (by SPT blow counts "N–value" if available)
- Additional details, per NJDEP Procedures Manual:

Mottling, particle shape, structure, horizon thickness (macro–features) and other details deemed appropriate by writer. (e.g., "probable" odors, staining, debris in fill, shell fragments, cemented grains/nodules) Notes of job–specific objectives also appropriate, e.g. recognizing typical historic fill materials.

Soil Fraction Descriptors

Trace	1–15%
Some	16–35%
and	>35%

Designation: D 2488 – 00

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)[2]

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and rock as Used in Engineering Design and Construction[3]

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)[2]

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:
Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and
Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 *clay*—soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved Feb. 10, 2000. Published May 2000. Originally published as D 2488 – 66 T. Last previous edition D 2488 – 93 ε1.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

*A Summary of Changes section appears at the end of this standard.

limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-μm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-μm) sieve.

fine—passes a No. 40 (425-μm) sieve and is retained on a No. 200 (75-μm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-μm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols*.

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means for evaluating some of those factors.

6. Apparatus

6.1 *Required Apparatus*:

6.1.1 *Pocket Knife or Small Spatula*.

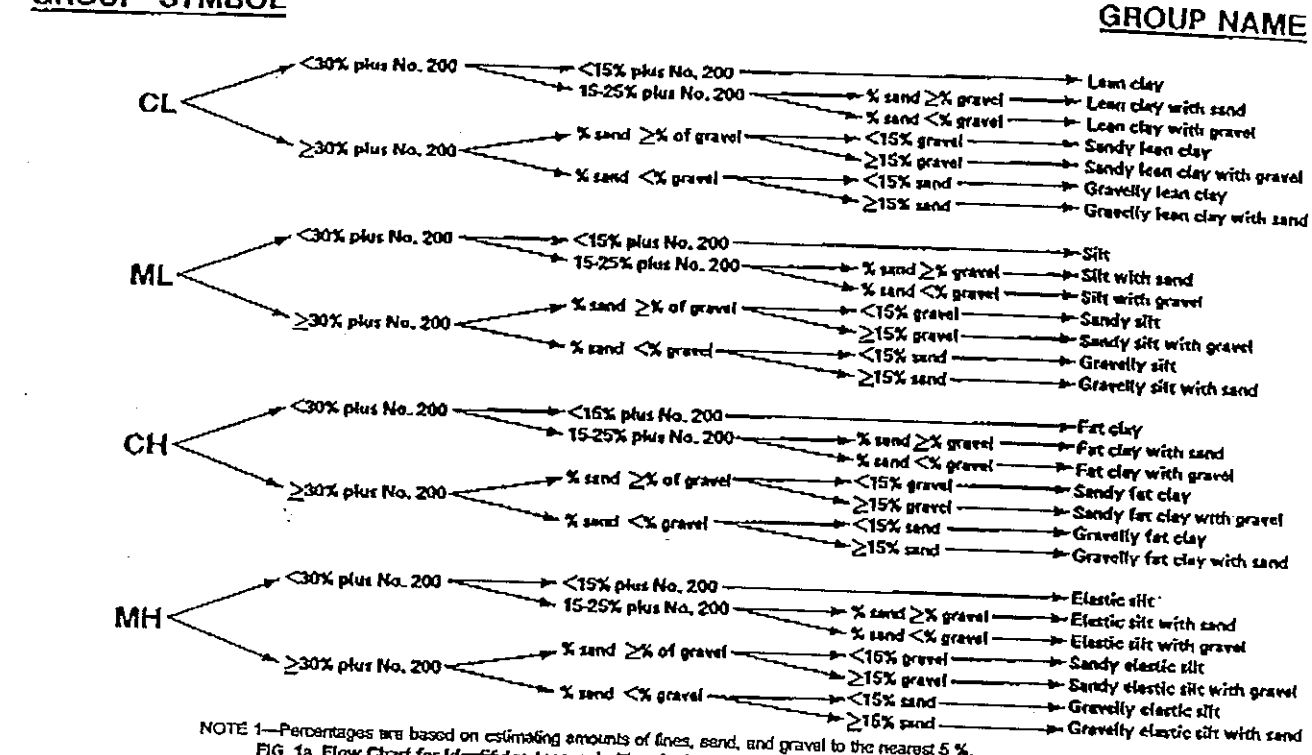
6.2 *Useful Auxiliary Apparatus*:

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens*.

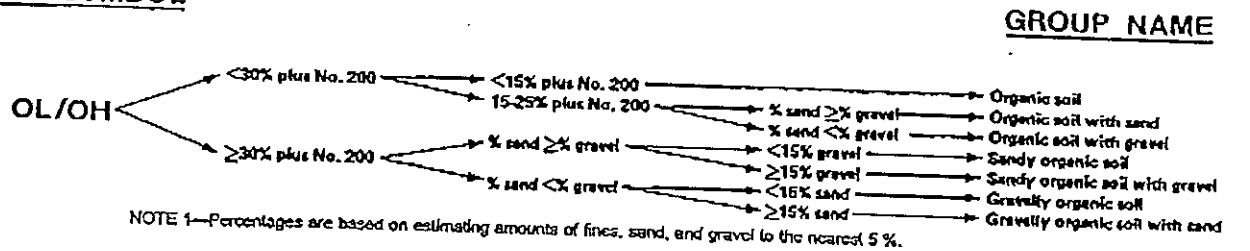
7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 Caution—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

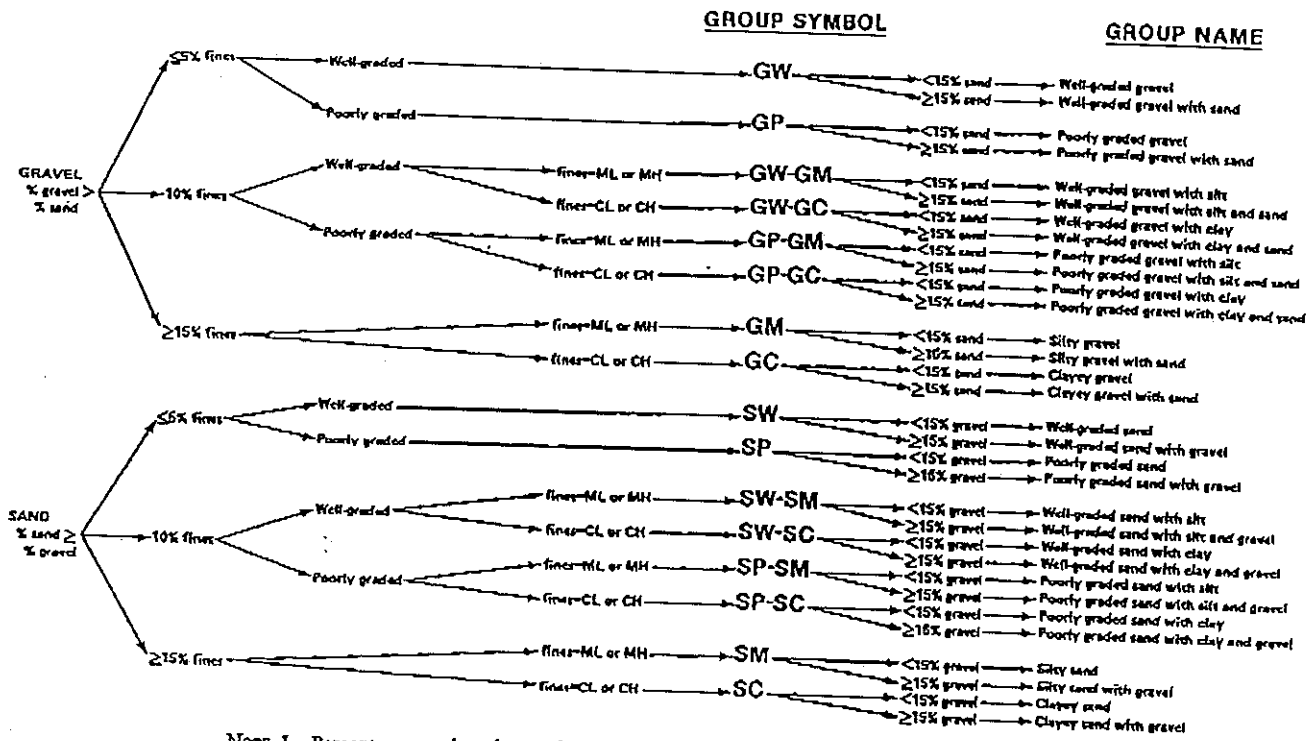
NOTE 6—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Test Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the proceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

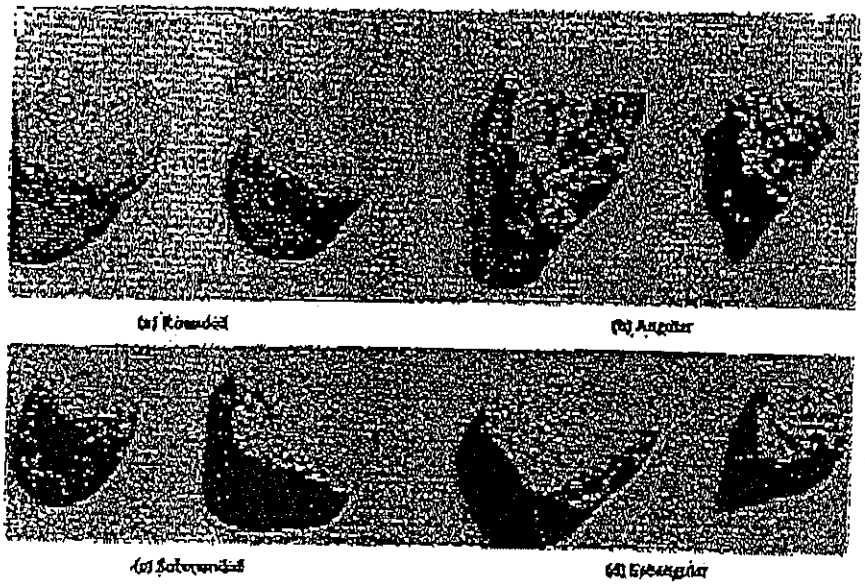


FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1 ½ in. (will pass a 1 ½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

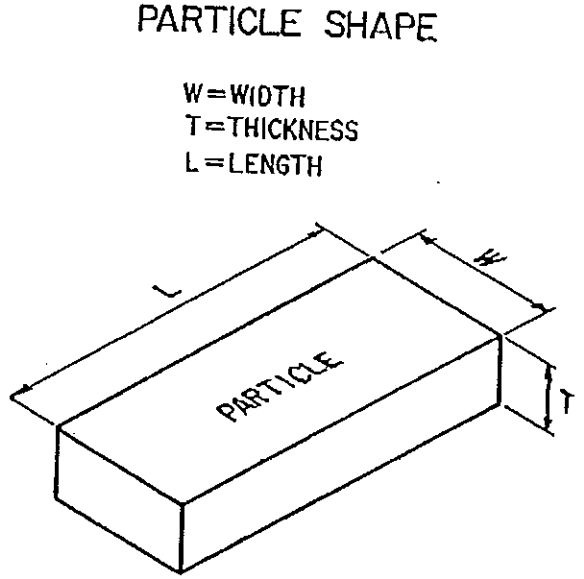


FIG. 4 Criteria for Particle Shape

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Dilatancy

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Toughness

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing ~~Dilatancy~~ Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength:*

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low,

medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy*:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness*:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

TABLE 8 Criteria for Describing ~~Toughness~~ Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.7 *Identification of Inorganic Fine-Grained Soils*:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

14.8 *Identification of Organic Fine-Grained Soils*:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic *silts* or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils (Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; "Poorly Graded Gravel with Sand (GP)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard,

angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix	Suffix

s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (1993 $^{\varepsilon 1}$) that may impact the use of this standard.

(1) Added Practice D 3740 to Section 2.

(2) Added Note 5 under 5.7 and renumbered subsequent notes.

Attachment 2: FIELD SAMPLING PROCEDURES PLAN

FIELD SAMPLING PROCEDURES PLAN

Rose Cleaners

December 2018

EWMA Project # 209288

Task 1 – Synoptic Water Level and Dense Non-Aqueous Phase Liquids (DNAPL) readings – All Wells

Take a water level reading and check for the presence of DNAPL from all wells on and offsite in accordance with the purge guide located in Attachment 1.

Task 2 - Emerging Contaminant of Concern and Biogeochemical Parameter Sampling

The following wells will be sampled for 1,4-dioxane, per-and polyfluoroalkyl substances (PFAS), and the biogeochemical parameters listed in Table 1:

- HP-2
- MW-D
- MW-H

PLEASE READ CAREFULLY Sampling of Monitoring Wells HP-2, MW-D, and MW-H will include Chemicals of Emerging Concern (ie. 1,4-dioxane and PFAS) and must be sampled using special equipment and conditions. Please see the NYSDEC's Groundwater Sampling for Emerging Contaminants and Collection of Groundwater Samples for Per- and Polyfluoroalkyl Substances (PFAS) from Monitoring Wells Sample Protocol (rev. 1.2) guidance documents which are attached to this Field Sampling Procedures Plan.

Since 1,4-dioxane and PFAS are byproducts of compounds that are found in consumer products as well as commonly used waterproof and/or stain resistant materials like Teflon and Gore-Tex, special sampling procedures are required to collect samples free from cross-contamination.

IAL will provide PFAS-free amber glass and HDPE bottles, and water for the sampling event.

No Teflon-lined equipment, such as tubing and bottles, will be used during the sampling event.

The equipment will be decontaminated using Alconox or similar non-PFAS surfactant before and after sampling. PFAS-free pumps (e.g. peristaltic, QED SamplePro, trash pump) and dedicated HDPE tubing for each well will be used during the sampling event. One equipment rinsate blank will be collected

from the tubing and pump to document any PFAS residual on the equipment before sampling. Nitrile gloves will be used throughout the sampling event.

The field personnel will be wearing prewashed cotton clothing and won't be exposing any equipment or sample bottles to their bodies to prevent exposure to any potential consumer products containing the parameters. The sampling event will entail the filling of two 1,000 ml amber glass bottles for 1,4-dioxane analysis, and two 250 ml HDPE bottles for PFAS analysis. The bottle ware will be capped with the appropriate cap and liner. The bottles will be labeled and placed in a cooler with ice. In addition to the equipment rinsate blank, a field duplicate, and matrix spike/matrix spike duplicate (MS/MSD) duplicate will be collected for 1,4-dioxane and PFAS analysis.

The biogeochemical parameter samples will be collected after the 1,4-dioxane and PFAS samples at each well. The sampling will entail the collection of two 40 ml vials, two 60ml vials, seven 250 ml bottles, one 500 ml bottle, and one 1 liter bottle. The bottle ware will be capped with the appropriate cap and liner. The bottles will be labeled and placed in a cooler with ice.

The analytical results will be released in a full Category B deliverable package and NYSDEC EQUiS electronic disk deliverable (EDD). The results will be validated by an independent 3rd party data validator who will issue a Data Usability Summary Report (DUSR). All of the analytical results, including EDDs and DUSRs will be submitted to the NYSDEC as a part of their study.

Task 3 – Volatile Organic Compound (VOC) Sampling

The following wells will be sampled based on Quality Control Section D2 of the groundwater sampling procedure located in Attachment 1. Please note that for the multi-screened wells, the tubing will be set at the lowest screened interval in the well.

<u>Single-Screen Wells:</u> Purge and sample 12-15 wells using the low-flow purging technique. Eleven to thirteen samples will be submitted for VO+15 analysis. The wells are as follows:

- MW-A
- MW-B
- MW-C
- MW-D
- MW-E
- MW-G
- MW-H
- MW-I*
- MW-K*
- MW-1
- MW-2
- HP-1
- BW-1

One to two samples will be submitted for VO+15 (report only) from the following wells:

- MW-F
- MW-J*

Multi-Screen Wells: Purge and sample 9-13 wells using low-flow purging techniques at the lowest screened interval in the well. Five to seven of the samples will be submitted for VO+15 analysis from the following wells:

- MW-3
- MW-7
- MW-9
- MW-10
- MW-11**
- MW-K*
- MW-L

Four to six samples will be submitted for VO+15 (report only) from the following wells:

- MW-4
- MW-5
- MW-6
- MW-8
- MW-I*
- MW-J*

Notes:

* - These wells have to be inspected, possibly with a down-hole camera, to determine the correct number of screened intervals.

** - The location of MW-11 on the figure is an approximation. If MW-11 is located and in good condition to be sampled, any samples will be analyzed using the VO+15 method.

Task 4 – Surface Water Sampling

The following locations along the stream will be sampled in accordance with this plan:

- SW-1 – Furthest downgradient from the Site
- SW-2 – Downgradient from the Site
- SW-3 – At the Site
- SW-4 – Upgradient from the Site

Surface water sampling only requires the use of the sample bottle, waders/waterproof clothing, life vest/jacket, YSI meter, and gloves. The sampler can make their own determination as to whether to enter the stream or not. If conditions are safe, then follow the procedure below. If conditions are not safe, then samples may have to be collected closer to the stream bank.

1. During surface water sampling, samples are collected in order from the downstream location to the upstream location. Samples are typically collected from the center of the stream with the sample being collected from the center of the water column.
2. Enter the stream perpendicular to flow, place the wand of the YSI meter in the stream immediately downgradient of the sample location to collect water indicator parameters. Once that is complete, collect the sample with the lab-supplied bottleware.
3. The sampler can either move to the next upgradient sample location or exit the stream, and repeat steps #1-2.
4. If it's not possible to collect the samples from the downgradient sample points first, then start collection at the upgradient points. After sample collection, exit the stream and walk to the next sample location and reenter the stream. Only collect the sample after any disturbed sediment has passed through the sample location.

For Tasks #3 & #4, the sampling event will entail the filling of two 40 ml glass vials with zero headspace for VO analysis. The bottle ware will be capped with the appropriate cap and liner. The bottles will be labeled and placed in a cooler with ice. In addition to the field blank, a field duplicate, and matrix/matrix spike duplicate (MS/MSD) duplicate will be collected for VO analysis. The analytical results for the single-screen wells, designated multi-screen wells (i.e. MW-3, MW-7, MW-9 to MW-11, MW-K*, and MW-L), and surface water samples will be released in a full Category B deliverable package and NYSDEC EQUiS electronic disk deliverable (EDD). The results will be validated by an independent 3rd party data validator who will issue a Data Usability Summary Report (DUSR). The other multi-screen wells will be released in a sample report only. All of the analytical results, including EDDs and DUSRs will be submitted to the NYSDEC as a part of their study.

Collection of Groundwater Samples for Per- and Polyfluoroalkyl Substances (PFAS) from Monitoring Wells Sample Protocol

Samples collected using this protocol are intended to be analyzed for perfluorooctanoic acid (PFOA) and other perfluorinated compounds by Modified (Low Level) Test Method 537.

The sampling procedure used must be consistent with the NYSDEC March 1991 Sampling Guidelines and Protocols http://www.dec.ny.gov/docs/remediation_hudson_pdf/sgpsect5.pdf with the following materials limitations.

At this time acceptable materials for sampling include: stainless steel, high density polyethylene (HDPE) and polypropylene. Additional materials may be acceptable if proven not to contain PFAS. **NOTE: Grunfos pumps and some bladder pumps are known to contain PFAS materials (e.g. Teflon™ washers for Grunfos pumps and LDPE bladders for bladder pumps).** All sampling equipment components and sample containers should not come in contact with aluminum foil, low density polyethylene (LDPE), glass or polytetrafluoroethylene (PTFE, Teflon™) materials including sample bottle cap liners with a PTFE layer. Standard two step decontamination using detergent and clean water rinse will be performed for equipment that does come in contact with PFAS materials. Clothing that contains PTFE material (including GORE-TEX®) or that have been waterproofed with PFAS materials must be avoided. Many food and drink packaging materials and "plumbers thread seal tape" contain PFAS.

