Final

Tier II Sampling and Analysis Plan
Site 12 Long-Term Monitoring

Naval Weapons Station Yorktown
Yorktown, Virginia

Contract Task Order WE42

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Executive Summary

This Sampling and Analysis Plan (SAP) presents the rationale and technical approach for long-term monitoring (LTM) at Site 12, Barracks Road Landfill, at Naval Weapons Station (WPNSTA) Yorktown, Yorktown, Virginia. This investigation is being conducted for the Department of the Navy (Navy), Naval Facilities Engineering Command (NAVFAC) Mid-Atlantic, under the Comprehensive Long-term Environmental Action – Navy (CLEAN) Program, in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986, and, to the extent practicable, the National Oil and Hazardous Substances Contingency Plan.

This SAP has been completed under contract number N62470-11-D-8012, Contract Task Order (CTO) WE42, in accordance with the Navy's Uniform Federal Policy (UFP)-SAP guidance (USEPA, 2005) to ensure that environmental data collected are scientifically sound, of known and documented quality, and suitable for the intended purposes. The objectives and technical approach included in this SAP were jointly scoped by the Yorktown Tier I Partnering Team, which includes representatives from the Navy, United States Environmental Protection Agency (USEPA) Region 3, and Virginia Department of Environmental Quality (VDEQ).

As required by the Final Site 12 Record of Decision (ROD) (Baker, 1997) and clarified in the Explanation of Significant Difference (ESD) (CH2M HILL, 2012), LTM will be performed to confirm that the Area A cover remains protective of human health and the environment, and that downgradient areas are not adversely impacted by potential future releases from this area. Therefore, the primary objective of the long-term groundwater sampling program outlined in this SAP is to monitor the quality of the groundwater at Site 12, specifically Area A, to determine if concentrations of chemical constituents increase downgradient of the landfill from their current, acceptable levels to levels that indicate a release that might adversely impact human health and the environment may have occurred. This objective will be attained through collection of groundwater samples from eight monitoring wells (including one newly installed monitoring well) for analysis of select metals comprising of Resource Conservation and Recovery Act (RCRA) 8 metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) plus antimony and manganese. Samples will also be analyzed for 1,3,5-trinitrobenzene and 2,3,7,8-tetrachlorodibenzo-para-dioxin (TCDD). These analytes have been selected for monitoring based on ROD-identified constituents of concern (COCs) (1,3,5-trinitrobenzene, antimony, cadmium, manganese, and lead), additional RCRA 8 metals (arsenic, barium, chromium, mercury, selenium, and silver) that are not identified as ROD COCs but were recommended for monitoring in the previous LTM report (CH2M HILL, 2008), and a potential data gap for dioxins (2,3,7,8-TCDD) that have not previously been evaluated at the site.

Downgradient analytical data will be compared to WPNSTA background upper tolerance limits (UTLs)[1] and upgradient data to determine whether a release from the landfill has occurred. If it is determined that a release has occurred, results will be compared to human health and ecological screening values (ESVs) to determine if there are potentially unacceptable risks to human health or the environment. Because 2,3,7,8-TCDD, arsenic, barium, chromium, mercury, selenium, and silver are not ROD-identified COCs, they will be evaluated during the first round of LTM sampling and if they are not detected or are detected at levels that do not pose a potential unacceptable risk to human health or ecological receptors, future monitoring of these constituents will not be necessary to ensure protectiveness of the remedy and they will be removed from future rounds of LTM sampling.

This SAP contains the required elements outlined in the Navy's UFP-SAP Tier II guidance. Tables are embedded within the document and figures are provided following the text. The laboratory information cited in this SAP is specific to CHEMTECH Consulting Group of Mountainside, New Jersey, and ALS Environmental of Houston, Texas. If additional laboratory services are requested requiring modification to the existing SAP, revised SAP sections will

[1] Because 1,3,5-trinitrobenzene is not naturally occurring, a comparison to basewide background UTLs will not be made for this constituent. Only a comparison to upgradient results will be performed to determine if a site release has occurred.

be submitted to the Navy and regulatory agencies for approval. Laboratory Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) accreditations are included as **Appendix A**.

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Acronyms and Abbreviations

°C	degree Celsius
µg/L	microgram per liter
%D	percent difference
AM	Activity Manager
AQM	Activity Quality Manager
bgs	below ground surface
BTAG	Biological Technical Assistance Group
CA	corrective action
CAS	Chemical Abstract Service
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CLEAN	Comprehensive Long-term Environmental Action – Navy
COC	constituent of concern
COPC	constituent of potential concern
CSM	conceptual site model
CTO	Contract Task Order
DL	detection limit
DoD	Department of Defense
DQI	data quality indicator
DQO	data quality objective
DV	Data Validator
EB	Equipment Blank
ELAP	Environmental Laboratory Accreditation Program
ERP	Environmental Restoration Program
ESD	Explanation of Significant Difference
ESV	ecological screening value
FD	field duplicate
ft/day	foot per day
FTL	Field Team Leader
H&S	health and safety
HPLC	high performance liquid chromatography
HQ	hazard quotient
HRGC/HRMS	high-resolution gas chromatography/high-resolution mass spectrometry
HSP	Health and Safety Plan
IAS	Initial Assessment Study
ICAL	initial calibration
ICP-MS	inductively coupled plasma-mass spectroscopy
IDW	investigation-derived waste
IR	Installation Restoration
IS	internal standard
L	liter
LCL	lower control limit
LCS	Laboratory Control Sample
LOD	limit of detection

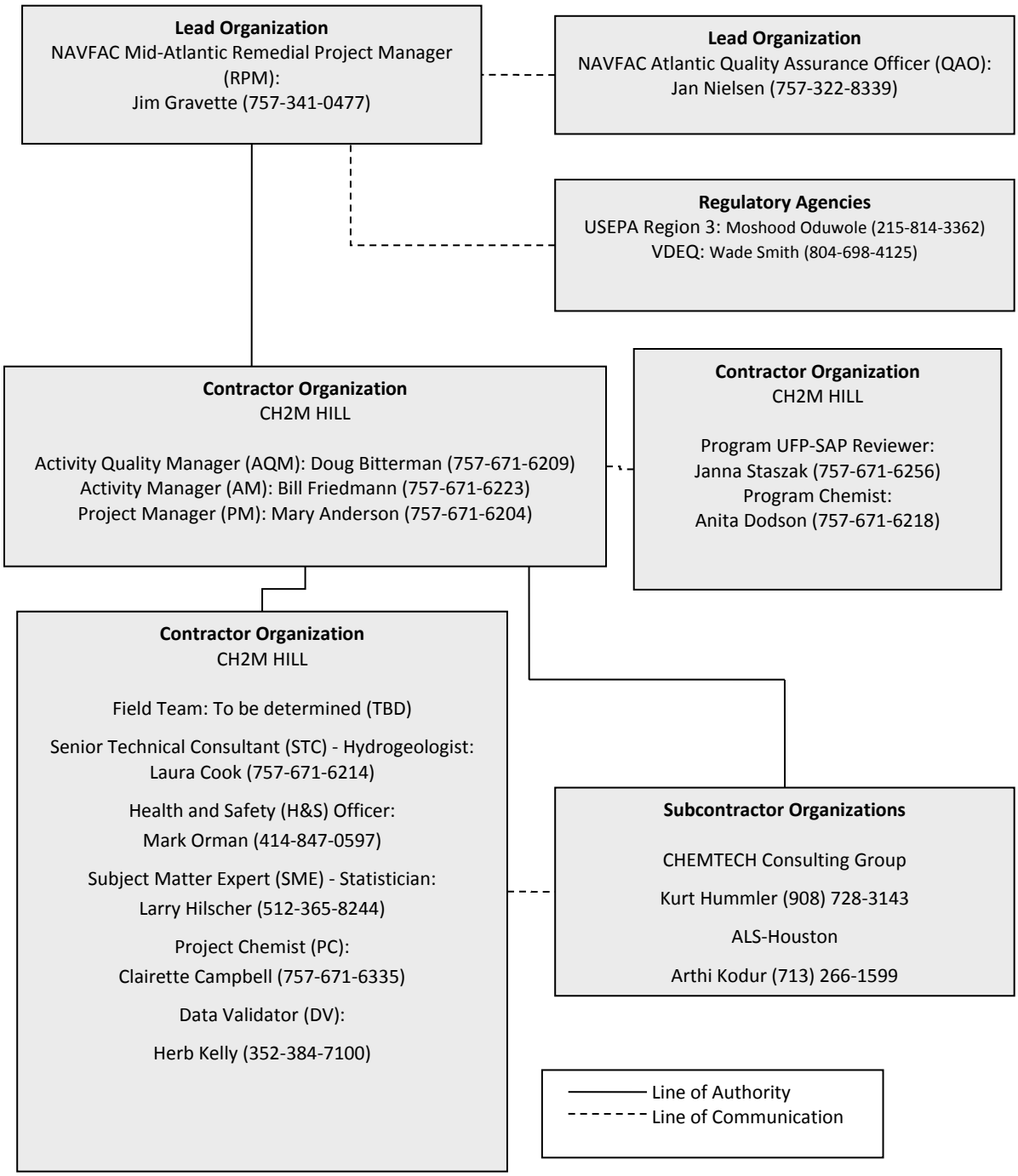
LOQ	limit of quantitation
LTM	long-term monitoring
LUC	land use control
ml	milliliter
MPC	Measurement Performance Criteria
MS	matrix spike
MSD	matrix spike duplicate
N/A	not applicable
NAVFAC	Naval Facilities Engineering Command
Navy	Department of the Navy
NC	no criterion
ORP	oxidation-reduction potential
PAL	Project Action Limit
PC	Project Chemist
PCB	polychlorinated biphenyl
PCDD/F	polychlorinated dibenzodioxin/furan
pg/L	picogram per liter
PM	Project Manager
POC	point of contact
PPE	personal protective equipment
PQL	project quantitation limit
PS	post-digestion spike
PVC	polyvinyl chloride
QA	quality assurance
QAO	Quality Assurance Officer
QC	quality control
QL	quantitation limit
QSM	Quality Systems Manual
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
ROD	Record of Decision
RPD	relative percent difference
RPM	Remedial Project Manager
RSL	Regional Screening Level
RTC	response to comment
SAP	Sampling and Analysis Plan
SME	Subject Matter Expert
SOP	Standard Operating Procedure
SSC	Site Safety Coordinator
STC	Senior Technical Consultant
SVOC	semivolatile organic compound
TBD	to be determined
TCDD	tetrachlorodibenzo-para-dioxin
TCE	trichloroethene
UCL	upper control limit
UFP	Uniform Federal Policy

USEPA	United States Environmental Protection Agency
UTL	upper tolerance limit
UV-vis	ultraviolet-visible spectrometer
VDEQ	Virginia Department of Environmental Quality
VOC	volatile organic compound
WPNSTA	Naval Weapons Station

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1 Project Organization

1.1 Project Organizational Chart



1.2 Communication Pathways

The communication pathways for the Sampling and Analysis Plan (SAP) are shown as follows.