All clothing worn by sampling personnel must have been laundered multiple times. The sampler must wear nitrile gloves while filling and sealing the sample bottles.

Pre-cleaned sample bottles with closures, coolers, ice, sample labels and a chain of custody form will be provided by the laboratory.

1. Fill two pre-cleaned 250 mL HDPE or polypropylene bottle with the sample.
2. Cap the bottles with an acceptable cap and liner closure system.
3. Label the sample bottles.
4. Fill out the chain of custody.
5. Place in a cooler maintained at 4 ± 2º Celsius.

Collect one equipment blank for every sample batch, not to exceed 20 samples.

Collect one field duplicate for every sample batch, not to exceed 20 samples.

Collect one matrix spike / matrix spike duplicate (MS/MSD) for every sample batch, not to exceed 20 samples.

Request appropriate data deliverable (Category A or B) and an electronic data deliverable.

Groundwater Sampling for Emerging Contaminants

July 2018

Issue: NYSDEC has committed to analyzing representative groundwater samples at remediation sites for emerging contaminants (1,4-dioxane and PFAS) as described in the below guidance.

Implementation

NYSDEC project managers will be contacting site owners to schedule sampling for these chemicals. Only groundwater sampling is required. The number of samples required will be similar to the number of samples where "full TAL/TCL sampling" would typically be required in a remedial investigation. If sampling is not feasible (e.g., the site no longer has any monitoring wells in place), sampling may be waived on a site-specific basis after first considering potential sources of these chemicals and whether there are water supplies nearby.

Upon a new site being brought into any program (i.e., SSF, BCP), PFAS and 1,4-dioxane will be incorporated into the investigation of groundwater as part of the standard "full TAL/TCL" sampling. Until an SCO is established for PFAS, soil samples do not need to be analyzed for PFAS unless groundwater contamination is detected. Separate guidance will be developed to address sites where emerging contaminants are found in the groundwater. The analysis currently performed for SVOCs in soil is adequate for evaluation of 1,4-dioxane, which already has an established SCO.

Analysis and Reporting

Labs should provide a full category B deliverable, and a DUSR should be prepared by an independent 3rd party data validator. QA/QC samples should be collected as required in DER-10, Section 2.3(c). The electronic data submission should meet the requirements provided at: https://www.dec.ny.gov/chemical/62440.html ,

The work plan should explicitly describe analysis and reporting requirements.

PFAS sample analysis: Currently, ELAP does not offer certification for PFAS compounds in matrices other than finished drinking water. However, laboratories analyzing environmental samples (ex. soil, sediments, and groundwater) are required, by DER, to hold ELAP certification for PFOA and PFOS in drinking water by EPA Method 537 or ISO 25101.

Modified EPA Method 537 is the preferred method to use for groundwater samples due to the ability to achieve 2 ng/L (ppt) reporting limits. If contract labs or work plans submitted by responsible parties indicate that they are not able to achieve similar reporting limits, the project manager should discuss this with a DER chemist. Note: Reporting limits for PFOA and PFOS should not exceed 2 ng/L.

PFAS sample reporting: DER has developed a PFAS target analyte list (below) with the intent of achieving reporting consistency between labs for commonly reportable analytes. It is expected that reported results for PFAS will include, at a minimum, all the compounds listed. This list may be updated in the future as new information is learned and as labs develop new capabilities. If lab and/or matrix specific issues are encountered for any particular compounds, the NYSDEC project manager will make case-by-case decisions as to whether particular analytes may be temporarily or permanently discontinued from analysis for each site. Any technical lab issues should be brought to the attention of a NYSDEC chemist.

Some sampling using this full PFAS target analyte list is needed to understand the nature of contamination. It may also be critical to differentiate PFAS compounds associated with a site from other sources of these chemicals. Like routine refinements to parameter lists based on investigative findings, the full PFAS target analyte list may not be needed for all sampling intended to define the extent of contamination. Project managers may approve a shorter analyte list (e.g., just the UCMR3 list) for some reporting on a case by case basis.

1,4-Dioxane Analysis and Reporting: The method detection limit (MDL) for 1,4-dioxane should be no higher than 0.35 µg/l (ppb). Although ELAP offers certification for both EPA Method 8260 SIM and EPA Method 8270 SIM, DER is advising the use of method 8270 SIM. EPA Method 8270 SIM provides a more robust extraction procedure, uses a larger sample volume, and is less vulnerable to interference from chlorinated solvents.

Full PFAS Target Analyte List

Group	Chemical Name	Abbreviation	CAS Number
Perfluoroalkyl sulfonates	**Perfluorobutanesulfonic acid**	**PFBS**	**375-73-5**
	Perfluorohexanesulfonic acid	**PFHxS**	**355-46-4**
	Perfluoroheptanesulfonic acid	PFHpS	375-92-8
	Perfluorooctanessulfonic acid	**PFOS**	**1763-23-1**
	Perfluorodecanesulfonic acid	PFDS	335-77-3
Perfluoroalkyl carboxylates	Perfluorobutanoic acid	PFBA	375-22-4
	Perfluoropentanoic acid	PFPeA	2706-90-3
	Perfluorohexanoic acid	PFHxA	307-24-4
	Perfluoroheptanoic acid	**PFHpA**	**375-85-9**
	Perfluorooctanoic acid	**PFOA**	**335-67-1**
	Perfluorononanoic acid	**PFNA**	**375-95-1**
	Perfluorodecanoic acid	PFDA	335-76-2
	Perfluoroundecanoic acid	PFUA/PFUdA	2058-94-8
	Perfluorododecanoic acid	PFDoA	307-55-1
	Perfluorotridecanoic acid	PFTriA/PFTrDA	72629-94-8
	Perfluorotetradecanoic acid	PFTA/PFTeDA	376-06-7
Fluorinated Telomer Sulfonates	6:2 Fluorotelomer sulfonate	6:2 FTS	27619-97-2
	8:2 Fluorotelomer sulfonate	8:2 FTS	39108-34-4
Perfluorooctane-sulfonamides	Perfluroroctanesulfonamide	FOSA	754-91-6
Perfluorooctane-sulfonamidoacetic acids	N-methyl perfluorooctanesulfonamidoacetic acid	N-MeFOSAA	2355-31-9
	N-ethyl perfluorooctanesulfonamidoacetic acid	N-EtFOSAA	2991-50-6

Bold entries depict the 6 original UCMR3 chemicals

Attachment 3: FIELD INSTRUMENT CALIBRATION & MAINTENANCE

EQUIPMENT CALIBRATION LOG

Instrument Type:

I.D./Serial #:

Manufacturer:

Date Purchased:

Date	Initial Setting	Calibration Gas	Procedure/Adjustments	Final Setting	Calibrator Initials	Comments

Rae Systems Inc. Mini RAE 2000 Portable VOC Monitor

CAUTION : For safety reasons this equipment must be operated and serviced by qualified personnel only. Read and understand instruction manual completely before operating or servicing

ATTENTION : Pour des raisons de sécurité, cet équipment doit être utilisé, entretenu et réparé uniquement par un personnel qualifié. Étudier le manuel d'instructions en entier avant d'utiliser, d'entretenir ou de réparer l'équipement

WARNINGS:
Use only RAE Systems battery packs, part nos. 012-3050, 012-3051 or 012-3052. 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.

AVERTISSEMENT:
Utiliser seulement l'ensemble de batterie RAE Systems, la reference 012-3050, 012-3051 au 012-3052. Cet instrument n'a pas été essayé dans une atmosphère de gaz/air explosive ayant une concentration d'oxygène plus élevée que 21%. La substitution de composants peut compromettre la sécurité intrinsique. Ne charger les batteries que dans emplacements désignés non dangereux.

1. GENERAL INFORMATION

MiniRAE 2000 Portable VOC Monitor (Model PGM 7600) is a compact monitor designed as a broadband VOC gas monitor and datalogger for work in hazardous environments. It monitors Volatile Organic Compounds (VOC) using a Photo-Ionization Detector (PID) with a 9.8 eV, 10.6 eV, or 11.7 eV gas discharge lamp. Features are:

- **Lightweight and Compact**
  -Compact, light weight (19 oz.) and rugged design
  -Built-in sample draw pump

- **Dependable and Accurate**
  - Up to 10 hours of continuous monitoring with rechargeable battery pack
  - Designed to continuously monitor VOC vapor at ppm levels

- **User Friendly**
  -Preset alarm thresholds for STEL, TWA, low and high level peak values. Audio buzzer and flashing LED display are activated when the limits are exceeded.

- **Datalogging Capabilities**
  -15,000 point datalogging storage capacity for data download to PC

MiniRAE 2000 consists of a PID with associated microcomputer and electronic circuit. The unit is housed in a rugged ABS + PC case with a backlit 1 line by 8

Real-time Clock:	Automatic date and time stamps on data logged information
Data logging:	15,000 points with time stamp, serial number, user ID, site ID, etc.
Communication:	Upload data to PC and download instrument setup from PC through RS-232 port
Sampling Pump:	Internally integrated. Flow rate: 450-550 cc/min.
Temperature:	0° to 45°C (32° to 113°F)
Humidity:	0 % to 95 % relative humidity (non-condensing)
Housing:	ABS + PC, conductive coating, splash and dust proof, will withstand 1 meter drop test with rubber boot
Attachment:	Wrist strap, rubber boot and belt clip

2. OPERATION OF MINIRAE 2000

The MiniRAE 2000 Portable VOC Monitor is a compact Monitor designed as a broadband VOC gas monitor and datalogger for work in a hazardous environment. It gives real time measurements and activates alarm signals whenever the exposure exceeds preset limits. Prior to factory shipment the MiniRAE 2000 is preset with default alarm limits and the sensor is pre-calibrated with standard calibration gas. After the monitor is fully charged, it is ready for immediate operation.

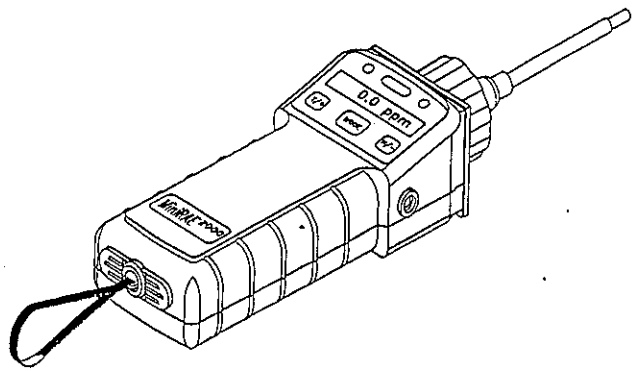


Figure 2-1 MiniRAE 2000

4.3 Entering into Programming Mode

1. Turn on the MiniRAE 2000 monitor and wait for the **"Ready.."** message or the instantaneous reading display **"0.0 ppm"** message displayed.
2. Press and hold down both an**[N/-]** and **[MODE]** keys for three seconds to enter programming mode. This delay is to prevent the user from entering programming mode by accident.
3. The first menu item " Calibrate/select Gas?" will be displayed.
4. Release both **[MODE]** and **[N/-]** keys simultaneously to start the programming mode
5. Press **[N/-]** key to scroll to the next menu item of the programming menu. Press **[Y/+]** key to select the displayed menu item.

The following Sections 4.4-4.7 describe the details of each menu options.

4.4 Calibrate and Select Gas

In the first menu of the programming mode, the user can perform functions such as calibration of the MiniRAE 2000 Monitor, select default cal memories, and modify cal memories. See Table 4.4.

Table 4.4

Calibrate/Select Gas Sub-Menu
Fresh Air Cal ?
Span Cal ?
Select Cal Memory ?
Change Span Value?
Modify Cal Memory ?
Change Correction Factor ?

Calibrating the MiniRAE 2000 monitor is a two-point process using "fresh air " and the standard reference gas (also known as span gas). First a "Fresh air" calibration, which contains no detectable VOC (0.0 ppm), is used to set the zero point for the sensor. Then a standard reference gas that contains a known concentration of a given gas is used to set the second point of reference.

Note: The span value must be set prior to calibrating for fresh air or span.

In addition to calibrations, the first menu allows the user to store calibrations for up to 8 different measurement gases.

The default gas selections are as follows:
Cal Memory #0.....Isobutylene
Cal Memory #1.....Hexane
Cal Memory #2.....Xylene
Cal Memory #3.....Benzene
Cal Memory #4.....Styrene
Cal Memory #5.....Toluene
Cal Memory #6.....Vinyl Chloride
Cal Memory #7.....Custom?

Memory #0 can not be modified. The other 7 cal memories may be modified to one of 102 preprogrammed chemicals or to a user-defined custom gas. In the gas library, only the gases that can be detected by the installed UV lamp will actually be displayed. If Isobutylene in memory #0 is calibrated and the selected gas in memory #1 to #7 is not calibrated, the correction factor from the library will be used automatically, so the reading for the selected gas will be correct even without calibration. If the selected gas has been calibrated, no correction factor is applied.

To change a default gas to a library or custom gas , first go to Select Cal Memory (Section 4.4.3) and then proceed to Modify Cal Memory (Section 4.4.5) to enter the desired gas.

4.4.1 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 MiniRAE 2000 to a "fresh" air source such as from a cylinder or Tedlar bag (option accessory). The "fresh" air is clean dry air without any organic impurities. If such an air cylinder is not available, any clean ambient air without detectable contaminant or a charcoal filter can be used.

1. The first sub-menu shows: "Fresh air Cal ?"
2. Make sure that the MiniRAE 2000 is connected to one of the "fresh" air sources described above.
3. Press the **[Y/+]** key, the display shows "zero in progress" followed by "wait.." and a countdown timer.
4. After about 15 seconds pause, the display will show the message "zeroed... reading = X.X ppm...". Press any key or wait about 20 seconds, the monitor will return back to "Fresh air Calibration?" submenu.

Note: The charcoal filter has a check box so that user can mark off a box each time the filter has been used. The charcoal filter should be replaced after 4 calibrations.

4.4.2 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 needed to perform this procedure. Choose 500 cc/min. regulator only because the flow rate matches the flow rate of the pump inside. Alternatively, the span gas can first be filled into a Tedlar Bag. Connect the calibration adapter to the inlet port of the MiniRAE 2000 Monitor, and connect the tube to the regulator or Tedlar bag.

Before executing a span calibration, make sure the span value has been set correctly (see next sub-menu).

1. Make sure the monitor is connected to one of the span gas sources described above.
2. Press the **[Y/+]** key at the "Span Cal?" to start the calibration. The display shows the gas name and the span value of the corresponding gas.
3. The display shows " Apply gas now!". Turn on the valve of the span gas supply.
4. Display shows " wait.... 30" with a count down timer showing the number of remaining seconds while the monitor performs the calibration.
5. To abort the calibration, press any key during the count down. The display shows "Aborted!" and return to "Span Cal?" sub-menu.
6. When the count down timer reaches 0, the display shows the calibrated value.

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

7. During calibration, the monitor waits for an increased signal before starting the countdown timer. If a minimal response is not obtained after 35 seconds, the monitor displays "No Gas!". Check the span gas valve is on and for lamp or sensor failure before trying again.
8. The calibration can be started manually by pressing any key while the "Apply gas now!" is displayed.
9. After a span calibration is completed, the display will show the message "Span Cal Done! Turn Off Gas"
10. Turn off the flow of gas. Disconnect the calibration adapter or Tedlar bag from the MiniRAE 2000 Monitor.
11. Press any key and it returns back to "Span Gas Cal?".

4.4.3 Select Cal Memory

This function allows the user to select one of eight different memories for gas measurement. Gas concentration reading will be automatically calculated using the correction factor inside and the calibration data in cal memory #0 if the gas is not calibrated. The user may calibrate the selected gas for that memory if no automatic conversion is wanted. The default gas selections are listed in Section 4.4

1. "Select Cal Memory?" is the third sub-menu item in the Calibration sub-menu. Pressing the **[Y/+]** key, the display will show "Gas =" gas name followed by "Mem # x?"
2. Press **[N/-]** to scroll through all the memory numbers and the gas selections respectively. Press **[Y/+]** to accept the displayed Cal Memory number.
3. After the **[Y/+]** key is pressed, the display shows "Save?". Press **[Y/+]** key to save and proceed. Press **[N/-]** to discard the entry and advance to the next sub-menu.
4. If the gas in a newly selected Cal Memory number is not calibrated, the display shows "CF= x.xx". A correction factor with the value "x.xx" will be applied.
5. If the gas of a newly selected cal memory number has been calibrated previously, the display shows "Last calibrated xx/xx/xx".

4.4.4 Change Span Value

This function allows the user to change the span values of the calibration gases.

1. "Change Span Value?" is the fourth sub-menu item in the Calibration sub-menu
2. Press **[Y/+]**, display shows the gas name and the span value. A cursor will blink at the first digit of the Span value. To modify the span gas value, go to step 3. Otherwise, press and hold the **[MODE]** key for 1 second to accept the previously stored span gas value and move to the next sub-menu.
3. Starting from the left-most digit of the span gas value, use the **[Y/+]** or **[N/-]** key to change the digit value and press **[MODE]** key momentarily to advance to next digit. Repeat this process until all digits are entered. Press and hold the **[MODE]** for 1 second to exit.
4. The display shows "Save?". To accept the new value, press the **[Y/+]** key. Press the **[N/-]** key or the **[MODE]** key to discard the change and move to the next sub-menu.

EXO User Manual

ADVANCED WATER QUALITY MONITORING PLATFORM

Item# 603789REF
Revision G

a xylem brand

Section 4
Sensors and Calibration

4.1 Sensors Overview

The EXO product line includes sensors that detect a variety of physical, chemical, and biological properties of water. EXO sensors are designed to collect highly accurate data under ever-changing conditions.

Data Filtering

All EXO sensors share some common embedded software, including the filtering of real-time data. Sensors acquire environmental data at a constant rate, and use this stream of data as the input to the filtering algorithm that produces results seen by the user. EXO sondes collect data from the EXO sensors and are able to output data at rates up to 4 Hz. The EXO sensor data filtering process consists of four components (none of which is user-selectable):

Basic Rolling Filter

The filter is fundamentally a rolling or window average of past acquired inputs to the filter, such that as a new data value is added to the summation, the oldest data value is removed, and the total summation is divided by the total number of data values. It is a simple average, just rolling or moving in time. Starting with the February 2014 software release, different rolling time windows for the filter are now supported.

Data Filtering Modes

Data filtering options are included in the handheld and desktop version of KorEXO. These settings can be modified within the Sonde Options menu (Options>Sonde) as well as within the deployment template settings. ***NOTE: Making any changes to data filtering options will stop a deployment.*** As a sonde takes measurements, it compares new readings to those taken in the previous 2-30 seconds (depending on the selected option). If the new reading is not significantly different than past measurements, then it merely factors into the rolling average with older data points to create a smooth curve. If the new reading is significantly different than past measurements, then it restarts the rolling average of data points.

Averaging options

Default – This mode provides optimum data filtering for all sensors. Provides the highest accuracy, automatic averaging during unattended monitoring or fixed mooring. This mode has up to 40 seconds of filtering on the sensors.
NOTE: This is the mode all sensors ship in and how sensors filtered data prior to this update.

Accelerated* – This mode should be used for spot sampling and slow (or paused) depth profiles. The sensors are averaging 5-10 seconds of data in a rolling window, unless there are any outliers.

Rapid* – This mode should be used where the sonde is moving quickly through the water, such as with rapid profiling and unique applications like auvs, gliders, or towed applications. The data will be noisy and will never settle on a single steady number. This mode has 2-3 second filtering on the sensors.

*TIP: Enable the Vertical Position parameter in the Depth unit options to view the real-time position of the sonde in the water column. This is helpful in profiling applications to ensure the sonde is lowered to the desired depth without waiting for the Depth data to stabilize.

Confirm averaging settings

To quickly check a sonde's data filtering options, examine the summary information at the top of either the desktop or handheld versions of KorEXO. On the desktop software, the word Default, Accelerated, or Rapid will be adjacent to the sonde's serial number. Similarly, on the handheld, the letter D, A, or R will be listed at the top right of the screen.

Adaptive Filtering

The drawback to a basic rolling filter is that response time to an impulse event is delayed, and the more entries in the average summation, the longer the delay for the result to converge on the true value. To correct this, the filter algorithm monitors the new data arriving and compares it to the current averaged result, looking for indication of an impulse event. When new data deviate from the average by more than a predetermined tolerance, the number of data entries within the rolling average is reduced to a minimum count and the remaining values are flushed with the new data. The result is a more accurate capture of the impulse event data, entirely eliminating the inherent delay caused by the rolling average.

Outlier Rejection

Every time a newly acquired data value is added, the rolling average entries are scanned for outlier data. Although such data has already been determined to fall within the tolerances defined above, the remaining worst offenders are removed from the rolling average calculation. This outlier rejection allows for smoother continuous data results.

Calibration Stability

During calibration, the filtering is active as described, plus an additional feature works to provide stability feedback to the user. When the user attempts to calibrate a sensor, the sudden changes in environment are perceived as impulses or plunge events and the filtering reacts accordingly. The results immediately show the value of the solution, and after a few moments, the filter incrementally engages fully and supplies the smoothest data. However, as the sensor and the calibration solution work towards equilibrium, the measurement may slowly drift. The sensor will monitor the results from the filter and determine if the measurement is stable. It watches the results and calculates a slope from each and every result to the next. Once the slope settles and is consistently flat for approximately 30 seconds, the sensor is considered stable. KorEXO is then notified and the user will see a message that the calibration reading is stable.

Sensor Response Times

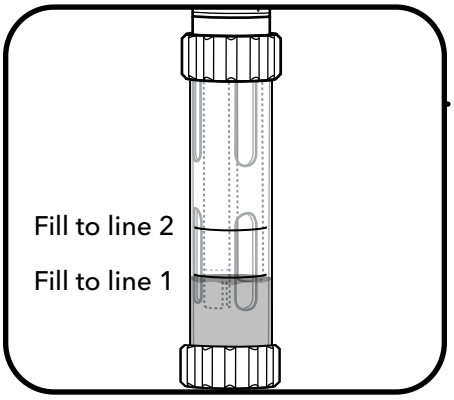
Response times for EXO sensors are based on laboratory testing. This testing, though stringent, cannot mimic the actual response times in the field due to the wide variety of use cases. To characterize an EXO sensor's response time, a step change in the sensor's primary output parameter is applied, and the time to reach 63% of the final stimulus value is recorded. Repeated characterization of multiple sensors provides the T63 specification.

Sensor Accuracy Specifications

To maintain accuracy specifications for EXO sensors, we recommend that users calibrate sensors in the lab in standards with temperatures as close to the ambient temperature of the field water as possible.

4.2 Calibration
Basic Overview

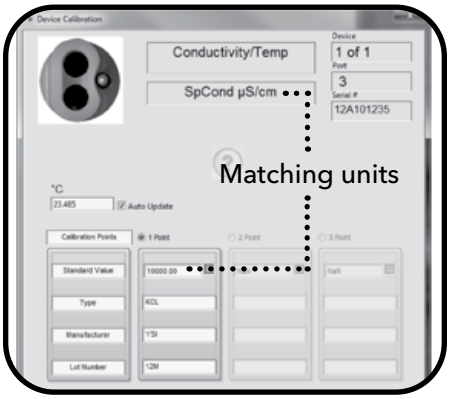
NOTE: *All EXO sensors should be user-calibrated before initial use.*
EXO sensors (except temperature) require periodic calibration to assure high performance.
Calibration procedures follow the same basic steps with slight variations for particular parameters.



Calibration set-up

For accurate results, thoroughly rinse the EXO calibration cup with water, and then rinse with a small amount of the calibration standard for the sensor you are going to calibrate. Two to three rinses are recommended. Discard the rinse standard, then refill the calibration cup with fresh calibration standard. Fill the cup to approximately the first line with a full sensor payload or the second line with small sensor payload. Recommended volumes will vary, just make certain that the sensor is submerged. Be careful to avoid cross-contamination with other standards.

Begin with clean, dry probes installed on the EXO sonde. Install the clean calibration guard over the probe(s), and then immerse the probe(s) in the standard and tighten the calibration cup onto the EXO sonde. We recommend using one sonde guard for calibration procedures only, and another sonde guard for field deployments. This ensures a greater degree of cleanliness and accuracy for the calibration procedure.



Basic calibration in KOR software

Go to the Calibrate menu in KorEXO software. This menu's appearance will vary depending on the sensors installed in the sonde. Select the sensor you are going to calibrate from the list. Next select the parameter for the sensor you are going to calibrate. Some sensors have only one parameter option, while other sensors have multiple options.

In the next menu, select a 1-, 2-, or 3-point calibration, depending on your sensor. Enter the value of the standard you are using. Check that the value you enter is correct and its units match the units at the top of the menu (e.g., microSiemens versus milliSiemens). You may also enter optional information for type of standard, manufacturer of standard, and lot number.

Click the Start Calibration button. This action initiates the probe's calibration in the standard; initially the data reported will be unstable and then will move to stable readings. Click the Graph Data button to compare the pre-cal and post-cal values in graph form. Users should confirm that the value is within their acceptable margin of error. Once readings are stable, click Apply to accept this calibration point. Repeat the process for each calibration point. **Click Complete when all points have been calibrated.**

A calibration summary appears with a QC score. View, export, and/or print the calibration worksheet. If a calibration error appears, repeat the calibration procedure.

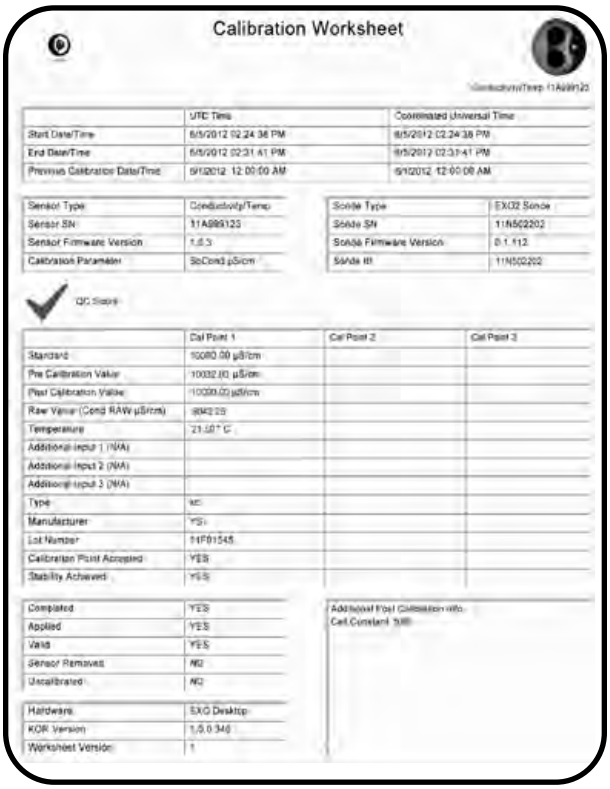
4.3 Calibration
Calibration Worksheet

The Calibration Worksheet is a record of the calibration for an EXO sensor. The worksheet contains quality assurance information including date and time of calibration, date of previous calibration, sensor firmware version, type of calibration performed, standard used, and QC score.

Calibration Worksheets are saved in the Calibration Files folder on the computer or the EXO Handheld that was used during calibration (not on the sonde or the sensors). All saved Worksheets can be accessed and viewed through the Data menu in KorEXO software.

Sample Worksheets:

1-point calibration of specific conductance on EXO conductivity/temperature probe



1-point calibration of percent saturation on EXO optical dissolved oxygen probe

Additional Post-Calibration Info

ODO Gain: The ODO gain is a diagnostic value recorded on the Calibration Worksheet and used for advanced diagnostic purposes. The nominal value is 1, and accurate calibrations of the DO sensor will only slightly deviate from this number.

Cell Constant: The cell constant is the current value of the conductivity and is a function of the factory original cell constant and the most recent user calibration. The cell constant will drift over time based on the sensor's electrodes, and the cell constant can be used to track drift.

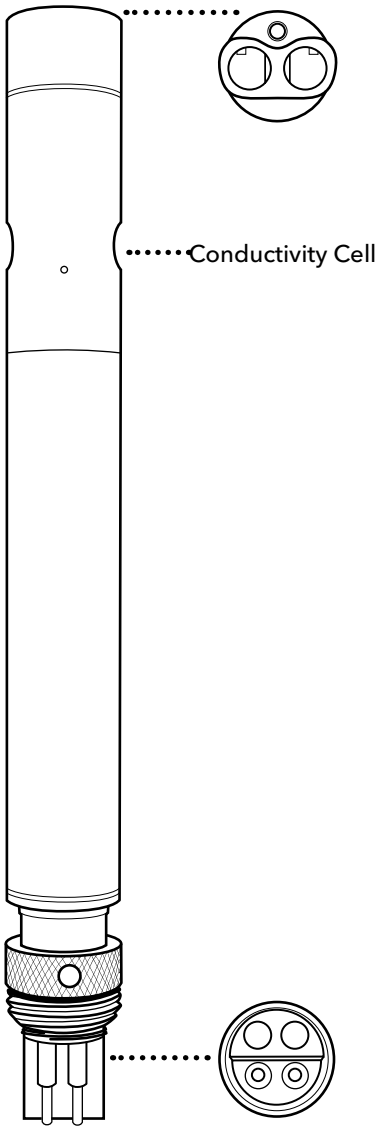
Slope: The slope for the pH sensor is the mV per decade (pH unit) where 59 is the typical value. Slope allows the user to track drift away from 59 to determine the life/aging of the sensor module.

Change mV: The change millivolts is the mV change between either 4 and 7 or 7 and 10 calibration values for the pH sensor. It is the mV deviation away from the middle calibration point number.

4.4 Conductivity/Temperature Sensor Overview

The EXO combination conductivity and temperature sensor should be installed in nearly all sonde applications. Not only will this sensor provide the most accurate and fastest response temperature data, but it will also provide the best data for the use in temperature compensation for the other EXO probes. The conductivity data is used to calculate salinity, non-linear function (nLF) conductivity, specific conductance, and total dissolved solids, and compensate for changes in density of water (as a function of temperature and salinity) in depth calculations if a depth sensor is installed.

(continued)



599870-01

Specifications

Conductivity

Default Units	microSiemens/centimeter
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Range	0 to 200 mS/cm
Accuracy	0-100 mS/cm: ±0.5% of reading or 0.001 mS/cm, whichever is greater; 100-200 mS/cm: ±1% of reading
Response	T63<2 sec
Resolution	0.0001 to 0.01 mS/cm range-dependent
Sensor Type	4-electrode nickel cell

Temperature

Default Units	°Celsius
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Accuracy	-5 to 35°C: ±0.01°C 35 to 50°C: ±0.05°C
Response	T63<1 sec
Resolution	0.001°C
Sensor Type	Thermistor

Temperature Thermistor

The temperature sensor uses a highly stable and aged thermistor with extremely low-drift characteristics. The thermistor's resistance changes with temperature. The measured resistance is then converted to temperature using an algorithm. The temperature sensor receives a multi-point NIST traceable wet calibration and the accuracy specification of 0.01˚C is valid for expected life of the probe. No calibration or maintenance of the temperature sensor is required, but accuracy checks can be conducted against a NIST-traceable temperature probe supplied by the user.

Conductivity Electrodes

The conductivity sensor uses four internal, pure-nickel electrodes to measure solution conductance. Two of the electrodes are current driven, and two are used to measure the voltage drop. The measured voltage drop is then converted into a conductance value in milliSiemens (millimhos). To convert this value to a conductivity value in milliSiemens per cm (mS/cm), the conductance is multiplied by the cell constant that has units of reciprocal cm (cm^{-1}). The cell constant for the conductivity cell is approximately 5.1/cm ±10%. For most applications, the cell constant is automatically determined (or confirmed) with each deployment of the system when the calibration procedure is followed.

Temperature Compensation

EXO sensors have internal thermistors for quality assurance purposes. Turbidity uses the internal thermistor for temperature compensation, while all other EXO sensors reference the C/T probe for temperature compensation. To display and log temperature, a C/T probe must be installed in an EXO sonde. Thermistor readings are logged in the sonde's raw data–viewable in KorEXO software–but are not included in data exported to Excel.

Conductivity = This is a measurement of water conductance from the drive and sense electrodes on the conductivity electrode. The output is in mS/cm or µS/cm. Note that the conductivity of solutions of ionic species is highly dependent on temperature, and the conductivity output is NOT compensated for temperature.

Specific Conductivity = When Specific Conductance is selected, the sonde uses the temperature and raw conductivity values associated with each determination to generate a specific conductance value compensated to 25°C by default. Both the Temperature Coefficient and reference temperature can be adjusted in the advanced sensor menu under calibration.

nLF Conductivity = The non-linear function (nLF) is defined by the ISO 7888 standard and is applicable for the temperature compensation of electrolytic conductivity of natural waters. This convention is typically used in German markets.

Salinity = Salinity is determined automatically from the sonde conductivity and temperature readings according to algorithms found in Standard Methods for the Examination of Water and Wastewater (ed. 1989). The use of the Practical Salinity Scale results in values that are unitless, since the measurements are carried out in reference to the conductivity of standard seawater at 15 °C.

4.5 Conductivity / Temperature Calibration

Clean the conductivity cell with the supplied soft brush before calibrating *(see section 5.9).*
Also, review the basic calibration description in section 4.2.

This procedure calibrates conductivity, non-linear function (nLF) conductivity, specific conductance, salinity, and total dissolved solids.

A variety of standards are available based on the salinity of your environment. Select the appropriate calibration standard for your deployment environment; we recommend using standards greater than 1 mS/cm (1000 µS/cm) for greatest stability.

Pour conductivity standard into a clean and dry or pre-rinsed EXO calibration cup. YSI recommends filling the calibration cup up to the second marked line to ensure the standard is above the vent holes on the conductivity sensor. Immerse the probe end of the sonde into the solution, gently rotate and/or move the sonde up and down to remove any bubbles from the conductivity cell.

Allow at least one minute for temperature equilibration before proceeding.

In the Calibrate menu, select Conductivity and then a second menu will offer the options of calibrating conductivity, nLF conductivity, specific conductance, or salinity. Calibrating any one option automatically calibrates the other parameters. After selecting the option of choice (specific conductance is normally recommended), enter the value of the standard used during calibration. Be certain that the units are correct and match the units displayed in the second window at the top of the menu.

Click Start Calibration. Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

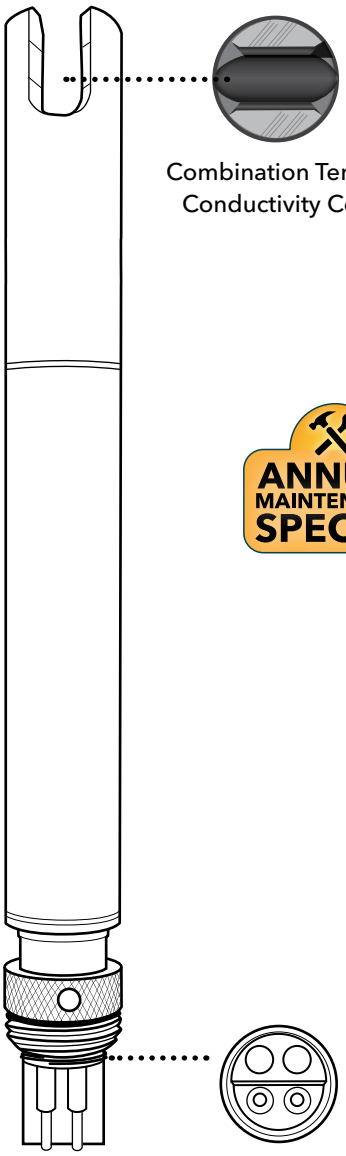
- If the data do not stabilize after 40 seconds, gently rotate the sonde or remove/reinstall the cal cup to make sure there are no air bubbles in the conductivity cell.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

Rinse the sonde and sensor(s) in tap or purified water and dry.

4.6 Wiped Conductivity / Temperature Sensor Overview

Biofilms, barnacles, and algal growth are common culprits of poor data quality, clogging up conductivity cells and coating sensor optics. While EXO2's Central Wiper can mechanically remove biofouling from other sensors to maintain data integrity over long deployment periods, in particularly high fouling environments the EXO Wiped C/T sensor provides superior conductivity data by avoiding stagnant readings and reducing the impact of micro-environments.



599827

EXO Wiped C/T Considerations

Sensor performance and specifications are well suited for continuous monitoring applications, where the EXO sonde is installed at a fixed location. For sampling and vertical profiling applications the legacy (599870) Conductivity Temperature probe which has a much faster temperature response should be used.

The Wiped C/T will have a different cell constant than the legacy Conductivity probes. A nominal cell constant of 0.469 +/-0.05 is typical on wiped conductivity.

ANNUAL MAINTENANCE SPECIAL

The EXO central wiper (599090) must have the wiper shaft seal serviced in the past year to use with your new wiped C/T probe. The wiper will work harder grooming the new sensor, therefore if your wiper hasn't had the shaft seal properly maintained there is a chance it could stall mid deployment.

Download our Maintenance Brochure

Preventive Maintenance Note
An annual wiper shaft o-ring replacement is required to maintain optimal performance of the EXO cental wiper.

Contact us to learn more:
repairs@ysi.com or +1 (800) 765-4974 (US)

Specifications

Conductivity

Range	0-100,000 µS/cm
Accuracy	±1% of reading or 2 µS/cm w.i.g.

Specific Conductance

Range	0-100,000 µS/cm
Accuracy	±1% of reading or 2 µS/cm w.i.g.

w.i.g. = whichever is greater

Temperature

Range	-5 to 50°C
Accuracy	±0.2°C
Response Time	T95<30sec

Watch Online
EXO2 Wiped (C/T) Video Quick Start Guide:
https://goo.gl/w67OQU

4.7 Wiped Conductivity / Temperature Calibration and Deployment

Calibration

A wet calibration of your new conductivity sensor should be completed before initial use. It is recommended that you complete a single point calibration in a standard similar to the conductivity readings that you expect to measure. It is recommended not to use standards below 1,000 µs/cm for fresh water applications as they can become easily contaminated. The temperature sensor cannot be user calibrated. Best practice is to periodically test the performance of the temperature sensor against a NIST traceable thermometer at several reference points. **NOTE:** *All EXO sensors should be user calibrated before initial use.*

Deployment Setup

The Wiped C/T sensor is optimized for continuous monitoring where a variety of environmental fouling conditions would affect the performance of the sensor without wiping. Numerous solutions can be employed to mitigate the effects of bio-fouling. These can include the use of copper tape, anti-fouling guards, anti-fouling paints, as well as local techniques developed for site specific challenges. However, none of these options can be directly applied to the conductivity cell of the wiped C/T sensor. Using the central wiper to groom the conductivity cell before readings prevents biofouling-induced drift of the conductivity cell.