TABLE 1-1
Communication Pathways

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or E-mail	Procedure
Communication with Department of the Navy (Navy) (lead agency)	Naval Facilities Engineering Command (NAVFAC) Remedial Project Manager (RPM)	Jim Gravette	(757) 341-0477	Primary point of contact (POC) for Navy; can delegate communication to other internal or external POCs. RPM will notify the United States Environmental Protection Agency (USEPA) and Virginia Department of Environmental Quality (VDEQ) via e-mail within 24 hours for field changes affecting the scope.
Communication with USEPA (regulatory agency)	USEPA RPM	Moshood Oduwole	(215) 814-3362	Primary POC for USEPA; can delegate communication to other internal or external POCs. Upon notification of field changes, USEPA will have 24 hours to approve or comment.
Communication with VDEQ (regulatory agency)	VDEQ RPM	Wade Smith	(804) 698-4125	Primary POC for VDEQ; can delegate communication to other internal or external POCs. Upon notification of field changes, USEPA will have 24 hours to approve or comment.
Oversight of Environmental Restoration Program (ERP) implementation	CH2M HILL Activity Manager (AM)	Bill Friedmann	(757) 671-6223	Primary POC for stakeholder and agency managers; can delegate communication to other contract staff as appropriate. Issues reported to the NAVFAC RPM immediately and followed up in writing within 2 business days.
Management of ERP implementation	CH2M HILL Project Manager (PM)	Mary Anderson	(757) 671-6204	Primary modes of communication are phone, e-mail, letter, document submittal; timing dependent on nature of communication and predefined schedules as applicable and as requested by stakeholder agencies. All project information and materials will be forwarded to the AM on a daily basis.
Overall quality and technical communications for project implementation and data interpretation	CH2M HILL Activity Quality Manager (AQM)	Doug Bitterman (hydrogeologist)	(757) 671-6209	Team members will contact the AQM/Senior Technical Consultant (STC)/Subject Matter Expert (SME) regarding questions and issues encountered in the field, input on data interpretation, and so forth, as needed. Senior consultants will have 24 hours to respond to technical field questions as necessary. Responses will be communicated to the PM via e-mail or phone. Senior consultants will review data and deliverables as necessary prior to distribution.
	CH2M HILL STC	Laura Cook	(757) 671-6214	
	CH2M HILL SME	Larry Hilscher (statistician)	(512) 365-8244	
Implementation of sampling activities, field corrective actions (CAs), and daily field progress reports	CH2M HILL Field Team Leader (FTL)	To be determined (TBD)	TBD	Notify the PM by phone or e-mail within 24 hours of changes to the SAP made in the field and the reasons for those changes. Documentation of deviations from the SAP will be kept in the field logbook; deviations will be made only with the approval of the PM. The need for CA for field issues will be determined by the FTL and/or senior consultants. The senior consultants will ensure SAP requirements are met by the field staff. The FTL will notify the PM of any needed field CAs. The Navy RPM will be notified of any field data quality issues as soon as possible. The PM will have 24 hours to respond to the request for CA.

TABLE 1-1
Communication Pathways

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or E-mail	Procedure
Stop Work Order	CH2M HILL AM FTL Site Safety Coordinator (SSC) Field Team Members	Bill Friedmann TBD TBD TBD	(757) 671-6223 TBD TBD TBD	Any field member can immediately stop work if an unsafe condition which is immediately threatening to human health is observed. The field staff, FTL, or SSC, should notify the CH2M HILL PM and AM immediately along with the Navy RPM. Ultimately, the FTL, PM, and AM can stop work for a period of time. NAVFAC Mid-Atlantic can stop work at any time.
Ensure health and safety (H&S) in the field	CH2M HILL SSC	TBD	TBD	Responsible for the adherence of team members to the site safety requirements described in the Health and Safety Plan (HSP). Will report H&S incidents and near-misses to the PM. Will record daily safety tailgates, daily observations, real-time discussions of observations, and changes to be implemented. If safety issues are identified the SSC will stop work and inform the PM.
Data tracking from collection through upload to database	CH2M HILL Project Chemist (PC)	Clairette Campbell	(757) 671-6335	PC will track data from sample collection through upload to the data base, ensuring SAP requirements are met by laboratory and field staff. The PC will coordinate variances to the SAP that are determined during sample receipt and login. The PM and AM are informed within 24 hours to pass on communications to Navy and regulators, as appropriate.
Management of analytical lab and data validation sub contractors; analytical CAs and release of analytical data.	CH2M HILL PC	Clairette Campbell	(757) 671-6335	The need for CA by the analytical laboratory will be determined by the PC. The PC will ensure the SAP requirements are met by the laboratory. No analytical data can be released until data usability is completed and approved by the PC. The PC will review all data as soon as possible upon receipt from the Data Validator (DV). The PC will review the data validation narrative and request CA from the DV if necessary. Communicates with subs by phone, followed up with e-mail to document decisions and actions. The PC will notify the PM of any needed analytical CAs. Any CAs for analytical issues identified by the PC will be reported to the PM as soon as possible. Analytical laboratory CAs will be identified by, or brought to the attention of, the PC as soon as they are discovered. Facilitates resolution on a same-day basis after consulting with the PM and AQM and the Navy chemist (if changes in the SAP are warranted) to ensure SAP requirements are met by the laboratory. Communicates with subs by phone, followed up with e-mail to document decisions and actions Should analytical laboratory issues affect data usability by rendering a significant amount of rejectable or unusable data such that the project completeness goal cannot be obtained, the PC will notify the project team including the Navy RPM and Navy Quality Assurance Officer (QAO).
Reporting Analytical Laboratory Data Quality Issues	CHEMTECH Consulting Group ALS-Houston	Kurt Hummler Ms. Arthi Kodur	(908) 728-3143 khummler@ chemtech.net (713) 266-1599	All quality assurance (QA)/quality control (QC) issues with project field samples will be reported within 1 day by the laboratory to the PC as soon as they are discovered.
Reporting Data Validation Issues	CH2M HILL DV	Herb Kelly	(352) 384-7100	The DV reviews and qualifies analytical data as necessary. The data, along with a validation narrative, are returned to the PC within 14 calendar days. All issues discovered during data validation will be reported to the PC. CAs (revisions and additional information, if necessary) will be requested from the laboratory.