The sensor includes a new central wiper brush (599673). A brush's wear and replacement intervals vary greatly based on specific application challenges, but 2-12 months use has been observed. Below are three examples of brush wear that will occur with use. It is recommended the wiper brush be replaced before it reaches level 3 for optimal cleaning. We recommend using a new wiper brush with the initial deployment.

Level 1- New brush, minimal "splay"

Level 2- Moderate splaying, have spare ready

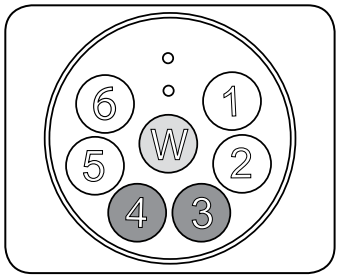
Level 3- Excessive splay, replace to prevent stalling of wiper

NOTICE: It is not recommended using wiped C/T in conjuction with EXO Ammonium, Nitrate, or Chloride electrodes as they are protected with a guard which accelerates the brush splay.

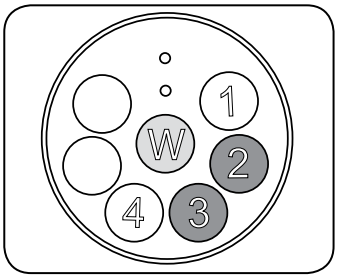
Sensor Installation

A new sensor includes a kit (599831) containing probe alignment o-rings and disposable zip ties. These items are to be used to optimally align the wiped conductivity probe cell with the brush. Refer to the instruction sheet included in the kit for directions and recommendations for applying the spacers. EXO sensors can be installed in any port, however for optimal cleaning avoid installing the Wiped C/T sensor as the first or last sensor in a group. If two conductivity sensors are installed in a single sonde, the temperature from the sensor with the lower port will be used for temperature compensation of other parameters.

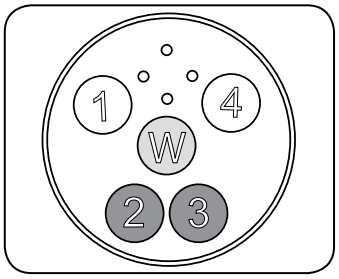
Having the sensor installed towards the middle of an array is optimal. Below are some examples:



EXO2 Optimal Wiped C/T positions: 3 or 4



EXO2 Optimal Wiped C/T positions: 2 or 3



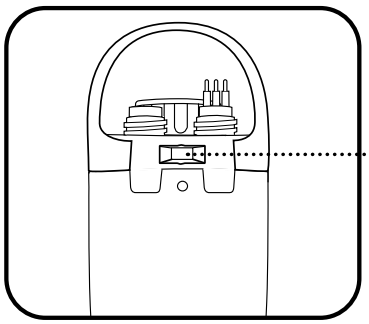
EXO3 Optimal Wiped C/T positions: 2 or 3

NOTICE: When installing a wiped conductivity/ temperature sensor in an EXO3 sonde, use ports 2 and 3.

4.8 Depth and Level Sensor Overview

EXO measures depth of water with a non-vented strain gauge. (See section 6 if your sonde is equipped with vented level.) A differential strain gauge transducer measures pressure with one side of the transducer exposed to the water and the other side exposed to a vacuum. We calculate depth from the pressure exerted by the water column minus atmospheric pressure. Factors influencing depth measurement include barometric pressure, water density, and temperature. Calibration in the atmosphere "zeros" the sensor with respect to the local barometric pressure. A change in barometric pressure will result in a zero shift unless the transducer is recalibrated to the new pressure.

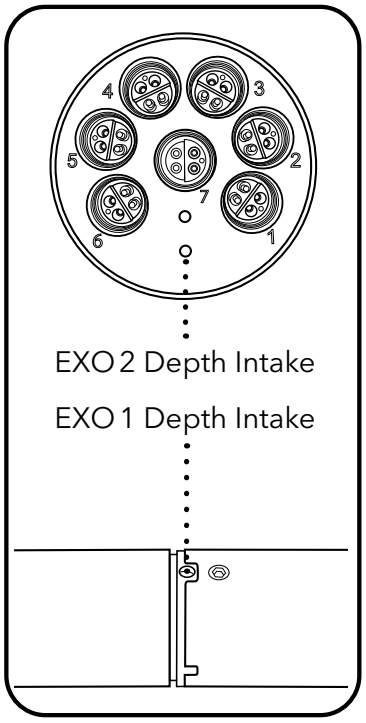
EXO sondes have intake openings to allow water to act on the strain gauge. The EXO1 intake is located in the yellow section between the battery compartment and label of the sonde.The EXO2 intake openings are two small holes on the face of the sonde bulkhead.



Location of Depth Sensor

Depth sensors on the EXO2 sondes are not on center. When deploying the sonde ***vertically,*** take care to ensure the sonde is redeployed in same position. Often a marker pin inside a PVC pipe is used. In ***horizontal*** deployments, take care to ensure the redeployments are always in the same orientation. This is especially important for the EXO2 sonde because the depth sensor is off-axis.

To assist with consistent horizontal orientation, the EXO2 sonde has an indentation at the top of the sonde for a marker or positioning pin.



Depth Sensor Location relative to other water quality sensors (see EXO sonde label)

Depth Sensor Location
27.2 cm (EXO1), 13.9 cm (EXO2)
to WQ Sensors

The sonde should be installed with at least 1 cm of water above the intake ports. If a conductivity sensor is installed, the depth will be compensated automatically for changes in the density of water as temperature and salinity change.

Depth Configuration

EXO sondes must be ordered with a specific depth sensor option:

59950x-00 = no depth
59950x-01 = 0-10 m depth
59950x-02 = 0-100 m depth
59950x-03 = 0-250 m depth
59950x-04 = 0-10 m vented level

The depth configuration must be chosen at time of ordering. Once a sonde is shipped with a depth configuration it cannot be changed by the user.

Specifications

Units	PSI, Depth (m, ft, bar)
Temperature	
Operating	-5 to +50°C
Storage	-20 to +80°C
Range	*Shallow:* 0 to 33 ft (10 m) *Medium:* 0 to 328 ft (100 m) *Deep:* 0 to 820 ft (250 m) *Vented:* 0 to 33 ft (10 m)
Accuracy	*Shallow:* ±0.04% FS (±0.013 ft or ±0.004 m) *Medium:* ±0.04% FS (±0.13 ft or ±0.04 m) *Deep:* ±0.04% FS (±0.33 ft or ±0.10 m) *Vented:* ±0.03% FS (±0.010 ft or ±0.003 m)
Response	T63<2 sec
Resolution	0.001 ft (0.001 m)
Sensor Type	Stainless steel strain gauge

4.9 Depth and Level Calibration

NOTE: *This calibration option is available only if your sonde is equipped with an integral depth sensor or a vented level sensor.*

For the calibration, make certain that the depth sensor or vented level sensor is in air and not immersed in any solution. *Also, review the basic calibration description in section 4.2.*

In the Calibrate menu, select port D-Depth, then select Depth or Level from the second menu.

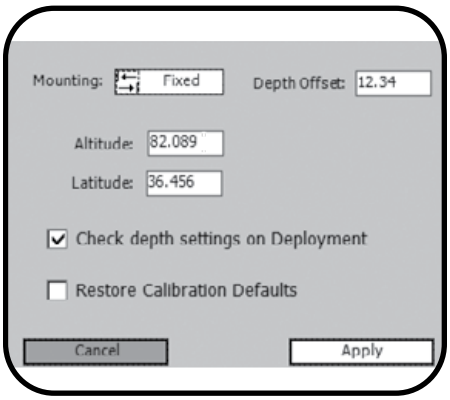
Click 1 Point for the Calibration Points. Enter 0 or go to the Advanced menu to enter a known sensor offset.

- If a depth offset is entered, the output value will shift by the value of the offset. Users may use an offset if referencing a water elevation against a known point.

Click Start Calibration. Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point. This process zeros the sensor with regard to current barometric pressure.

Click Exit to return to the sensor calibration menu, and then the back arrows to return to the Calibrate menu.

For best performance of depth measurements, users should ensure that the orientation of the sonde remains constant while taking readings. This is especially important for vented level measurements. Keep the sonde still and in one position while calibrating.



Advanced

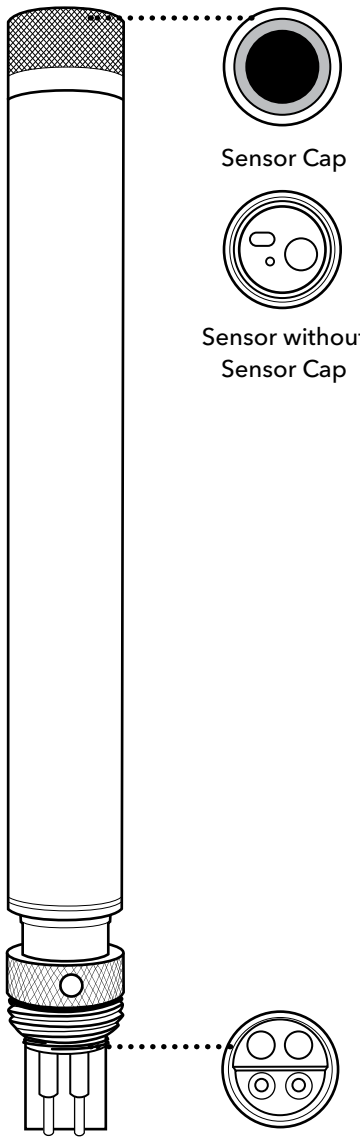
Mounting: Use the Advanced menu to select if a sonde will be mounted in a moving/profiling deployment instead of a fixed location.

Depth Offset: Enter a datum or barometric pressure offset at time of calibration. Barometric pressure offset allows the depth data to be post-processed for barometric pressure changes over the course of the deployment.

Altitude/Latitude: Enter the coordinates for the local altitude (in feet, relative to sea level) and latitude (in degrees) where the sonde is sampling. Latitude values are used in the calculation of depth or level to account for global variations in the gravitational field.

4.10 Dissolved Oxygen Sensor Overview

The principle of operation of the EXO optical dissolved oxygen sensor is based on the well-documented concept that dissolved oxygen quenches both the intensity and the lifetime of the luminescence associated with a carefully chosen chemical dye. The EXO DO sensor operates by shining a blue light of the proper wavelength on this luminescent dye which is immobilized in a matrix and formed into a disk. The blue light causes the immobilized dye to luminesce and the lifetime of this dye luminescence is measured via a photodiode in the probe. To increase the accuracy and stability of the technique, the dye is also irradiated with red light during part of the measurement cycle to act as a reference in the determination of the luminescence lifetime.



599100-01;
599110 sensor cap

When there is no oxygen present, the lifetime of the signal is maximal; as oxygen is introduced to the membrane surface of the sensor, the lifetime becomes shorter. Thus, the lifetime of the luminescence is inversely proportional to the amount of oxygen present and the relationship between the oxygen pressure outside the sensor and the lifetime can be quantified by the Stern-Volmer equation: **((Tzero/T) – 1) versus O_2 pressure**

For most lifetime-based optical DO sensors, this Stern-Volmer relationship is not strictly linear (particularly at higher oxygen pressures) and the data must be processed using analysis by polynomial non-linear regression. Fortunately, the non-linearity does not change significantly with time so that, as long as each sensor is characterized with regard to its response to changing oxygen pressure, the curvature in the relationship does not affect the ability of the sensor to accurately measure oxygen for an extended period of time.

(continued)

Specifications

Units	% Saturation, mg/L
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Range	0 to 500% air sat. 0 to 50 mg/L
Accuracy	0-200%: ±1% reading or 1% air sat., whichever is greater; 200-500%: ±5% reading 0-20 mg/L: ±1% of reading or 0.1 mg/L; 20-50 mg/L: ±5% reading
Response	T63<5 sec
Resolution	0.1% air sat. 0.01 mg/L
Sensor Type	Optical, luminescence lifetime

Variables that Affect DO Measurements

Variables that could affect dissolved oxygen measurements include temperature, salinity, and barometric pressure. Temperature and salinity are compensated for during instrument calibration and field use with the use of additional sensors and/or instrument software settings. Barometric pressure relates to the pressure of oxygen in the calibration environment, and barometric pressure changes due to a change in altitude or local weather. Generally the effect of barometric pressure is overcome by proper sensor calibration to a standard pressure. However, if the user measures dissolved oxygen in something besides percent saturation, then the EXO DO sensor can store a local barometric reading put into the KorEXO software (DO % local) or the EXO handheld can take a live barometric reading with its internal barometer (ODO % EU).

ODO % Sat = Raw DO reading corrected with temperature and local barometric pressure at the time of calibration: (local mmHg / 760 mmHg) x 100 = %Sat

ODO % Local = Raw DO reading corrected with temperature and % Sat output fixed to 100% regardless of barometric pressure entry. (The entered local barometric pressure is used by KorEXO software for mg/L calculations.)

ODO % EU = ODO % Sat reading corrected with live barometric reading (available only on EXO Handheld). Fixes the % Sat output to 100%, and conforms to British and EU standards.

4.11 Dissolved Oxygen Calibration

First review the basic calibration description in section 4.2.

ODO % sat and ODO % local – 1-point

Place the sonde with sensor into either water-saturated air or air-saturated water:
(a) Water-saturated air: Ensure there are no water droplets on the DO sensor or the thermistor. Place into a calibration cup containing about 1/8 inch of water that is vented by loosening the threads. (Do not seal the cup to the sonde.) Wait 10-15 minutes before proceeding to allow the temperature and oxygen pressure to equilibrate. Keep out of direct sunlight.
(b) Air-saturated water: Place into a container of water which has been continuously sparged with an aquarium pump and air stone for one hour. Wait approximately 5 minutes before proceeding to allow the temperature and oxygen pressure to equilibrate.

In the Calibrate menu, select ODO, then select ODO % sat or ODO % local. Calibrating in ODO % sat automatically calibrates ODO mg/L and ODO % local and vice versa.

Enter the current barometric pressure in mm of Hg (Inches of Hg x 25.4 = mm Hg).

> **NOTE:** *Laboratory barometer readings are usually "true" (uncorrected) values of air pressure and can be used "as is" for oxygen 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" (where the BP readings MUST be in mm Hg) is:
> True BP = [Corrected BP] – [2.5 * (Local Altitude in ft above sea level/100)]

Click 1 Point for the Calibration Points. Enter the standard value (air saturated).

Click Start Calibration. Observe the readings under Current and Pending data points and when they are Stable (or data show no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

mg/L – 1-point

Place the sonde with sensor in a container which contains a known concentration of dissolved oxygen in mg/L and that is within ±10% of air saturation as determined by one of the following methods:

- Winkler titration
- Aerating the solution and assuming that it is saturated
- Measurement with another instrument

NOTE: *Carrying out DO mg/L calibrations at values outside the range of ±10 % of air saturation is likely to compromise the accuracy specification of the EXO sensor. For highest accuracy, calibrate in % saturation.*

In the Calibrate menu, select ODO, then select ODO mg/L. Calibrating in ODO mg/L automatically calibrates ODO % sat and vice versa.

Click 1 Point for Calibration Points. Enter the known mg/L concentration for the standard value. Click Start Calibration. Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point. Click Complete.

Rinse the sonde and sensor(s) in tap or purified water and dry.

ODO % sat, ODO % local or mg/L – 2-point (or zero point)

Normally it is not necessary to perform a 2-point calibration for the DO sensor, and the procedure is not recommended unless (a) you are certain that the sensor does not meet your accuracy requirements at low DO levels and (b) you are operating under conditions where you are certain to be able to generate a medium which is truly oxygen-free.

For ODO % sat or ODO % local, calibrate your sonde at zero oxygen and in water-saturated air or air-saturated water. For ODO mg/L, calibrate your sonde at zero oxygen and a known concentration of oxygen within ±10% of air-saturation. The key to performing a 2-point calibration is to make certain that your zero-oxygen medium is truly oxygen-free:

- If you use nitrogen gas for the zero-point calibration, make certain that the vessel you use has a small exit port to prevent back diffusion of air and that you have completely purged the vessel before confirming the calibration.
- If you use sodium sulfite solution for the zero-point calibration, prepare the solution at a concentration of approximately 2 g/L at least two hours prior to use and keep it sealed in a bottle which does not allow diffusion of oxygen through the sides of the container. Transfer the sodium sulfite solution rapidly from its container to the calibration cup, fill the cup as full as possible with solution to minimize head space, and seal the cup to the sonde to prevent diffusion of air into the vessel.

Place the sonde with DO and temperature sensors in the zero-oxygen medium.

In the Calibrate menu, select ODO, then select either ODO % sat, ODO % local or ODO mg/L.

Click 2 Point for the Calibration Points. Enter Zero Point as the value of the first standard.

Click Start Calibration. Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

- If you used sodium sulfite solution as your zero calibration medium, you must thoroughly remove all traces of the reagent from the probes and wiper prior to proceeding to the second point. We recommend that the second calibration point be in air-saturated water if you use sodium sulfite solution.

Next place the sensors in the medium containing a known oxygen pressure or concentration and wait at least 10 minutes for temperature equilibration. Click Proceed in the pop-up window. Then enter either the barometer reading in mm Hg (for ODO %) or the actual concentration of oxygen as determined from a Winkler titration (for ODO mg/L), for instance. Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

NOTE: *Carrying out DO mg/L calibrations at values outside the range of ±10 % of air saturation is likely to compromise the accuracy specification of the EXO sensor. For highest accuracy, calibrate in % saturation.*

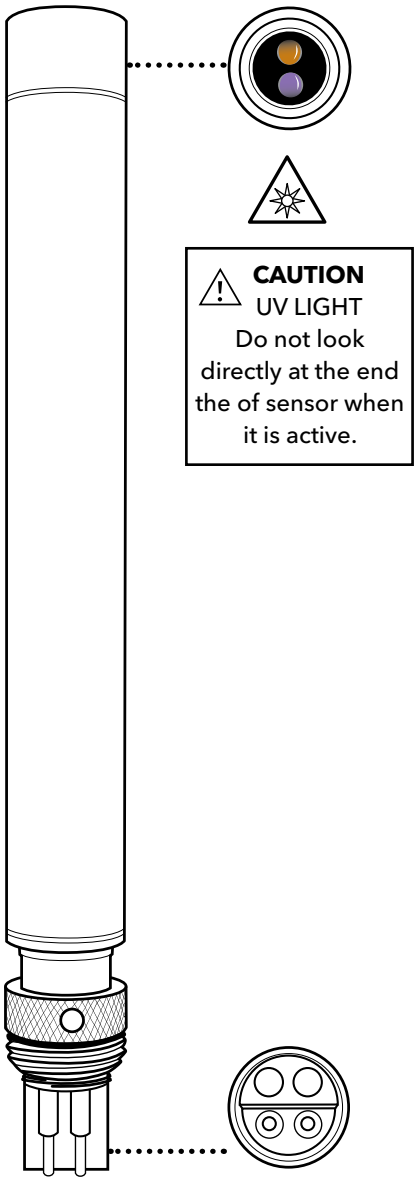
Rinse the sonde and sensor(s) in tap or purified water and dry.

4.12 fDOM Sensor Overview

The EXO fDOM (Fluorescent Dissolved Organic Matter) sensor detects the fluorescent component of DOM (Dissolved Organic Matter) when exposed to near-ultraviolet (UV) light.

Colored Dissolved Organic Matter

Users might wish to quantify ***colored*** dissolved organic matter (CDOM) in order to determine the amount of light which is absorbed by stained water and thus is not available for photosynthesis. In most cases, fDOM can be used as a surrogate for CDOM.



599104-01

Quinine Sulfate

A surrogate for fDOM is quinine sulfate, which, in acid solution, fluoresces similarly to dissolved organic matter. The units of fDOM are quinine sulfate units (QSUs) where 1 QSU = 1 ppb quinine sulfate and thus quinine sulfate is really an indirect surrogate for the desired CDOM parameter.

The EXO fDOM sensor shows virtually perfect linearity (R^2=1.0000) on serial dilution of a colorless solution of quinine sulfate. However, on serial dilution of stained water field samples, the sensor shows some underlinearity. The point of underlinearity in field samples varies and is affected by the UV absorbance of the DOM in the water. Testing shows that underlinearity can occur at fDOM concentrations as low as 50 QSU. This factor means that a field sample with an fDOM reading of 140 QSU will contain significantly more than double the fDOM of a sample that reads 70 QSU. This effect—good linearity in colorless quinine sulfate solution, but underlinearity in stained field samples—is also exhibited by other commercially available fDOM sensors and thus the performance of the EXO sensor is likely to be equivalent or better than the competition while providing the advantages of easy integration into a multiparameter package and automatic mechanical cleaning when used in monitoring studies with an EXO2 sonde.

Specifications

Units	Quinine Sulfate Units (QSU), ppb
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Range	0 to 300 ppb QSU
Response	T63<2 sec
Resolution	0.01 ppb QSU
Sensor Type	Optical, fluorescence
Linearity	R^2>0.999 for serial dilution of 300 ppb Quinine Sulfate solution
Detection Limit	0.07 ppb QSU
Optics: Excitation	365±5 nm
Emission	480±40 nm

4.13 fDOM Calibration Standards

Quinine Sulfate Solution for fDOM Sensor

⚠ **WARNING:** Before using a quinine sulfate reagent (solid or solution) or sulfuric acid reagent, read the safety instructions provided by the supplier. Take extra precautions when making dilutions of concentrated sulfuric acid, as this reagent is particularly dangerous. Remember that only trained personnel should handle chemicals.

Preparation

Use the following procedure to prepare a 300 µg/L solution of quinine sulfate (300 QSU) that can be used to calibrate the EXO fDOM sensor for field use:

1. Purchase solid quinine sulfate dihydrate (CAS# 6119-70-6) with a high purity (>99%).
2. Purchase 0.1 N (0.05 M) sulfuric acid (CAS# 7664-93-3), to avoid the hazards of diluting concentrated sulfuric acid to make this reagent.
3. Weigh 0.100 g of solid quinine sulfate dihydrate and quantitatively transfer the solid to a 100-mL volumetric flask. Dissolve the solid in about 50 mL of 0.05 M (0.1 N) sulfuric acid (H_2SO_4), dilute the solution to the mark of the volumetric flask with additional 0.05 M sulfuric acid, and mix well by repeated inversion. This solution is 1000 ppm in quinine sulfate (0.1%).
4. Transfer 0.3 mL of the 1000 ppm solution to a 1000 mL volumetric and then fill the flask to the top graduation with 0.05 M sulfuric acid. Mix well to obtain a solution of 300 µg/L (300 QSU or 100 RFU).
5. Store the concentrated standard solution in a darkened glass bottle in a refrigerator to retard decomposition. The dilute standard prepared in the previous step should be used within 5 days of preparation and should be discarded immediately after exposure to EXO's metal components.

Degradation of quinine fluorescence by copper and chloride

NOTICE: Exposure of the quinine sulfate solution to any copper-based component of the EXO sonde and sensors (primarily the wiper assembly) will begin to degrade the solution significantly within minutes. Quinine fluorescence is also degraded by the presence of chloride or halide ions, found in estuarine or seawater, conductivity standards, and Zobell solution. Thus, clean your sensors thoroughly and perform your calibration as quickly as possible on immersion of the sensors into the quinine sulfate solution. Discard the used standard. When quinine sulfate standards are required in the future, perform another dilution of the concentrated solution.

Effect of temperature on fluorescence

The intensity of the fluorescence of many dyes shows an inverse relationship with temperature. This effect must be accounted for when calibrating the EXO fDOM sensor with quinine sulfate solution. Enter the QSU or RFU value from the table below that corresponds to the temperature of the standard.

Temp (˚C)	RFU	QSU	Temp (˚C)	RFU	QSU
30	96.4	289.2	18	101.8	305.4
28	97.3	291.9	16	102.7	308.1
26	98.2	294.6	14	103.6	310.8
24	99.1	297.3	12	104.6	313.8
22	100	300	10	105.5	316.5
20	100.9	302.7	8	106.4	319.2

4.14 fDOM Calibration

Review the basic calibration description in section 4.2.
Before calibrating, be certain that the sensing window is clean *(cleaning instructions, section 5.8)*.

This procedure calibrates fDOM RFU or fDOM QSU/ppb. If the user has both units selected, then this procedure must be performed twice, once for each unit, to completely calibrate the parameter.

For 2-point calibrations, the first standard must be clear water (0 µg/L). The second standard should be a 300 µg/L quinine sulfate solution. *(For detailed instructions for mixing this solution, see section 4.13.)*

NOTICE: Do not leave sensors in quinine sulfate solution for a long time. A chemical reaction occurs with the copper on the sonde (wiper assembly, sonde bulkhead, copper tape) that degrades the solution and causes it to drift. Also, start with very clean sensors, as the presence of chloride and halide ions (from estuarine or seawater, conductivity standards, and Zobell solution) can compromise QS fluorescence.

QSU – 1- or 2-point

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water.

In the Calibrate menu, select fDOM, then select QSU/ppb. Select either a 1- or 2-point calibration. Enter 0 for first standard value and 300 µg/L for second standard value.

Click Start Calibration. Observe the readings under Current and Pending data points, and when they are Stable, click Apply to accept this calibration point.

Remove the central wiper from the EXO2 sonde before proceeding to the next step.

Next place the sensors in the correct amount of 300 µg/L quinine sulfate standard in the calibration cup. Click Proceed on the pop-up window. Observe the readings under Current and Pending data points. While stabilizing, verify that no air bubbles reside on the sensing face of the sensor. If there are bubbles, gently shake or move the sensor to dislodge. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

RFU – 1- or 2-point

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water.

In the Calibrate menu, select fDOM, then select RFU. Select either a 1- or 2-point calibration. Enter 0 for first standard value and 100 RFU for second standard value.

Click Start Calibration. Observe the readings under Current and Pending data points, and when they are Stable, click Apply to accept this calibration point.

Remove the central wiper from the EXO2 sonde before proceeding to the next step.

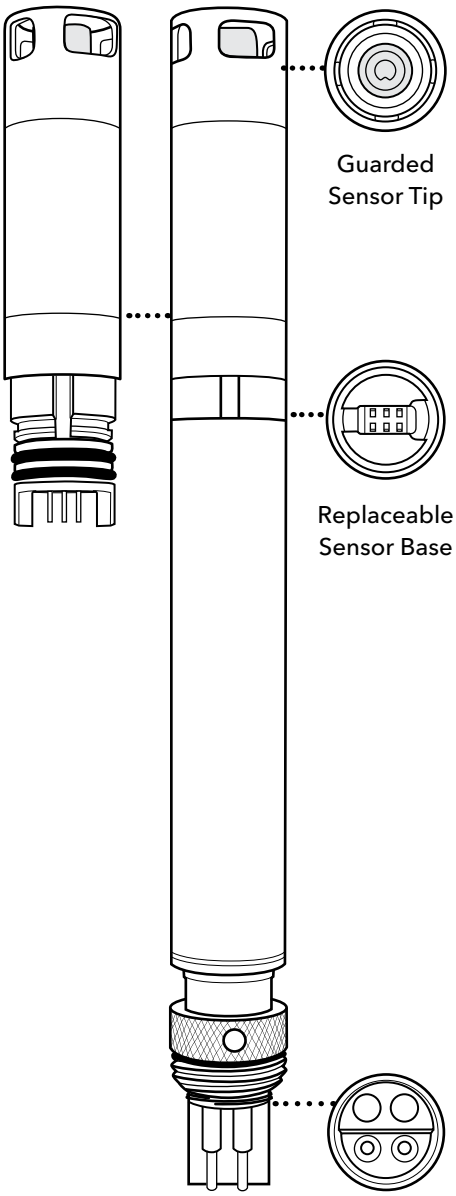
Next place the sensors in the 300 µg/L quinine sulfate standard in the calibration cup. Click Proceed on the pop-up window. Observe the readings under Current and Pending data points. While stabilizing, verify that no air bubbles reside on the sensing face of the sensor. If there are bubbles, gently shake or move the sensor to dislodge. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu. Rinse the sonde in tap or purified water and dry the sonde. Discard the used standard.

4.15 ISEs: Ammonium, Nitrate, & Chloride Sensors Overview

NOTE: ***Ammonium, nitrate, and chloride ion-selective electrodes (ISEs) should be used in freshwater applications only at depths of less than 55 feet (17 meters) and less than 25 psi.*** The ammonium and nitrate sensors use a silver/silver chloride wire electrode in a custom filling solution. The internal solution is separated from the sample medium by a polymer membrane, which selectively interacts with ammonium or nitrate ions. When the sensor is immersed in water, a potential is established across the membrane that depends on the relative amounts of ions in the sample and the internal solution. This potential is read relative to the Ag/AgCl reference electrode.

(continued)



599709, 599710, 599711;
599743-01, 599744-01, 599745-01 modules

Specifications

Ammonium - NH_4

Units	mg/L-N, millivolts
Temperature *Operating* *Storage*	 0 to 30˚C 0 to 30°C
Depth	0 to <55 ft (0 to <17 m)
Range	0 to 200 mg/L-N
Accuracy	±10% of reading or ±2 mg/L-N, whichever is greater
Response	T63<30 sec
Resolution	0.01 mg/L
Sensor Type	Ion-selective electrode
Conductivity	<1500 µS/cm

Nitrate - NO_3

Units	mg/L-N, millivolts
Temperature *Operating* *Storage*	 0 to 30˚C 0 to 30°C
Depth	0 to <55 ft (0 to <17 m)
Range	0 to 200 mg/L-N
Accuracy	±10% of reading or ±2 mg/L-N, whichever is greater
Response	T63<30 sec
Resolution	0.01 mg/L
Sensor Type	Ion-selective electrode
Conductivity	<1500 µS/cm

(Specs. continued)

Specifications *(continued)*

Chloride - Cl

Units	mg/L-Cl, millivolts
Temperature *Operating* *Storage*	 0 to 30˚C 0 to 30°C
Depth	0 to <55 ft (0 to <17 m)
Range	0 to 18000 mg/L-Cl
Accuracy	±15% of reading or ±5 mg/L-Cl, whichever is greater
Response	T63<30 sec
Resolution	0.01 mg/L
Sensor Type	Ion-selective electrode
Salinity	30 psu

NOTE: Qualification testing for chloride was performed in a stirred calibration solution. Due to the solid state nature of the chloride ISE, the sensor exhibits moderate flow dependence. Mitigation can be achieved by stirring during calibration.

The chloride sensor uses a solid-state membrane attached to a conductive wire. This sensor operates in a similar fashion to the ammonium and nitrate sensors.

For all ISEs, the linear relationship between the logarithm of the ammonium, nitrate or chloride activity and the observed voltage, as predicted by the Nernst equation, is the basis for the determination.

Ammonium is calculated from the pH, salinity, and temperature readings. If a pH sensor is not in use, the instrument will assume the sample is neutral (pH 7) for the calculation. If a conductivity sensor (salinity) is not in use, the instrument will use the salinity correction value entered in the ammonium sensor calibration screen for the calculation.

Replaceable Sensor Module

The EXO ammonium, chloride, and nitrate sensors have a unique design that incorporates a user-replaceable sensor tip (module) and a reusable sensor base that houses the processing electronics, memory, and wet-mate connector. This allows users to reduce the costs associated with these sensors by only replacing the relatively inexpensive module periodically and not the more costly base.

The connection of the module to the sensor base is designed for one connection only and the procedure must be conducted in an indoor and dry environment. Once installed the module cannot be removed until you are prepared to replace it with a new module.
See section 5.16 for detailed instructions.

The typical life expectancy of an ISE sensor is three to six months, depending on use.

Precautions

- ISEs are intended for sampling purposes and **must** be calibrated frequently due to sensor drift.
- ISEs can be used in long-term deployments for qualitative trends. Use with an EXO wiper will deform the brush over time and may require more frequent brush replacement. The brush deformation may intensify with the fouling present in the monitored environment.
- ISE sensors only come in guarded configurations. Customers should not remove the plastic guard that protects the ISE membrane.
- For long-term deployments, sensor data should be compared to that of grab samples throughout the monitoring period to note drift.

For a full list of precautions see the end of section 4.16

4.16 ISEs: Ammonium, Nitrate, & Chloride Calibration

This procedure calibrates the EXO ammonium, chloride, or nitrate sensor. The sensors can be calibrated to one, two or three points. The 3-point calibration method assures maximum accuracy when the temperature of the media to be monitored cannot be anticipated; we strongly recommend a 3-point calibration for best performance of ISE sensors. Review the basic calibration description in section 4.2.

The temperature response of ion-selective electrodes is not as predictable as that of pH sensors. Therefore, be sure to carry out a 3-point calibration the first time you use the sensor. This will provide a default setting for the effect of temperature on your sensor. After this initial calibration, you can use the less time-consuming 2-point and 1-point routines to update the 3-point calibration. However, we strongly recommend a new 3-point calibration after each deployment of 30 days or longer.

Due to the nature of ion-selective electrodes, it is recommended that they be used for sampling purposes for the greatest accuracy. Using an ISE in long-term deployments is possible, but it's important to note that drift occurs over an extended period of time. Collecting grab samples from the site is encouraged to correct for drift. Additionally, sample readings should be taken after sensors have fully stabilized. Calibrating in a continuously stirred solution from 1 to 5 minutes has shown to improve sensor performance. For best performance sensors should be calibrated as close to the expected field conditions as possible.

For more ISE precautions, drift, and accuracy notes please see "ISE Precautions" at the end of this section.

1-point

Select the 1-point option only if you are adjusting a previous calibration. If a 2-point or 3-point calibration has been performed previously, you can adjust the calibration by carrying out a 1-point calibration.

2-point

Select the 2-point option to calibrate the ammonium sensor using only two calibration standard solutions. In this procedure, the ammonium sensor is calibrated using a 1 mg/L NH_4^+-N and 100 mg/L NH_4^+-N calibration standard solutions. A 2-point calibration procedure (as opposed to a 3-point procedure) can save time if the temperature range of the media being monitored is known and stable.

3-point

Select the 3-point option to calibrate the ammonium sensor using three calibration standard solutions, two at ambient temperature and one at a temperature substantially different from ambient. The 3-point calibration method should be used to assure maximum accuracy when the temperature of the media to be monitored cannot be anticipated. 3-point calibration temperatures should span the range of interest, for example 20°C and 2°C for "cold" and 20°C and 30°C for "hot". The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to place the sensor in the additional calibration standard solution to complete the 3-point procedure. Be certain that the calibration standard solution and sensor are thermally equilibrated prior to proceeding with the calibration. The recommended order of calibration standards is (1) 1 mg/L NH_4^+-N standard at ambient temperature, (2) 100 mg/L NH_4^+-N standard at ambient temperature, and (3) 1 mg/L NH_4^+-N standard at a different temperature (usually lower) than ambient, ±10°C minimum.

- To save time during calibration, chill/heat a sufficient amount of 1 mg/L NH_4^+-N calibration standard solution prior to the start of calibration.

Ammonium Pre-calibration

Soaking

EXO Ammonium Sensors are shipped in a container that holds a sponge soaked in 100 mg/L ammonium standard solution. Before initial use the sensor membrane needs to be soaked in 100 mg/L ammonium standard solution (YSI part #003843). Most users find it useful to soak the sensors overnight; shorter soaking times may be used if the sensor output is monitored and is fully stabilized.

In addition to initially soaking the sensor, users may also see improved performance if the ammonium sensor is soaked in 100 mg/L solution after field deployments. This process helps remove any interfering ions from the sensor membrane. After the activation process the sensor should be rinsed thoroughly and the following calibration precautions should be observed.

The ammonium sensor should be calibrated using solutions of known total ammonium-nitrogen content or YSI Standards.

part #003841	1 mg/L
part #003842	10 mg/L
part #003843	100 mg/L

If a two point calibration protocol is used, the temperature of the standards should be as close as possible to that of the environmental medium to be monitored. The recommended calibration procedure is one involving three solutions. Two of the solutions should be at ambient temperature while the third should be at least 10˚C different from ambient temperature. This protocol minimizes the effects of taking readings at temperatures that are significantly different from ambient laboratory temperatures.

Calibration Tip

Exposure to the high ionic content of pH buffers can cause a significant, but temporary, drift in the Ammonium, Nitrate, and Chloride sensors. Therefore, when calibrating the pH/ORP probe, YSI recommends that you use one of the following methods to minimize errors in the subsequent readings:

1. Calibrate pH first, immersing all of the probes in the pH buffers. After calibrating pH, place the probes in 100 mg/L nitrate or ammonium standard or 1000 mg/L chloride standard and monitor the reading. Usually, the reading starts low and may take as long as 30 minutes to reach a stable value. When it does, proceed with calibration of the ISE sensor.

2. When calibrating pH, remove ISE modules from the sonde bulkhead and plug the ports. After pH calibration is complete, replace the ISE sensors and proceed with their calibration with no stabilization delay.

Despite the potential problems with interference when using ISEs, it is important to remember that almost all interfering species produce an artificially high ammonium reading. Thus, if the sonde indicates the presence of only small quantities of ammonium, it is unlikely that the reading is erroneously low because of interference. Unusually high ammonium readings (which could be due to interfering ions) should be confirmed by laboratory analysis after collection of water samples.

Ammonium 3-point

NOTICE: Do not expose electrodes to high-conductivity solutions. Exposure will reduce data quality and response of the sensors. During calibration of other sensors, remove the ISEs to avoid exposing them to conductivity standards, Zobell solution, pH buffer, or any solution with significant conductivity.

In the Calibrate menu, select ISE, then select ammonium.

Click 3-point for the Calibration Points. Enter 1 mg/L as the value of the first standard, 100 mg/L as the value of the second standard, and 1 mg/L as the value of the third standard.

Click Start Calibration.

Pour a sufficient amount of 1 mg/L NH_4^+ -N calibration standard solution at ambient temperature in a clean and dry or pre-rinsed calibration cup. Carefully immerse the sensor end of the sonde into the solution, making sure the sensor's tip is in solution by at least 1 cm. Allow at least 1 minute for temperature equilibration before proceeding.

Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point. Confirm that the Pending data value is close to the Setpoint value. Click Proceed and wait for the software to prompt you to move the sensor to the next calibration standard solution.

Rinse the sensors in deionized water between changes of the calibration solutions. Pour a sufficient amount of 100 mg/L of NH_4^+ -N calibration standard solution at ambient temperature into a clean, dry or pre-rinsed calibration cup and carefully immerse the sensor end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point. Confirm that the Pending data value is close to the Setpoint value. Click Proceed and wait for the software to prompt you to move the sensor to the next calibration standard solution.