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2 Project Approach

2.1 Project Scoping

2.1.1 Project Scoping Session 1

TABLE 2-1
Project Planning Session, May 2012

Project Name: Site 12 Groundwater Long-term Monitoring (LTM)			**Site Name:** Site 12		
Projected Date(s) of Sampling: December 2012			**Site Location**: Yorktown		
PM: Adam Forshey					
Date of Session: May 30, 2012					
Scoping Session Purpose: Site 12 Groundwater LTM Strategy					
Name	**Title**	**Affiliation**	**Phone Number**	**E-mail Address**	**Project Role**
Moshood Oduwole	RPM	USEPA Region 3	(215) 814-3362	Oduwole.Moshood@epamail.epa.gov	Regulator
Wade Smith	RPM	VDEQ	(804) 698-4125	wade.smith@deq.virginia.gov	Regulator
Jim Gravette	RPM	NAVFAC Mid-Atlantic	(757) 341-0477	james.gravette@navy.mil	Navy RPM
Donna Caldwell	Navy Technical Support	NAVFAC Atlantic	(757) 322-4816	donna.caldwell@navy.mil	Navy Technical Support
Bill Friedmann	AM	CH2M HILL	(757) 671-6223	william.friedmann@ch2m.com	AM
Adam Forshey	PM	CH2M HILL	(757) 671-6267	adam.forshey@ch2m.com	Recorder, Technical Support
Nancy Rouse	Team Facilitator	Management Edge	(760) 451-9786	nvrouse@gmail.com	Facilitator

A scoping session was held during the May 2012 Naval Weapons Station (WPNSTA) Yorktown Partnering Meeting to present and discuss the proposed Site 12 LTM sampling approach with the Tier I Partnering Team. The Team reviewed the site history, previous investigations conducted at Site 12, and 2007 LTM data. The main Team concern for groundwater from the 2007 LTM data was one detection of arsenic in monitoring well GW08. The sediment LTM data from 2007 had elevated levels of arsenic at two locations and elevated levels of selenium at one location; however, LTM data over time indicate an overall decreasing trend in metals concentrations in sediment. Therefore, it is concluded the landfill cap is functioning as intended and preventing surface runoff of contaminants to sediment.

The Team reviewed the proposed sampling approach. The objective of the proposed LTM sampling is to identify whether Area A will have future impacts on site media. To meet this objective, it is proposed that monitoring wells adjacent to the Barracks Road Landfill continue to be sampled once every 5 years for total and dissolved Resource Conservation and Recovery Act (RCRA) 8 metals. The Navy is currently developing the Uniform Federal Policy (UFP)-SAP and is scheduled to provide the Site 12 LTM UFP-SAP to the Team in July.

NAVFAC summarized that the important thing for the Team to note is that the 2007 through 2008 work recommended collection of sediment and groundwater data, but based on the Site 12 Explanation of Significant Difference (ESD), it was concluded that LTM is required for Area A only. As a result of this conclusion, sediment

and surface water sampling is no longer required, as potential impacts to sediment and surface water will be identified through regular landfill inspections and groundwater sampling. Based on the results of these activities, the need for additional investigation of other media would be determined. Therefore, the UFP-SAP will not include sediment sampling as part of the LTM.

Action Items

None

Consensus Decisions

None

2.1.2 Project Scoping Session 2

TABLE 2-2
Project Planning Session, August 2012

Project Name: Site 12 Groundwater LTM			**Site Name:** Site 12		
Projected Date(s) of Sampling: December 2012			**Site Location**: Yorktown		
PM: Adam Forshey					
Date of Session: August 23, 2012					
Scoping Session Purpose: Site 12 Groundwater LTM Strategy					
Name	**Title**	**Affiliation**	**Phone Number**	**E-mail Address**	**Project Role**
Jim Gravette	RPM	NAVFAC Mid-Atlantic	(757) 341-0477	james.gravette@navy.mil	Navy RPM
Bill Friedmann	AM	CH2M HILL	(757) 671-6223	william.friedmann@ch2m.com	AM
Cecilia Landin	PM	CH2M HILL	(757) 671-6266	Cecilia.landin@ch2m.com	UFP SAP Lead Author

A conference call was held to discuss the proposed changes to the LTM sampling plan. Proposed changes were based on data observations made during SAP development. Specifically, it was noted that the existing well network is likely to be insufficient in determining downgradient migration of contamination from the landfill. The Navy and CH2M HILL agreed one additional downgradient monitoring well will be installed to better identify a potential release from the landfill. Following monitoring well installation, LTM will consist of sampling six existing wells and the newly installed monitoring well once every 5 years for RCRA 8 metals. Monitoring well 12GW18 will be retained as a contingency monitoring well only sampled if a potentially unacceptable release from the landfill is identified.

Action Items

The Navy will inform the Tier I Partnering Team of proposed scope changes.

CH2M HILL will continue development of UFP SAP for submittal to the Navy Chemist.

Consensus Decisions

None

2.1.3 Summary of Additional Correspondence

After the two initial scoping sessions, a UFP-SAP was developed and submitted to the Partnering Team for review on September 27, 2012. Comments on the Draft Site 12 LTM UFP-SAP were received from VDEQ on October 17, 2012, and from USEPA on November 5, 2012. Responses to comments (RTCs) were provided to the Team on

January 18, 2013 (**Appendix B**). USEPA provided additional comment to the Team on February 7, 2013, and these comments were discussed with the Team during the February 2013 Partnering Meeting.

During this meeting the Team reviewed the February 7, 2013, USEPA comments, as responses had not yet been developed. To clarify the responses provided in January 2013 and the additional comments received, the final 2012 ESD was reviewed. USEPA clarified that the origin of many of the USEPA comments provided are based on the ESD indicating that only groundwater in Area A needs to be sampled, but it does not explain the reasoning for not including the other media in LTM. The intention of the ESD is to remove the LTM discussion from the Record of Decision (ROD) and to defer it to the work plan. Therefore, the USEPA believes that the UFP-SAP needs to provide the necessary justification for not including the other media outside of Area A groundwater. The Team discussed that the current decision logic in the SAP allows for surface water and sediment if the groundwater indicates a potential release. This decision will be made with the Partnering Team based on data results. Given the age of the landfill (over 50 years since disposal activities ended, suggesting a future release is not likely) and the fact that a new well will be located immediately downgradient of the landfill, the new well will give the data needed to determine whether sediment/surface water need to be sampled. This justification for not needing to sample surface water and sediment will be provided in the UFP-SAP.

Based upon the discussion at the February 2013 Partnering Meeting and the additional comments received from USEPA, additional RTCs were developed and provided to USEPA on March 13, 2013 (**Appendix B**), to address remaining comments and provide the technical justification for sampling only groundwater at Area A. The Team also agreed that eight monitoring wells, including 12GW18 (previously identified as a contingency well) and the newly installed 12GW28, will be included in the LTM sampling. Groundwater samples will be analyzed for RCRA 8 metals, 1,3,5-trinitrobenzene, and 2,3,7,8-tetrachlorodibenzo-para-dioxin (TCDD) and compared to the most current versions of USEPA Region 3 tap-water Regional Screening Levels (RSLs), federal MCLs, USEPA Region 3 Biological Technical Assistance Group (BTAG) Fresh Water Ecological Screening Values (ESVs) and base background 95 percent upper tolerance limits (UTLs). The Team agreed that 1,3,5-trinitrobenzene and 2,3,7,8-TCDD sampling is warranted to evaluate a potential data gap, as historical records indicate the disposal of ash material occurred at Area A but dioxins have not previously been evaluated at the site. On April 15, 2013, USEPA provided approval of the March 13, 2013, RTCs.

Finally, during the August 2013 Partnering Meeting, the Team reviewed and discussed additional changes that were recommended based upon Navy Chemist review of the UFP-SAP. The Team discussed that after Navy Chemist review of the previously agreed upon revisions to the UFP-SAP and review of the ROD, it was determined that two ROD constituents of concern (COCs) (antimony and manganese) were not included in the RCRA 8 analysis. The Team agreed that these two additional metals should be included in the list of analytes and will be incorporated into the UFP-SAP. The Team also agreed that the analytes that are included in the UFP-SAP for sampling but not identified as COCs in the ROD should be discontinued from future LTM sampling if they are not detected during the first round of LTM sampling following this UFP-SAP. Exclusion of any constituents will be detailed in the LTM report and will include trending graphs to justify that sampling for these analytes is no longer needed. The Team reviewed the decision trees that will be included in the UFP-SAP to detail the path forward for all constituents being evaluated. Two decision trees will be included; one will be for COCs identified in the ROD and the other will be for the remaining metals and 2,3,7,8-TCDD that will be sampled but are not ROD-identified COCs. The Team agreed that the decision trees would be included in the UFP-SAP.