Rinse the sensors in deionized water between changes of the calibration solutions. Immerse the sensor end of the sonde in the pre-chilled 1 mg/L NH_4^+ -N calibration standard solution ensuring that the temperature is at least 10°C different than ambient. Allow at least 1 minute for temperature equilibration before proceeding.

Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Confirm that the Pending data value is close to the Setpoint value.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu

Rinse the sonde in tap or purified water.

Nitrate 3-point

The calibration procedure for nitrate is identical to the procedure for ammonium, except that the calibration standard solution values are in mg/L NO_3^--N instead of NH4+ -N.

Chloride 3-point

The calibration procedure for chloride is identical to the procedure for ammonium and nitrate, except that the calibration standard solution values are in mg/L Cl^- instead of NH_4^+-N or NO_3^--N. YSI recommends that the user employ standards for chloride that are 10 times greater than for ammonium and nitrate and that span the expected deployment conditions. Typical calibration ranges are 10mg/L Cl^- and 1000mg/L Cl^- or 1000mg/L Cl^- and 18000mg/L Cl^-.

Chloride Standard for Chloride Sensor

⚠ **WARNING:** Read and follow all the safety instructions and MSDS documentation supplied with the chemical before proceeding. Remember that only trained personnel should handle hazardous chemicals.

Preparation

Use the following procedure to prepare 10 and 1000 mg/L chloride reagents for the EXO Chloride sensor. (Nitrate and Ammonium standards can be purchased from YSI or other laboratory supply companies.)

10 mg/L Standard

1. Accurately measure 10 mL of the above 1000 mg/L standard solution into a 1000 mL volumetric flask.
2. Add 0.5 grams of anhydrous magnesium sulfate to the flask.
3. Add 500 mL of 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.
4. Rinse the flask extensively with water prior to its use in the preparation of the 1000 mg/L standard.

1000 mg/L Standard

1. Purchase solid sodium chloride from a supplier.
2. Accurately weigh 1.655 grams of anhydrous sodium chloride and transfer into a 1000 mL volumetric flask.
3. Add 0.5 grams of anhydrous magnesium sulfate to the flask.
4. Add 500 mL of water to the flask, swirl to dissolve all of the reagents. Dilute to the volumetric mark with water. Mix well by repeated inversion and then transfer the 1000 mg/L standard to a storage bottle.

   Alternatively, simply add 0.5 grams of magnesium sulfate to a liter of a 1000 mg/L chloride standard from a certified supplier.

Sensor Drift

The ion-selective electrodes have the greatest tendency to exhibit calibration drift over time. This drift should not be a major issue for sampling studies where the instrument can be frequently calibrated. However, if the sensor is used in longer-term deployments, drift is almost certain to occur. The extent of the drift will vary depending on the age of the probe, the flow rate at the site, and the quality of the water. For all monitoring studies using ion-selective electrodes, the user should acquire a few grab samples during the deployment for analysis in the laboratory or with another sensor that has been recently calibrated.

Sensor Accuracy Specifications

The typical accuracy specification for the sensors (+/-10% of reading or 2 mg/L which ever is greater for ammonium and nitrate and ±15% of reading or 5 mg/L which ever is greater for chloride) refer to sampling applications where only minimal time has elapsed between calibration and field use.

To maintain accuracy specifications for EXO sensor, we recommend that users calibrate sensors in the lab in standards with temperatures as close to the ambient temperature of the field water as possible.

All ion-selective electrodes are subject to the interaction of species with the sensor membrane, which are similar in nature to the analyte. These interfering species thus include other halide ions (fluoride, bromide, and iodide) as well as other anions.

Despite the potential problems with interference when using ISEs, it is important to remember that almost all interfering species produce an artificially high reading. Thus, if the sensor indicates the presence of only small quantities, it is unlikely that the reading is erroneously low because of interference. Unusually high readings (which could be due to interfering ions) should be confirmed by laboratory analysis after collection of water samples.

ISE Precautions

Ion-selective electrodes may not stabilize as rapidly as pH sensors. Be sure to allow plenty of time for the readings to come to their final values during all calibration routines.

Ion-selective electrodes generally drift more than pH sensors. To check for this drift, read the sensor's value in a calibration standard solution at the end of each deployment.

Ammonium and nitrate standards are good growth media for a variety of microorganisms. This growth can significantly reduce the nitrogen content of your standards, an effect that is particularly important for the 1 mg/L solution. It is best to use new standards for each calibration, but if you decide to save your solutions for reuse, we recommend refrigerated storage to minimize the growth of these organisms.

Remember that the ammonium, nitrate, and chloride sensors will take longer to stabilize after exposure to high conductivity solutions such as a pH buffer. To accelerate the recovery process, soak the sensor in 100 mg/L ammonium or nitrate standard solution or 1000 mg/L Cl- standard solution for a few minutes after exposure. In addition, be particularly careful that readings are stable during subsequent calibrations.

Of all the sensors available on the sonde, ion selective electrodes have the greatest tendency to exhibit calibration drift over time. This drift should not be a major problem for sampling studies where the instrument can be frequently calibrated. However, if an ammonium sensor is used in a longer-term deployment study with the sonde, the user should be aware that drift is almost certain to occur. The extent of the drift will vary depending on the age of the probe, the flow rate at the site, and the quality of the water. For all monitoring studies using ion selective electrodes, the user should acquire a few "grab samples" during the course of the deployment for analysis in the laboratory by chemical means or with another ammonium sensor which has been recently calibrated. Remember that the typical accuracy specification for the sensor (+/- 10 % of the reading or 2 mg/L, whichever is larger) refers to sampling applications where only minimal time has elapsed between calibration and field use.

Many users find it useful to swap Ammonium sensors after 30 days of deployment with freshly calibrated sensors. On the EXO platform the calibration is retained inside the sensor, so they can be calibrated in the lab and installed in the field.

4.17 pH and ORP Sensor Overview

Users can choose between a pH sensor or a combination pH/ORP sensor to measure these parameters. pH describes the acid and base characteristics of water. A pH of 7.0 is neutral; values below 7 are acidic; values above 7 are alkaline. ORP designates the oxidizing-reducing potential of a water sample and is useful for water which contains a high concentration of redox-active species, such as the salts of many metals and strong oxidizing (chlorine) and reducing (sulfite ion) agents. However, ORP is a non-specific measurement—the measured potential is reflective of a combination of the effects of all the dissolved species in the medium. Users should be careful not to overinterpret ORP data unless specific information about the site is known.

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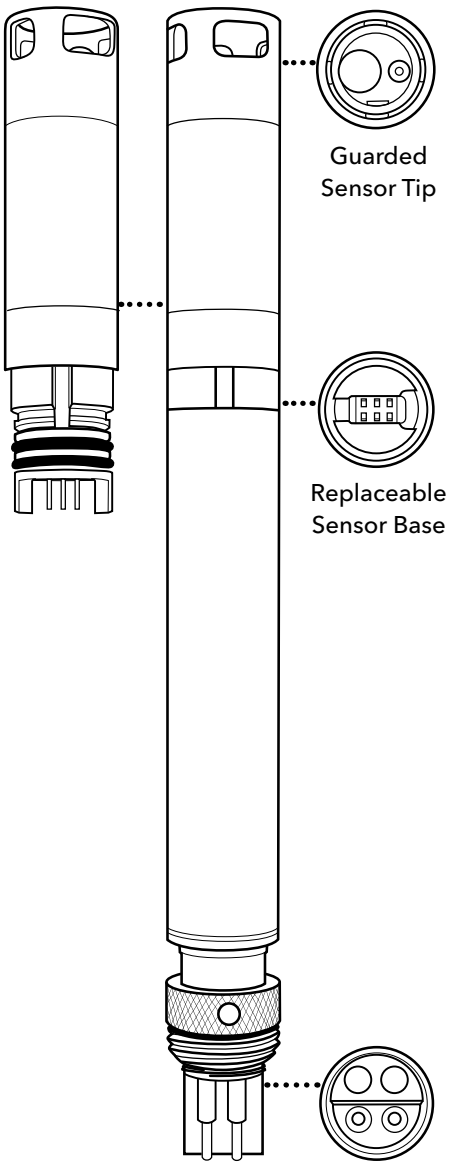

599701, 599702, 599705, 599706; 599795-01, 599795-02, 599797-01, 599797-02 modules

Specifications

pH

Units	pH units
Temperature *Operating* *Storage*	 -5 to +50°C 0 to 60°C
Range	0 to 14 units
Accuracy	±0.1 pH units within ±10°C of calibration temperature; ±0.2 pH units for entire temp range
Response	T63<3 sec
Resolution	0.01 units
Sensor Type	Glass combination electrode

ORP

Units	millivolts
Temperature *Operating* *Storage*	 -5 to +50°C 0 to 60°C
Range	-999 to +999 mV
Accuracy	±20 mV in Redox standard solution
Response	T63<5 sec
Resolution	0.1 mV
Sensor Type	Platinum button

Replaceable Sensor Module

The EXO pH and pH/ORP sensors have a unique design that incorporates a user-replaceable sensor tip (module) and a reusable sensor base that houses the processing electronics, memory, and wet-mate connector. This allows users to reduce the costs associated with pH and pH/ORP sensors by only replacing the relatively inexpensive module periodically and not the more costly base.

The connection of the module to the sensor base is designed for one connection only and the procedure must be conducted in an indoor and dry environment. Once installed the module cannot be removed until you are prepared to replace it with a new module. *See section 5.16 for detailed instructions.*

Users must order either a pH or pH/ORP sensor. Once ordered the sensor is ***only*** compatible with like-model sensor modules. For example, if a pH sensor is purchased initially, then the user must order a replaceable pH sensor module in the future; it cannot be replaced with a pH/ORP module.

Electrodes

EXO measures pH with two electrodes combined in the same probe: one for hydrogen ions and one as a reference. The sensor is a glass bulb filled with a solution of stable pH (usually 7) and the inside of the glass surface experiences constant binding of H^+ ions. The outside of the bulb is exposed to the sample, where the concentration of hydrogen ions varies. The resulting differential creates a potential read by the meter versus the stable potential of the reference.

The ORP of the media is measured by the difference in potential between an electrode which is relatively chemically inert and a reference electrode. The ORP sensor consists of a platinum button found on the tip of the probe. The potential associated with this metal is read versus the Ag/AgCl reference electrode of the combination sensor that utilizes gelled electrolyte. ORP values are presented in millivolts and are not compensated for temperature.

Signal Quality

Signal conditioning electronics within the pH sensor module improve response, increase stability, and reduce proximal interference during calibration. Amplification (buffering) in the sensor head is used to eliminate any issue of humidity in the front-end circuitry and reduce no .

4.18 pH Calibration

1-point

Select the 1-point option to calibrate the pH probe using one calibration standard.
NOTE: *While a 1-point pH calibration is possible, YSI recommends using a 2 or 3-point calibration for greater accuracy.*

2-point

Select the 2-point option to calibrate the pH probe using two calibration standards. In this procedure, the pH sensor is calibrated with a pH 7 buffer and a pH 10 or pH 4 buffer depending upon your environmental water. A 2-point calibration can save time (versus a 3-point calibration) if the pH of the media to be monitored is known to be either basic or acidic.

3-point

Select the 3-point option to calibrate the pH probe using three calibration standards. In this procedure, the pH sensor is calibrated with a pH 7 buffer and both the pH 10 and the pH 4. The 3-point calibration method assures maximum accuracy when the pH of the media to be monitored cannot be anticipated.

Review the basic calibration description in section 4.2.

Pour the correct amount of pH buffer in a clean and dry or pre-rinsed calibration cup. Carefully immerse the probe end of the sonde into the solution, making sure the sensor's glass bulb is in solution by at least 1 cm. Allow at least 1 minute for temperature equilibration before proceeding.

In the Calibrate menu, select pH or pH/ORP, then select pH.

Select the number of points desired for the calibration. Enter the value(s) of the pH buffer(s) that will be used for the calibration.

> **NOTE:** *Observe the temperature reading above the standard value.* The actual pH value of all buffers varies with temperature. Enter the correct value from the bottle label for your calibration temperature for maximum accuracy. For example, the pH of one manufacturer's pH 7 Buffer is 7.00 at 25˚C, but 7.02 at 20˚C.
> If no temperature sensor is installed, user can manually update temperature by entering a value.

Click Start Calibration. Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point. Confirm that the Pending data value is close to the Setpoint value. Click Proceed and wait for the software to prompt you to move the sensor to the next standard solution.

Rinse the sensor in deionized water. Pour the correct amount of the next pH buffer standard into a clean, dry or pre-rinsed calibration cup, and carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Repeat the calibration procedure and click Apply when the data are stable. Rinse the sensor and pour the next pH buffer, if necessary. Repeat calibration procedure for the third point and click Apply when data are stable.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

Rinse the sonde and sensors in tap or purified water and dry.

4.19 ORP Calibration

Review the basic calibration description in section 4.2.

Pour the correct amount of standard with a known oxidation reduction potential value (we recommend Zobell solution) in a clean and dry or pre-rinsed calibration cup. Carefully immerse the probe end of the sonde into the solution.

In the Calibrate menu, select pH/ORP, then select ORP mV.

Click Start Calibration. Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

NOTICE: Do not leave sensors in Zobell solution for a long time. A chemical reaction occurs with the copper on the sonde (sonde bulkhead, central wiper assembly, copper tape). While the reaction does not impact calibration, it will degrade the sonde materials over time. Discard the used standard.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

Rinse the sonde in tap or purified water and dry the sonde.

Effect of temperature on ORP

The oxidation reduction potential value shows an inverse relationship with temperature. This effect must be accounted for when calibrating the EXO ORP sensor with Zobell solution. Enter the mV value from the table below that corresponds to the temperature of the standard.

Temp (˚C)	mV	Temp (˚C)	mV
-5	270.0	25	231.0
0	263.5	30	224.5
5	257.0	35	218.0
10	250.5	40	211.5
15	244.0	45	205.0
20	237.5	50	198.5

4.20 Total Algae (Chl & BGA) Sensor Overview

The EXO total algae sensor is a dual-channel fluorescence sensor that generates two independent data sets; one resulting from a blue excitation beam that diexcites the chlorophyll ***a*** molecule, present in all photosynthetic cells, and a second from an orange excitation beam that excites the phycocyanin accessory pigment found in blue-green algae (cyanobacteria). This excitation triggers a transfer of energy from the phycocyanin to the central chlorophyll ***a***, where photosynthesis is initiated.

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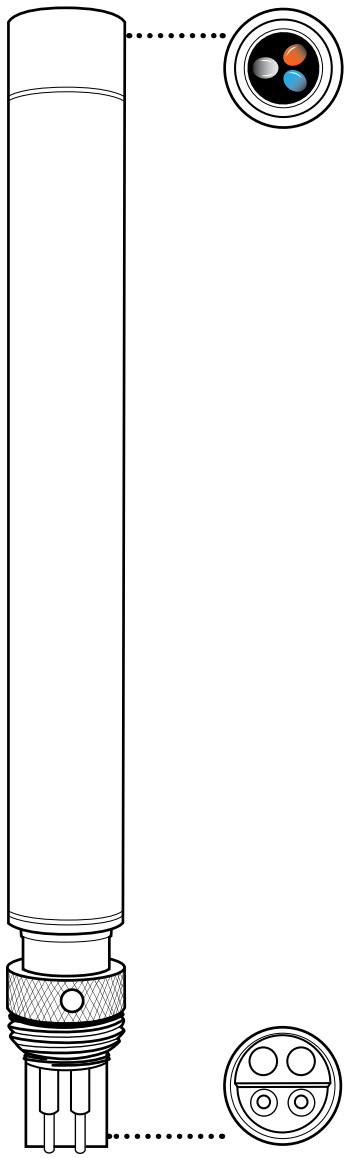


599102-01 (Phycocyanin)
599103-01 (Phycoerythrin)

Specifications

Units	
Chlorophyll	RFU, µg/L Chl
BGA-PC	RFU, µg/L PC
BGA-PE	RFU, µg/L PE
Temperature	
Operating	-5 to +50°C
Storage	-20 to +80°C
Range	*Chl:* 0-100 RFU, 0-400 µg/L Chl*; *BGA-PC:* 0-100 RFU, 0-100 µg/L*; *BGA-PE:* 0-100 RFU, 0-280 µg/L*
Response	T63<2 sec
Resolution	*Chl:* 0.01 RFU, 0.01 µg/L Chl; *BGA-PC:* 0.01 RFU, 0.01 µg/L; *BGA-PE:* 0.01 RFU, 0.01 µg/L
Sensor Type	Optical, fluorescence
Linearity	*Chl:* R^2>0.999 for serial dilution of Rhodamine WT solution from 0-400 µg/L Chl equivalents *BGA-PC:* R^2>0.999 for serial dilution of Rhodamine WT solution from 0-100 µg/L PC equivalents; *BGA-PE:* R^2>0.999 for serial dilution of Rhodamine WT solution from 0-280 µg/L PE equivalents
Optics: Chl Excitation	470±15 nm
PC Excitation	590±15 nm
PE Excitation	525±15 nm
Emission	685±20 nm

*Pigment concentration ranges of algae sensors were determined in monocultures of specific algae species. This range will vary depending on algae assemblage and environmental conditions. For accurate pigment concentration estimates at particular sites or samples, the user must determine the RFU to pigment concentration relationship on a site-by-site basis.

Although blue-green algae contain chlorophyll ***a***, the chlorophyll fluorescence signal detected by ***in situ*** fluorometers is weaker than in eukaryotic phytoplankton. This results in an underestimate of algae biomass when using a single-channel chlorophyll sensor when blue-green algae are present. The EXO total algae sensor generates a more accurate total biomass estimate of the planktonic autotrophic community by exciting chlorophyll ***a***, and phycocyanin or phycoerythrin.

The sensor generates data in three formats: RAW, RFU, and an estimate of the pigment concentration in µg/L.

The RAW value is a value unaffected by user calibrations and provides a range from 0-100, representing the per cent of full scale that the sensor detects in a sample. This parameter is typically used for diagnostic purposes only.

RFU stands for Relative Fluorescence Units and is used to set sensor output relative to a stable secondary standard, such as Rhodamine WT dye. This allows users to calibrate sensors identically; for example, calibrating all sensors in a network to read 100 RFU in a concentration of Rhodamine WT dye. The sensors can then be deployed and generate data that is relative to all other sensors. Once a sensor is retrieved, it can be checked against that same standard to assess sensor performance, drift, or the potential effects of biofouling.

The µg/L output generates an estimate of pigment concentration. The relationship between µg/L and sensor's RAW signal should be developed through following standard operating procedures of sampling the water body of interest, collecting sensor data from sample, and then extracting the pigment to establish a correlation. The higher the temporal and spatial resolution of the sampling, the more accurate this estimate will be.

Chlorophyll

The EXO chlorophyll sensor operates on the ***in vivo*** fluorescence principle with no disruption of the cells required to obtain either spot readings or long-term data. The EXO sensor has an excellent detection limit as determined under laboratory conditions and this advantage should be realized in many field applications.

EXO chlorophyll readings show excellent linearity on serial dilution of a surrogate solution of Rhodamine WT (R^2>0.9999) and this should ensure relative accuracy of field chlorophyll readings, i.e., a chlorophyll reading of 100 units will represent twice the pigment content of water with a chlorophyll reading of 50 units. Also, EXO chlorophyll readings show very low interference from turbidity, allowing for more accurate determination of algal content during rainfall events which release both sediment and algae into the water. The EXO chlorophyll sensor also exhibits very low interference from dissolved organics, increasing data accuracy.