2.2 Conceptual Site Model

WPNSTA Yorktown is a 10,624-acre installation located on the Virginia Peninsula in York and James City Counties and the City of Newport News, Virginia (**Figure 1**). Site 12, the Barracks Road Landfill, is located adjacent to the WPNSTA Industrial Area in the northeastern portion of the facility (**Figure 1**). The site is bordered by Barracks Road to the west, Ballard Creek to the east, and the Colonial National Historic Park to the south. Site 12 consists of three areas: Area A, Area B/C, and the Wood/Debris Disposal Area. Disposal activities took place from approximately 1925 to the mid-1960s, and the total estimated volume of waste disposed of in all three areas is

approximately 1,400 tons. Items disposed of include refuse, scrap wood, piping, steel containers, and/or nitramine-contaminated packaging. Area A is approximately 4.4 acres and was the former location of an industrial and non-industrial waste incinerator facility. Ash from the incinerator was disposed of in a ditch leading to Ballard Creek, located southwest of the incinerator building. In addition to the disposal of incinerator ash, open burning of waste was also conducted in the northern portion of Area A. Ash from open-burning activities was spread across the top of Area A toward the incinerator to the south. Scrap metal, charred wood, burnt cloth, and glass have been observed at Area A. Historical aerial photographs indicate a former railroad spur terminated in the vicinity of the incinerator facility at Area A. The date the railroad was removed is unknown; however, a review of historical aerial photographs indicates it had been removed prior to October 1986.

Area B/C is approximately 1.6 acres and is located adjacent to the access road leading to the incinerator facility. The Wood/Debris Disposal Area is approximately 3.3 acres and was created when lumber, wood pallets, and miscellaneous construction debris were disposed of in a ravine that leads to Ballard Creek and later covered with soil.

Site 12 investigation activities have included an Initial Assessment Study (IAS) (NEESA, 1984), Round 1 Confirmation Study (Dames & Moore, 1986), Round 2 Confirmation Study (Dames & Moore, 1988), Round 1 Remedial Investigation (RI) (Baker, 1993), and a Habitat Evaluation (Baker, 1995). Results of the investigations indicated potentially unacceptable human health and ecological risks from exposure to soil in Area A, potentially unacceptable ecological risks from exposure to surface water and sediment, and potentially unacceptable human health risks from exposure to volatile organic compounds (VOCs) in shallow aquifer groundwater. A Proposed Remedial Action Plan (Baker, 1996) and final ROD (Baker, 1997) were issued in 1996 and 1997, respectively. The ROD identified the following COCs for soil: 1,3,5-trinitrobenzene, antimony, cadmium, manganese, and lead. The selected remedy for Site 12 was demolishing the incinerator facility, regrading Area A, implementing erosion control measures, placing a soil and clay cover over the landfill at Area A, land use controls (LUCs), and groundwater and sediment LTM. The ROD documented no further action for Area B/C and the Wood/Debris Disposal Area. An ESD (CH2M HILL, 2012) was subsequently developed to 1) remove the details of the LTM requirements from the ROD and relocate them in an LTM Work Plan, 2) clarify that LTM is required only for the Area A portion of Site 12 (not Area B/C or the Wood/Debris Disposal Area), and 3) remove groundwater use restriction requirements for all areas of Site 12 (including Area B/C and the Wood/Debris Disposal Area) except for Area A. Additionally, the ESD eliminated all references in the ROD to trichloroethene (TCE) monitoring at the site, as the source of VOCs detected onsite was determined to be the industrial area (Installation Restoration [IR] Site 31) upgradient of Site 12. VOCs, including TCE, in groundwater are currently being addressed as part of IR Site 31.

The conceptual site model (CSM) for Site 12, Area A, is presented on **Figure 2**. The topography is varied across the site from gently rolling to steep ravines, but generally slopes to the south-southeast toward Ballard Creek. Area A generally consists of grass-covered fields. Surface runoff is drained by several stream channels leading to Ballard Creek and ultimately the York River. The site is inaccessible to the general public because the installation still holds the mission of supporting national military strategy; however, once on the facility, human access to the site is restricted only by ingress cable gates and signage.

Site 12 lies on the Lackey Plain terrace, above the Camp Peary scarp, and is characterized by unconsolidated deposits of fine-grained sand, silt, clay, and marine shells. In general, silt and clay are present at the ground surface and extend to a depth of 15 feet below ground surface (bgs), at which point unsaturated fine-grained sand is encountered. These sands extend to a depth of 25 to 30 feet bgs, where a 15-foot clay layer is encountered. The Cornwallis Cave aquifer, consisting of fine- to medium-grained sand and shell fragments underlies this clay layer and represents the shallow aquifer at the site. The aquifer is between 20 and 25 feet thick and overlies the 15-foot-thick Yorktown confining unit, which is composed of greenish gray clay and silt. The Yorktown confining unit overlies the Yorktown-Eastover aquifer, which consists of fine to coarse sands and shell fragments. Average groundwater flow velocities of 2.3×10^{-1} feet per day (ft/day) in the Cornwallis Cave aquifer and 7×10^{-4} ft/day in the Yorktown Eastover aquifer (using an assumed effective porosity for silty sand of 0.30) were calculated during previous investigations. Groundwater flow directions are shown on **Figure 3**. The primary mechanism for potential

contaminant transport from the landfill is leaching of contaminants from waste and waste-contaminated soil through precipitation and infiltration to groundwater as groundwater migrates through the site and discharges to the stream channels and Ballard Creek. However, this transport mechanism has been limited through the placement of a 24-inch soil and clay cover.

Remedial action construction for Area A began in July 1997 and consisted of monitoring well abandonment and demolition of the incinerator facility, incinerator stack, and a one-story maintenance shed, as well as implementation of erosion and sediment controls. Metal debris scattered throughout the site was removed and sent to a recycling facility. In addition, the limits of the landfill were defined and contaminated material located outside the limits of the landfill was excavated and placed within the landfill. The landfill was subsequently covered with a geosynthetic clay liner and soil. Finally, a surface drainage channel (constructed of Tri-Lock Block) and settling pond were installed and the site was re-vegetated (OHM, 1998).

LTM of groundwater and sediment was initiated in 1998. In June 1997, the Yorktown Partnering Team agreed Ballard Creek surface water monitoring was not warranted as part of Site 12 LTM (Baker, 2005). Groundwater and sediment analysis initially included VOCs, semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), nitramines, and inorganics (total and dissolved). Annual groundwater and sediment sampling was conducted from 1998 to 2003. In June 2003, September 2006, and September 2007 the Navy, USEPA, and VDEQ agreed to revise the LTM sampling network via consensus agreements. These consensus agreements changed the frequency of sampling, number of sampling locations, and analysis for each media. To date, groundwater LTM data do not indicate that a release of hazardous substances from the landfill has occurred. Additionally, sediment LTM data show concentrations in sediment are decreasing; therefore, the remedy is protective of contaminant migration from the landfill (CH2M HILL, 2008). The 2008 LTM report recommended continued LTM of groundwater and sediment for only RCRA 8 metals once every 5 years.

Because the ROD specifically details LTM requirements (that is, media, analysis, locations, depths, frequency, and duration), an ESD for Site 12 was completed to remove the details of the LTM program, clarify that LTM details will be addressed in future work plans, and clarify that the objectives of the LTM program are to: 1) detect potential releases to groundwater, at the waste boundary, of COCs in landfill material, 2) confirm that the clay cover remains protective of human health and the environment, and 3) confirm effective containment of waste and soils beneath the cover that do not meet unlimited use and unrestricted exposure levels (CH2M HILL, 2012). Additionally, the ESD eliminated analysis of TCE as a monitoring requirement at the site, as the source of VOCs detected onsite was determined to be the industrial area (IR Site 31) upgradient of Site 12. VOCs, including TCE, in groundwater are currently being addressed as part of IR Site 31.

Based upon the recommendation in the 2008 LTM report, Partnering Team agreements, the 2012 ESD, and the nature of the waste disposed of in Area A (scrap metal, charred wood, burnt cloth, and glass) samples outlined in this UFP-SAP will be analyzed for ROD-identified COCs (1,3,5-trinitrobenzene, antimony, cadmium, manganese, and lead), additional RCRA 8 metals (arsenic, barium, chromium, mercury, selenium, and silver) that are not identified as ROD COCs but were recommended for monitoring in the previous LTM report (CH2M HILL, 2008), and a potential data gap for dioxins (2,3,7,8-TCDD) that have not previously been evaluated at the site. Because the intention of the LTM sampling is to detect potential releases of COCs to groundwater at the waste boundary, constituents that are being evaluated that are not ROD-identified COCs (2,3,7,8-TCDD, arsenic, barium, chromium, mercury, selenium, and silver) will be evaluated during the first round of LTM sampling. If they are not detected, or are detected but at levels that do not pose a potential risk to human health or ecological receptors, future monitoring of these constituents will not be necessary to ensure protectiveness of the remedy, and they will be removed from future rounds of LTM sampling.

No potential releases are anticipated to site soil because the cap in place at Area A prevents infiltration. Additionally, given the age of the landfill (50-plus years since waste was last disposed), and historical sampling and LTM data indicating there have been no releases from Area A, future releases are not expected. Therefore, only groundwater sampling around Area A is necessary, unless groundwater LTM data and landfill inspection results indicate potential migration of contaminants to Ballard Creek.

2.3 Data Quality Objectives and Systematic Planning Process Statements

2.3.1 Project Statement and Objectives

The objective of this investigation is to monitor groundwater quality at Site 12 at regular intervals to determine if a landfill release to groundwater has occurred that might adversely affect human health or the environment. Continued protectiveness of the cover and containment of waste and soils will be verified through regular site inspections; therefore, surface water and sediment sampling will not be conducted unless groundwater LTM and landfill inspection results indicate potential migration of contaminants to Ballard Creek.

2.3.2 What are the environmental questions being answered?

Has a release to groundwater from the landfill occurred?

One new monitoring well (12GW28) will be installed in the Cornwallis Cave aquifer immediately downgradient of the Area A landfill boundary (**Figure 4**). Groundwater samples will be collected from the newly installed monitoring well, as well as from the seven existing monitoring wells located adjacent to the Area A LUC boundary (**Figure 4**), once every 5 years. Based upon the recommendation in the 2008 LTM report, Partnering Team agreement, and the nature of the waste disposed of in Area A (scrap metal, charred wood, burnt cloth, and glass), samples will be analyzed for select metals comprising of RCRA 8 metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) plus antimony and manganese. Samples will also be analyzed for 1,3,5-trinitrobenzene and 2,3,7,8-TCDD. In accordance with the decision trees for ROD-identified COCs (**Figure 5a**) and for the additional select metals and 2,3,7,8-TCDD that are not ROD-identified COCs (**Figure 5b**), the determination of whether a release has occurred will be made if constituent concentrations are detected in the newly installed monitoring well immediately downgradient of the landfill boundary above the WPNSTA Yorktown basewide background 95 percent UTLs[2] and upgradient groundwater concentrations. If there are detections above the background 95 percent UTLs and upgradient concentrations, the Partnering Team will re-convene to evaluate the data to determine if any detections are indicative of a release from the landfill area. If 2,3,7,8-TCDD is detected in groundwater, the Team will assess the data to determine if the detections are from a site-related release or whether they may be anthropogenic.