Blue-green Algae

The EXO BGA readings show excellent linearity on serial dilution of a surrogate solution of Rhodamine WT (R^2>0.9999) and this should ensure relative accuracy of field BGA readings, i.e., a BGA reading of 100 units will represent twice the pigment content of water with a BGA reading of 50 units.

4.21 Total Algae (Chl & BGA) Calibration

Review the basic calibration description in section 4.2.
Before calibrating, be certain that the sensing window is clean *(see cleaning instructions, section 5.8)*.

Chlorophyll

This procedure calibrates Chlorophyll RFU or Chlorophyll µg/L. If the user has both units selected, then this procedure must be performed twice, once for each unit, to completely calibrate the parameter.

For 2-point calibrations, one standard must be clear water (0 µg/L), and this standard must be calibrated first. The other standard should be in the range of a known chlorophyll content of the water to be monitored. Two general types of standards can be used: (a) phytoplankton suspensions of known chlorophyll content, determined by employing the extractive analysis procedure described in *Standard Methods for the Examination of Water and Wastewater*, or by analyzing the suspension *in situ* using a laboratory fluorometer, and (b) dye solutions whose fluorescence can be correlated to that of chlorophyll.

For option (b), we recommend using a 625 µg/L Rhodamine WT dye solution *(for detailed instructions, see the end of this section)*, and the solution is used in the calibration steps below.

µg/L – 1- or 2-point

This procedure will zero your fluorescence sensor and use the default sensitivity for calculation of chlorophyll concentration in µg/L, allowing quick and easy fluorescence measurements that are only semi-quantitative with regard to chlorophyll. However, the readings will reflect changes in chlorophyll from site to site, or over time at a single site.

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water.

In the Calibrate menu, select BGA-PC/Chlor, then select Chl µg/L. Select either a 1- or 2-point calibration. Enter 0 for first standard value and 66 for second standard value.

Click Start Calibration. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Next place the sensors in the Rhodamine WT standard. Click Proceed on the pop-up window. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.
Rinse the sonde in tap or purified water and dry the sonde.

RFU – 1- or 2-point

RFU is a percent full scale output; it outputs relative fluorescence from 0-100%. This calibration procedure is recommended if you are also using grab samples to post-calibrate *in vivo* chlorophyll readings.

The sonde will report relative values of fluorescence in the sample being measured. These values can be converted into actual chlorophyll concentrations in µg/L by using a post-calibration procedure, after the chlorophyll content of grab-samples taken during a deployment has been analyzed in a laboratory. This determination can involve conducting the extractive analysis procedure described for chlorophyll in *Methods for the Examination of Water and Wastewater* or by carrying out an *in situ* measurement of chlorophyll using a commercial benchtop fluorometer.

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water.

In the Calibrate menu, select BGA-PC/Chlor, then select Chl RFU. Select either a 1- or 2-point calibration. Enter 0 for first standard value and 16.4 for second standard value.

Click Start Calibration. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Next place the sensors in the Rhodamine WT standard. Click Proceed on the pop-up window. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

Rinse the sonde in tap or purified water and dry the sonde.

Blue-green Algae Phycocyanin

This procedure calibrates BGA RFU or BGA µg/L. If the user has both units selected, then this procedure must be performed twice, once for each unit, to completely calibrate the parameter.

For the 2-point calibration, one of the standards must be clear water (0 µg/L), and this standard must be calibrated first. The other standard should be in the range of the suspected BGA-PC content at the environmental site. Two general types of standards can be used: (a) phytoplankton suspensions of known BGA-PC content, and (b) dye solutions whose fluorescence can be correlated to that of BGA-PC. The user is responsible for determining the BGA-PC content of algal suspensions by using standard cell counting techniques.

For option (b), we recommend using a 625 µg/L Rhodamine WT dye solution *(for detailed instructions, see the end of this section)*, and the solution is used in the calibration steps below.

µg/L – 1- or 2-point

This procedure will zero your fluorescence sensor and use the default sensitivity for calculation of phycocyanin-containing BGA in µg/L, allowing quick and easy fluorescence measurements that are only semi-quantitative with regard to BGA-PC. However, the readings will reflect changes in BGA-PC from site to site, or over time at a single site.

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water.

In the Calibrate menu, select BGA-PC/Chlor, then select BGA µg/L. Select either a 1- or 2-point calibration. Enter 0 for first standard value and 16 for second standard value.

Click Start Calibration. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Next place the sensors in the Rhodamine WT standard. Click Proceed on the pop-up window. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.
Rinse the sonde in tap or purified water and dry the sonde.

RFU – 1- or 2-point

RFU is a percent full scale output; it outputs relative fluorescence from 0-100%. This calibration procedure is recommended if you are also using grab samples to post-calibrate *in vivo* algae readings.

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water.

In the Calibrate menu, select BGA-PC/Chlor, then select BGA RFU. Select either a 1- or 2-point calibration. Enter 0 for first standard value and 16 for second standard value.

Click Start Calibration. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Next place the sensors in the Rhodamine WT standard. Click Proceed on the pop-up window. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

Rinse the sonde in tap or purified water and dry the sonde.

Blue-green Algae Phycoerythrin

This procedure calibrates BGA RFU or BGA µg/L. If the user has both units selected, then this procedure must be performed twice, once for each unit, to completely calibrate the parameter.

For the 2-point calibration, one of the standards must be clear water (0 µg/L), and this standard must be calibrated first. The other standard should be in the range of the suspected BGA-PE content at the environmental site. Two general types of standards can be used: (a) phytoplankton suspensions of known BGA-PE content, and (b) dye solutions whose fluorescence can be correlated to that of BGA-PE. The user is responsible for determining the BGA-PE content of algal suspensions by using standard cell counting techniques.

For option (b), we recommend using a 25 µg/L Rhodamine WT dye solution *(for detailed instructions, see the end of this section)*, and the solution is used in the calibration steps below.

µg/L – 1- or 2-point

This procedure will zero your fluorescence sensor and use the default sensitivity for calculation of phycoerythrin-containing BGA in µg/L, allowing quick and easy fluorescence measurements that are only semi-quantitative with regard to BGA-PE. However, the readings will reflect changes in BGA-PE from site to site, or over time at a single site.

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water. In the Calibrate menu, select BGA-PE/Chlor, then select BGA µg/L. Select either a 1- or 2-point calibration. When using Rhodamine WT enter 0 for the first standard value and 126 for the second standard value.

Click Start Calibration. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Next place the sensors in the Rhodamine WT standard. Click Proceed on the pop-up window. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu. Rinse the sonde in tap or purified water and dry the sonde.

RFU – 1- or 2-point

RFU is a percent full scale output; it outputs relative fluorescence from 0-100%. This calibration procedure is recommended if you are also using grab samples to post-calibrate *in vivo* algae readings.

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water. In the Calibrate menu, select BGA-PE/Chlor, then select BGA RFU. Select either a 1- or 2-point calibration. When using Rhodamine WT enter 0 for the first standard value and 45 for the second standard value.

Click Start Calibration. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Next place the sensors in the Rhodamine WT standard. Click Proceed on the pop-up window. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu. Rinse the sonde in tap or purified water and dry the sonde.

Effect of temperature on fluorescence

The intensity of the fluorescence of many dyes shows an inverse relationship with temperature. This effect must be accounted for when calibrating the EXO Total-Algae sensor with Rhodamine WT. Enter the µg/L or RFU value from the table below that corresponds to the temperature of the standard.

Temp (˚C)	RFU Chl	µg/L Chl	RFU BGA-PC	µg/L BGA-PC	RFU BGA-PE	µg/L BGA-PE
30	14.0	56.5	11.4	11.4	37.3	104.0
28	14.6	58.7	13.1	13.1	39.1	109.0
26	15.2	61.3	14.1	14.1	41.0	115.0
24	15.8	63.5	15.0	15.0	43.0	120.0
22	16.4	66	16.0	16.0	45.0	126.0
20	17.0	68.4	17.1	17.1	47.0	132.0
18	17.6	70.8	17.5	17.5	49.2	138.0
16	18.3	73.5	19.1	19.1	51.4	144.0
14	18.9	76	20.1	20.1	53.6	150.0
12	19.5	78.6	21.2	21.2	55.9	157.0
10	20.2	81.2	22.2	22.2	58.2	163.0
8	20.8	83.8	22.6	22.6	60.6	170.0

Rhodamine WT Dye Solution for Total Algae Sensor

⚠ **WARNING:** Read and follow all the safety instructions and MSDS documentation supplied with the dye before proceeding. Remember that only trained personnel should handle chemicals.

Preparation

Use the following procedure to prepare a Rhodamine WT solution for use as a sensor stability check reagent for the EXO Total Algae (Chlorophyll and Blue-green Algae) sensor:

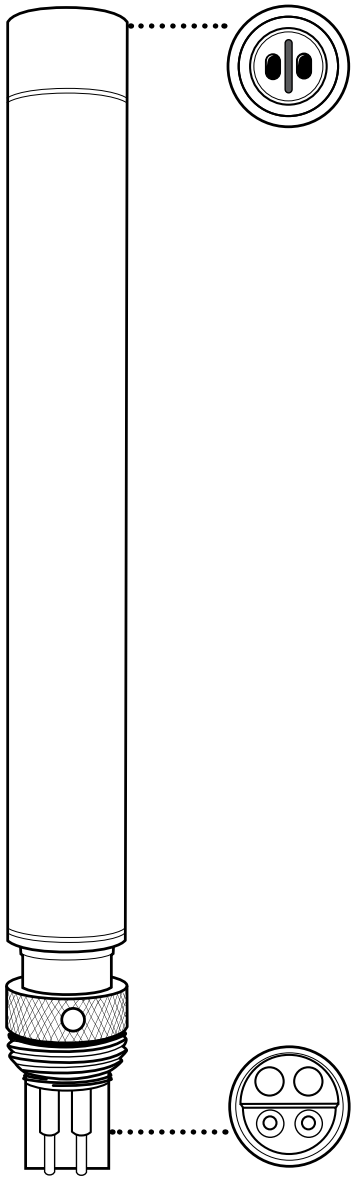
1. Purchase Rhodamine WT dye in solution form, which can vary somewhat in nominal concentration. Recommended supplier for a solution that is approximately 2.5% in Rhodamine WT:
   Fluorescent FWT Red Dye (item #106023)
   Kingscote Chemicals
   3334 South Tech Blvd., Miamisburg, OH 45342 USA
   1-800-394-0678
2. Accurately transfer 5.0 mL of the Rhodamine WT solution into a 1000 mL volumetric flask. Fill the flask to the volumetric mark with deionized or distilled water and mix well to produce a solution that is approximately 125 mg/L of Rhodamine WT. Transfer this standard to a glass bottle and retain it for future use.
3. Accurately transfer 5.0 mL of the solution prepared in the above step to a 1000 mL volumetric flask and then fill the flask to the volumetric mark with deionized or distilled water. Mix well to obtain a solution, which is 0.625 mg/L in water (a 200:1 dilution of the concentrated solution).
4. For BGA-PE calibration, accurately transfer 0.2 mL of the 125 mg/L solution prepared in step 2 to a 1000 mL volumetric flask and then fill the flask to the volumetric mark with deionized or distilled water. Mix well to obtain a solution that is 25 µg/L or 0.025 mg/L of Rhodamine WT.
5. Store the concentrated standard solution in a glass bottle in a refrigerator to retard decomposition. The dilute standard prepared in the previous step should be used within 24 hours of its preparation.

Discard the used standard. When Rhodamine standards are required in the future, perform another dilution of the concentrated Rhodamine WT solution after warming it to ambient temperature.

4.22 Turbidity Sensor Overview

Turbidity is the indirect measurement of the suspended solid concentration in water and is typically determined by shining a light beam into the sample solution and then measuring the light that is scattered off of the particles which are present. The suspended solid concentration is an important water quality paramter and is a fundamental measure of environmental change. The source of the suspended solids varies in nature (examples include silt, clay, sand, algae, organic matter) but all particles will impact light transmittance and result in a turbidity signal.

The EXO Turbidity sensor employs a near-infrared light source and detects scattering at 90 degrees of the incident light beam. According to ASTM D7315 method, this type of turbidity sensor has been characterized as a nephelometric near-IR turbidimeter, non-ratiometric[1]. This method calls for this sensor type to report values in formazin nephelometric units (FNU). FNU is the default calibration unit for the EXO sensor but users are able to change calibration units to nephelometric turbidity units (NTU), raw sensor signal (RAW), or total suspended solids (TSS) assuming the user enters the appropriate correlation data.



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The RAW value is a value unaffected by user calibrations and provides a range from 0-100, representing the per cent of full scale that the sensor detects in a sample.

While all turbidity sensors will read consistently in formazin, other calibration solutions and field readings will vary between different models of turbidity sensors. These differences are thought to be a result of differing optical components and geometries and the resulting detection of varying suspended sediment characteristics. This effect is inherent in the nature of every turbidity sensor, and as a result readings between different model turbidity sensors are likely to show different field values even after calibration in the same standards.

Specifications

Default Units	FNU
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Range	0 to 4000 FNU
Accuracy	0-999 FNU: 0.3 FNU or ±2% of reading, whichever is greater; 1000-4000 FNU: ±5% of reading[2]
Response	T63<2 sec
Resolution	0-999 FNU: 0.01 FNU 1000-4000 FNU: 0.1 FNU
Sensor Type	Optical, 90° scatter
Optics: Excitation	 860±15 nm

For long-term, ***in situ*** continuous monitoring of turbidity, the EXO2 sonde has a wiper to clean the turbidity sensor to avoid sensor fouling and maintain accuracy.

1 *ASTM D7315-07a "Test Method for Determination of Turbidity Above 1 Turbidity Unit (TU) in Static Mode."*

2 *Performance based on 3-point calibration done with YSI AMCO-AEPA standards of 0, 124, and 1010 FNU. The same type of standard must be used for all calibration points.*

4.23 Turbidity Calibration

Before calibrating, be certain that the probe is clean and free of debris. Solid particles, particularly those carried over from past deployments, will contaminate the standards during your calibration protocol and cause either calibration errors and/or inaccurate field data *(cleaning instructions, section 6.13)*. Use a clean, spare sonde guard. *Also, review the basic calibration description in section 4.2.*

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). Acceptable standards include (a) formazin prepared according to *Standard Methods,* especially for calibration points greater than 1010; (b) dilutions of 4000 NTU formazin concentrate purchased from Hach; (c) Hach StablCal™ standards in various NTU denominations; and (d) AMCO-AEPA standards prepared specifically for the EXO turbidity sensor by the manufacturer *(see table next page)*.

NOTE: *The use of standards other than those mentioned above will result in calibration errors and inaccurate field readings.* It is important to use the same type of standard for all calpoints. (i.e. do not mix formazine and AMCO-AEPA standard for different points in a multi-point cal).

2-point

Pour the correct amount of 0 NTU standard (clear deionized or distilled water) into the calibration cup. Immerse the probe end of the sonde into the water.

In the Calibrate menu, select Turbidity, then select Turbidity FNU.

Click 2 Point for the Calibration Points. Enter 0 FNU for first standard value and 124 FNU for second standard value. (0 must be calibrated first.)

- If the water to be evaluated is known to be low in turbidity, an appropriate choice of standards might be 0 and 12.4. However, for general purpose measurements an appropriate choice of standards is usually 0 and 124.
- If deploying with a copper anti-fouling guard, use this guard during calibration to calibrate for any offset; input 0.5 or 1 instead of 0. The guard must be clean and free of sediment and debris.

Click Start Calibration. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data show no significant change for approximately 40 seconds), click Apply to accept this calibration point.

- If the temperature of your field site is substantially different from the lab temperature, allow the sensor to sample for 3-5 minutes at each calibration point before accepting it. This step ensures the best possible temperature compensation when deployed.

Next place the sensors in the second calibration standard. Click Proceed on the pop-up window. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

Rinse the sonde in tap or purified water and dry the sonde.

3-point

Select the 3-point calibration option for maximum accuracy over a wider range. The first standard must be 0 FNU. Because of the linearity characteristics of the sensors, we recommend that the other two standards have turbidity values of 124 and 1010 FNU. It is important to use a consistent type of standard for all calibration points. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to proceed to an additional solution to complete the 3-point procedure.

Calibration Limits

Due to the non-linear response of the turbidity sensor, calibration ranges may be limited. A 1-, 2-, or 3-point calibration may be completed, using the following limits:

First Point	Second Point	Thrid Point
0-1 FNU (or NTU)	5-199 FNU (or NTU)	200-4200 FNU (or NTU)

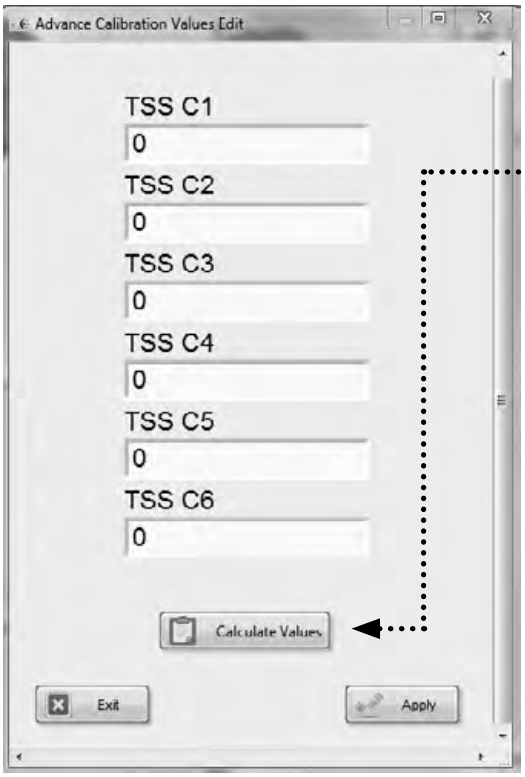
Calibration standards

The following standards are available for the EXO turbidity sensor:

608000	0 NTU (all turbidity sensors); 1 gallon
607200	12.4 FNU (EXO); 12.7 NTU (YSI 6-Series); 1 gallon
607300	124 FNU (EXO); 126 NTU (YSI 6-Series); 1 gallon
607400	1010 FNU (EXO); 1000 NTU (YSI 6-Series); 1 gallon

4.24 Total Suspended Solids Calculation

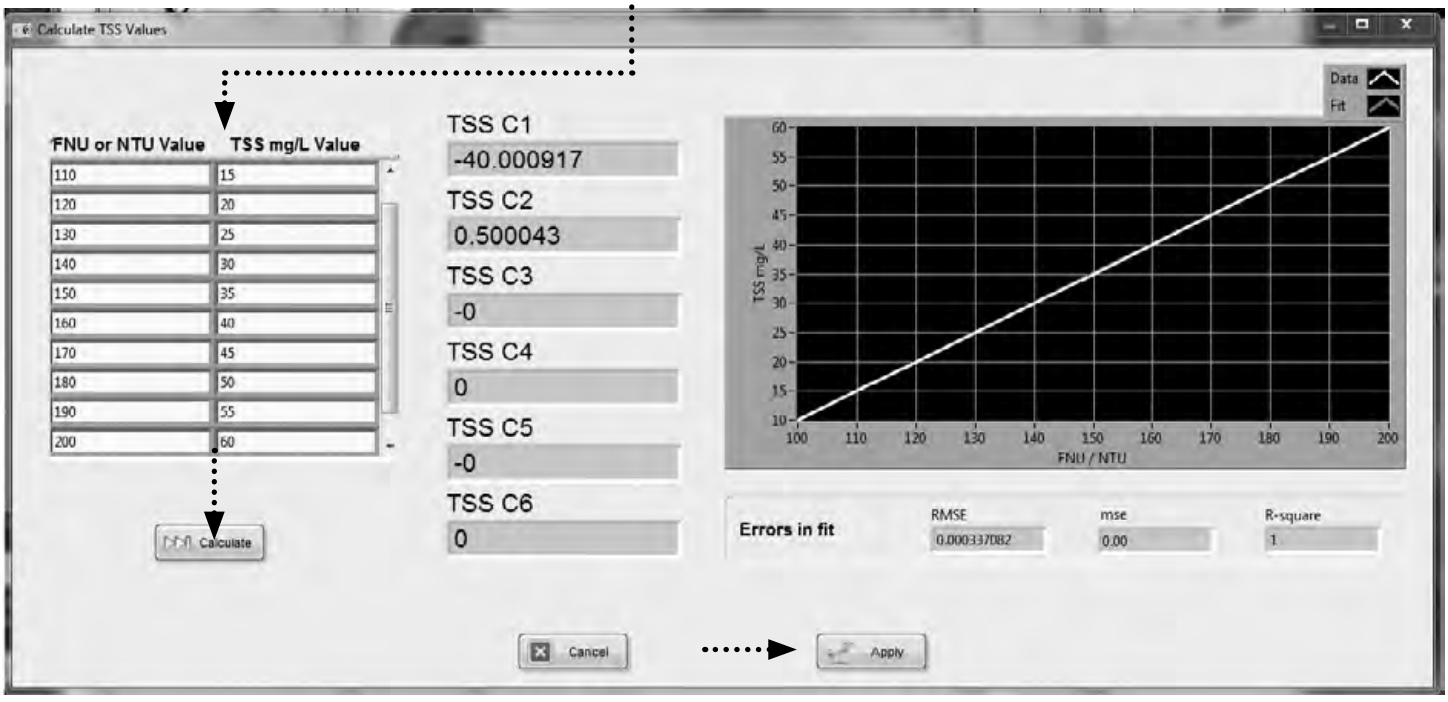
Please follow the process below to calculate TSS.
NOTE: *This process cannot be performed via the EXO handheld. It must be done using desktop KorEXO.*

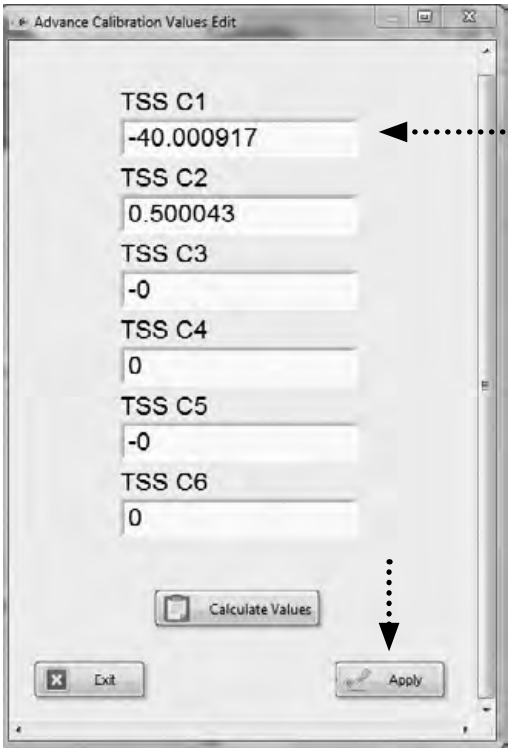


Step 1
Make sure the turbidity probe is installed in the sonde.

Step 2
Open KorEXO Desktop, connect to the sonde, and navigate to Calibrate>Turbidity>Advanced>Edit and click Calculate Values.

Step 3
Type in the turbidity NTU/FNU values and the corresponding TSS values obtained through lab analysis into the table on the left. Click Calculate. You will see the TSS coefficients populate and a graph generated. Click Apply.



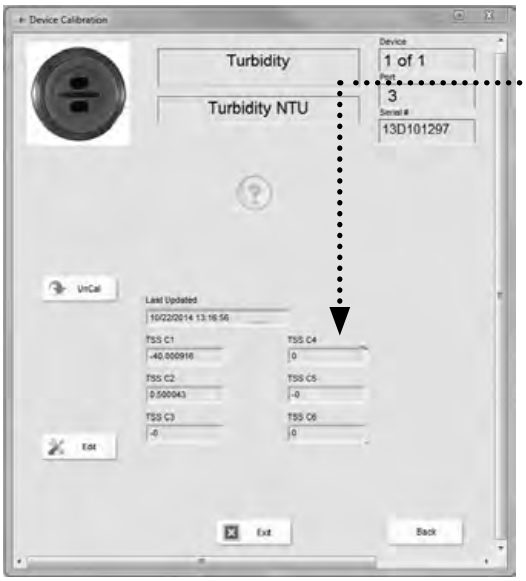


Step 4

The values will appear on the previous screen.
Click Apply again.

Step 5

The message below will be displayed and the coefficients will be applied to the turbidity probe. Click OK.



Step 6

The coefficients will be displayed in the Advanced menu of the turbidity probe calibration. Click Exit or Back.

Step 7

TSS values will now be displayed on the Dashboard based on the values entered via KorEXO and saved to the turbidity probe.

Step 8

If the TSS parameter is not displayed on the Dashboard, go to Options>Units>Turb to activate the TSS parameter. Click Apply and return to the Dashboard.

Step 9

The units to display TSS will need to be activated separately in the EXO handheld following the same path mentioned above.

Solinst Model 121 sonic, product/water interface probe

Solinst *Interface Meter Operating Instructions*

Model : 121

The Solinst Model 121 Interface Meter works as follows: An infra-red circuit detects the presence of a liquid. A conductivity circuit differentiates between conductive liquid (water) and non-conductive liquid (LNAPL or DNAPL product).

> Product = Steady tone and two lights
> Water = Intermittent tone and one light

Main switch is toggle switch on reel faceplate.

Probe switch is knurled steel ring at top of probe.
0 = Off and 1 = On

Zero measurement point is the junction between the stainless steel body of the probe and the brown Teflon/Delrin base plug.

Equipment Check

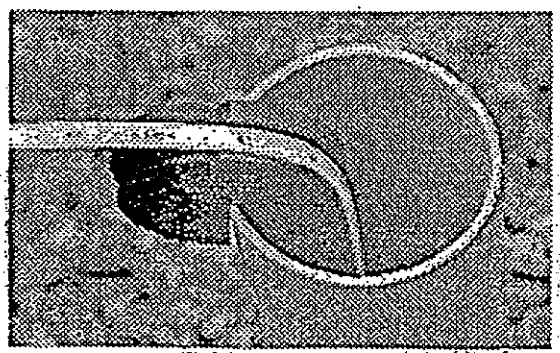
Before leaving the office, or commencing any measurements, carry out the following electronics and battery condition checks.

Battery in reel check: turn main switch on. Steady tone and two lights will be activated (as long as the probe switch is off and main switch is on) .

Battery in probe check: remove probe from holder and with main switch still on, turn probe switch on. Steady tone and two lights turn off. **If only** left light is on, or one light and a weak buzzer: probe battery is very low and needs replacing immediately.

Infra-red circuit check: with both switches on, insert the cleaning brush into the base of the probe until it reaches the zero measurement point. This cuts the infra-red beam and activates the steady tone and two lights.

Conductivity circuit check: with both switches on, insert the probe into normal tap water, as far as the zero measurement point. This causes a single light and intermittent tone to activate.



Use tape guide to protect tape from damage on well lip.

Field Measurements

1. **Turn both switches on.** Place the slotted part of the tape guide/datum onto the edge of the casing. Lay the Interface Meter tape into the groove on the periphery of the tape guide, as illustrated. Measurements will be read at the apex of the V-notch on the tape guide. A compensation factor is stamped onto the side of the tape guide. Subtract this factor to obtain accurate depth measurements from the top of the casing.

2. **Lower probe slowly.**

   If there is no floating product, a single light and intermittent tone will come on. Briefly upon first entering water the steady tone and both lights will activate, but not upon subsequent insertions or removal.

   If there is a thin film of product, the steady tone and two lights will activate briefly each time the probe enters or exits the liquid.

   If there is floating product, steady tone and two lights will activate.

3. Raise and lower the probe gently to determine the exact upper level of any non-conductive floating product. Read the level of the air/product interface from the marked tape.

4. **To read the product/water interface,** lower the probe into the water until only one light and intermittent tone remain 'on'. Shake probe slightly to clear product from the conductivity sensor. Raise the probe slowly until steady tone and two lights activate. Read the level directly from the tape. **Note:** Remember to subtract the amount on the tape guide from each measurement.

5. Repeat steps 3 & 4 a number of times to confirm.

6. **To determine the thickness of product,** subtract reading in step 3 from reading in step 4.

7. **To determine if any sinking product is in the well,** continue lowering the probe slowly. If steady tone and two lights come on, determine the top of the sinking layer by reading directly from the tape. Continue lowering the probe slowly until the tape slackens when the well bottom is reached. Read the level directly from the tape. **Do not drop to bottom of well: damage to probe tip may result.**

   Note: 0.1 ft. must be added to the readings in step 7, to compensate for the difference between the measurement point and the bottom of the probe.

8. **At completion of readings:** turn the probe and reel switches 'off'; clean tape and probe; return probe to holder and follow maintenance instructions as necessary.

NOTES

- Battery will drain rapidly if probe is left 'on' and out of holder.
- Do not drop probe: damage to probe tip may result.
- O-ring seals may be affected by the use of cleaning fluids other than detergent and water.
- Check and lubricate all O-rings regularly.

If only left light is on, or left light and a weak buzzer:
- probe battery is very low and needs replacing immediately.

Cleaning and Maintenance

After each use, the tape should be wiped clean and carefully rewound onto the reel.

The probe should be cleaned as follows:
- wash probe thoroughly with detergent.
- use cleaning brush through side and base holes to remove all product from inner part of the probe.
- use steel wool to scrub bottom pin.
- rinse probe thoroughly with distilled water, wipe dry.
- return the probe to the holder, ensuring that both switches are turned off.

Other suitable cleaning methods include:
- Hexane and distilled water rinsing.
- Steam cleaning for tape only.

Battery Replacement

If incorrect signals occur, change both batteries and retest the unit. Batteries should be replaced after approximately 9-10 hours "on time" Use 9V Duracell MN1604 or Eveready 522. **Note: Always replace both batteries at the same time, and lubricate O-rings.**

To replace battery inside reel: remove three screws in faceplate and carefully lift to one side to prevent damage to wiring. Replace with specified battery, noting proper polarity. Replace faceplate and three screws, being careful to keep all wires within the hub.

To replace probe battery: remove three screws (Phillips type) at top of probe. Being careful not to damage wire connector, gently pull body apart to expose the battery holder. Remove and replace battery with type specified. Ensure correct polarity. Check O-rings for damage. Replace if necessary. Lubricate O-rings lightly prior to reassembly. **Ensure that the three wire connector is placed below the battery in the slot** provided, and push probe body back together. Replace Phillips screws but **do not over-tighten.**

TROUBLE SHOOTING	CAUSE	REMEDY
No lights operational	Reel switch not on	Turn main switch on reel to 'on' position.
	Low batteries	Replace both batteries as described above.
	Moisture in probe	Check O-rings for damage. Replace if necessary. If O-rings not at fault, return probe to Solinst for assessment and repair.
Water signal not operational	Dirty probe	Clean as described above.
	Low Batteries	Replace both batteries as described above.
	Moisture in probe	Check O-rings for damage. Replace if necessary. If O-rings not at fault, return probe to Solinst for repair.
	Damage to bottom pin	Return probe to Solinst for repair.
Product signal not operational	Probe switch not on	Turn knurled ring on probe to 'on' position.
	Dirty probe	Clean as described above.
	Low batteries	Replace both batteries as described above.
Water light stays on	Low batteries	Replace both batteries as described above.
	Dirty probe	Clean as described above.
Continuous tone and lights	Dirty probe	Clean as described above.
	Dead battery in probe	Replace both batteries as described above.
	Dirty contacts	Disconnect probe; clean contacts with steel wool and smear with vaseline.
	Allignment pin damaged	Disconnect probe; if pin damaged return probe to Solinst.
	Damaged wiring in probe	Open probe, check wires to battery; if you cannot repair damage, return probe to Solinst.
	Cannot detect any error	Return complete unit to Solinst
Probe swtich will not turn	Switch dirty	Spray ring with a little WD40 and clean thoroughly.

When Reassembling Probe:

1. Ensure battery is properly connected.
2. Small connector between probe sections must be attached.
3. Connector must be placed under battery to prevent crushing.
4. Lightly lubricate O-rings.
5. Gently push probe body over battery holder portion of probe. NB some resistance will be felt, due to the O-rings.
6. Replace three screws at top of probe.

When Reinstalling Faceplate:

1. Line up Solinst logo on faceplate over circuit board.
2. Take care not to crush wires or electronics.
3. Replace three faceplate screws.

When Reattaching Probe:

1. Make sure contacts are clean.
2. Lubricate O-rings.
3. Line up pin in female connector with hole in male connector.
4. Screw down retaining ring; snug, but not overtight.

Parts and Service

Should your Interface Meter require any spare parts, service or repairs, please contact *Solinst*.

Solinst Canada Ltd. The Williams Mill, 515 Main Street, Glen Williams, ON. L7G 3S9
FAX: (416 or 905) 873-1992 *TEL: (416 or 905) 873-2255* **Solinst**

character dot matrix LCD and 3 keys to provide easy user interface.

General Specifications Table 1.1

Portable VOC monitor Specification	
Size:	8.2"L x 3.0"W x 2.0"H
Weight:	19.5 oz with battery pack
Detector:	Photo-ionization sensor with 9.8, 10.6, or 11.7 eV UV lamp
Battery:	A 4.8V /1250 mAH Rechargeable Nickel Metal Hydride battery pack (snap in, field replaceable)
Battery charging:	10 hours charge through built-in charger
Operating Hours:	Up to10 hours continuous operation
Display:	1 line by 8 characters 5x7 dot matrix LCD (0.4" character height) with LED back light automatically in dim light
Range, Resolution & Response time (t_{90}):	
Isobutylene (calibration gas)	
	0-99 ppm 0.1 ppm 2 sec
	100-1,999 ppm 1.0 ppm 2 sec
	2000-10,000 ppm 1.0 ppm 2 sec
Measurement accuracy (Isobutylene):	
	0 – 2000 ppm: ± 2 ppm or 10% of reading.
	> 2000 ppm: ± 20% of reading
PID Detector:	Easy access to lamp and sensor for cleaning and replacement

Correction Factors:	Built-in 102 VOC gases
Calibration:	Two-point field calibration of zero and standard reference gas
Calibration Memory:	Store up to 8 separate calibration, alarm limits and span value
Inlet probe:	Flexible 5" tubing
Keypad:	1 operation key and 2 programming keys
Direct Readout:	Instantaneous, average, STEL and peak value, battery voltage and elapsed time
Intrinsic Safety:	UL & cUL Class 1, Division I, Group A,B,C,D (US & Canada), EEx ia IIC T2 (Europe)
EM Interference:	No effect when exposed to 0.43 W/cm^2 RF interference (5 watt transmitter at 12 inches)
Alarm Setting:	Separate alarm limit settings for Low, High, STEL and TWA alarm
Operating Mode:	Survey or Hygiene mode
Alarm:	90 dB buzzer and flashing red LEDs to indicate exceeded preset limits, low battery voltage, or sensor failure.
External Alarm:	Optional plug-in pen-size vibration alarm or remote alarm
Alarm Mode:	Latching or automatic reset

Solinst Model 101 &102 sonic water interface probe

Solinst *Water Level Meter:* Operating Instructions

Models 101 & 102

Upon receipt of meter the following operational checks should be performed:

1. Set toggle switch to "on" or turn rotary dial fully clockwise.
2. Submerse the electrode (probe) in tap water. This completes the circuit and activates the buzzer.
3. Depress button to test the battery and circuitry (excluding the probe).

Water Level Measurement

	The zero measurement point is:
Model 101	tip of the inner electrode visible near the centre of the probe
Model 102	base of the outer body electrode

- clockwise rotation of rotary dial turns meter on and increases sensitivity.
- always set switch to the highest sensitivity position, then decrease if necessary.

Note: The P4 Probe has been designed to allow substanial submergence. Use of the P1, P2 or P3 probes to sound the bottom of the well may cause water ot enter the probe.

Routine Care of the Water Level Meter

1. After the depth of water has been recorded the cable should be carefully rewound onto the reel, the probe wiped dry and replaced into the probe holder.
2. The probe, cable and reel can all be cleaned with soap or detergent and water.
3. Use of a Water Level Meter Carrying Bag adds to the service life of the meter.
4. Use of a Tape Guide adds to the life of the tape.

Care of P4 Probe

Note: Do not remove or twist the strain relief pieces at the back of the probe as this will cause damage to the pressure seal. If the pressure seal integrity is in question, please call Solinst for the authorized repair centre nearest you.

1. While holding firmly onto the black Delrin section on the top of the probe, turn clockwise slightly and pull the P4 sleeve body down.
2. Remove any dirt and water from inside the sleeve body, the centre electrode and the Teflon pieces.
3. Remove and clean the O-rings. Clean the recessed areas and check the O-rings for damage. Lightly lubricate and replace the O-rings.
4. Carefully pull the coil spring from its recessed area and onto the centre electrode. **The coils of the coil spring must curve clockwise.**
5. Clean the recessed area where the coil spring rests and check to see that the exposed wire is in place and clean.
6. Push the coil spring back into place.
7. Turning clockwise, push the sleeve body over the electrode to the black Delrin piece.
8. To test, turn the unit on and lower the probe into a glass of water. When the probe touches water, the buzzer will sound and the light will come on.

Troubleshooting

SYMPTOM	CAUSE	REMEDY
No sound when probe immersed in water.	Dead battery.	Replace with 9v Alkaline.
	Water conductivity is very low.	Increase sensitivity switch setting (turn clockwise) or call Solinst for assistance.
	Disconnected wires on circuit board.	Check all connections inside hub of reel for loose/disconnected wires - solder or reconnect.
	Broken wire in tape.	Locate break in tape - splice and seal.
	Disconnected wire inside probe.	Contact Solinst to obtain parts / repair instructions.
Continuous sound after probe is removed from water.	Water conductivity is very high.	Decrease sensitivity switch setting (turn counter-clockwise).
	Damaged components or improper wiring on circuit board.	Contact Solinst to obtain parts / repair instructions.

Battery Replacement

- battery type - alkaline, 9 volt.

1. The battery is housed in the reel hub and is replaced by removing the front plate of the reel.
2. To remove front plate, unscrew three faceplate screws and carefully lift off to the side to avoid damage to wiring.
3. Remove battery and put in new one, making sure the polarity is correct.
4. Replace faceplate of the reel and screws, making sure the wires are fully inside.

Water Level Meter Replacement Parts

The following parts can be provided should they become lost or damaged.

- probes and probe tips
- tapes and cables
- cable reels
- lights, switches, etc.

For further operating information or for repair information, please call Solinst:
(905) 873-2255 or (800) 661-2023
fax: (905) 873-1992

11/93