Because 2,3,7,8-TCDD, arsenic, barium, chromium, mercury, selenium, and silver are not ROD-identified COCs, they will be evaluated during the first round of LTM sampling. If they are not detected, or are detected but at levels that do not pose a potential risk to human health or ecological receptors, future monitoring of these constituents will not be necessary to ensure protectiveness of the remedy, and they will be removed from future rounds of LTM sampling (**Figure 5b**).

Do groundwater conditions (that is, groundwater flow direction and velocity) indicate a change in long-term monitoring strategy is warranted?

Synoptic water level measurements will be collected from 16 Cornwallis Cave aquifer monitoring wells (15 existing and one new) during each sampling event, as depicted on **Figure 4**. Data will be used to determine groundwater flow direction, gradient, and velocity. The Partnering Team will re-convene to determine an appropriate path forward for Site 12 should changes in groundwater conditions be observed. Next steps could include changes in LTM sampling frequency, revision to the monitoring well network, or installation of additional monitoring wells.

If a release has occurred, do concentrations in groundwater pose potentially unacceptable risk to human health or the environment?

If a release is identified, a human health and ecological risk screening will be conducted in the manner defined as follows under "What will the data be used for?" to determine whether the release from the landfill poses potentially unacceptable risk (**Figure 5a and 5b**). Screening values include the most recent version of the USEPA

[2] Because 1,3,5-trinitrobenzene is not naturally occurring, a comparison to basewide background UTLs will not be made for this constituent. Only a comparison to upgradient results will be performed to determine if a site release has occurred.

Region 3 tap-water RSLs, federal MCLs, USEPA Region 3 BTAG fresh water ESVs, and base background 95 percent UTLs, as presented in the Reference Limits and Evaluation Tables (**Section 4.1**).

Because 2,3,7,8-TCDD, arsenic, barium, chromium, mercury, selenium, and silver are not ROD-identified COCs, they will be evaluated during the first round of LTM sampling. If they are not detected at levels that pose a potential risk to human health or ecological receptors, future monitoring of these constituents will not be necessary to ensure protectiveness of the remedy, and they will be removed from future rounds of LTM sampling (**Figure 5b**). If concentrations of 2,3,7,8-TCDD exceed screening values but are not site related (that is, are anthropogenic), a potential data gap may exist.

If potentially unacceptable risk to human health or the environment is identified or if a potential data gap for 2,3,7,8-TCDD exists, what is the appropriate next step?

The Partnering Team will re-convene to determine an appropriate path forward for Site 12 should potentially unacceptable risks attributable to releases from the landfill be identified during the risk screening process or should detections of 2,3,7,8-TCDD be present at levels indicating a potential data gap. Next steps could include a quantitative risk assessment, additional compounds for future LTM, additional groundwater investigation or increase frequency of sampling, investigation of other site media (surface water and/or sediment), or additional remedial action.

What are the Project Action Limits?

The Project Action Limits (PALs) for groundwater data are WPNSTA background UTL values (where established), most-current USEPA Region 3 tap-water RSLs, federal MCLs, and USEPA Region 3 BTAG fresh water ESVs. Additionally, downgradient groundwater detections will be compared against detected upgradient concentrations. Established PALs are compared to laboratory-specific reporting limits in the Reference Limits and Evaluation Tables (**Section 4.1**).

What will the data be used for?

The groundwater data will be used to determine if a release of hazardous substances from the landfill has potentially occurred, and if so, whether contaminants pose potentially unacceptable risks to human health or the environment. A determination that a potential release has occurred will be made if downgradient groundwater concentrations exceed WPNSTA background UTLs (where established), as well as site-specific upgradient concentrations. If a release is identified, the data will be used to conduct human health and ecological risk screening. Data for 2,3,7,8-TCDD will also be used to determine if a potential data gap exists in the current data set. 2,3,7,8-TCDD results will be used to determine if additional investigation for these constituents is necessary.

For the human health risk screening assessment, the groundwater data will be compared to human health risk-based PALs (the USEPA tap-water RSLs). RSLs based on noncarcinogenic effects will be divided by 10 to account for exposure to more than one noncarcinogenic constituent that affects the same target organ (such as the liver). RSLs based on carcinogenic endpoints will be used as presented in the most up-to-date RSL table (May 2013). If the maximum detected concentration of a constituent exceeds the screening-level and WPNSTA background UTL (where established), the constituent will be carried forward to the next step of the screening, where a risk ratio will be calculated multiplying the maximum detected concentration by the acceptable risk level (a hazard of 1 for noncarcinogens and a carcinogenic risk of 10^{-6} for carcinogens) and dividing by the RSL (the RSLs based on noncarcinogenic endpoints will not be divided by 10, as is done in the first step). If the sum of the calculated risk ratios for all noncarcinogenic constituents with the same target organ exceeds 0.5 or the sum of the calculated risk ratios for all carcinogenic constituents exceeds $5x10^{-5}$, those constituents contributing to the noncarcinogenic hazard or carcinogenic risk will be identified as human health constituents of potential concern (COPCs), warranting further consideration.

Although ecological receptors do not typically have direct exposure to groundwater, Region 3 BTAG fresh water ESVs will be compared to site groundwater data in order to provide a conservative evaluation of the potential for significant contaminant transport via groundwater to downgradient water bodies. For the screening-level ecological risk assessment, groundwater data will be compared to the ecological PALs (BTAG surface water ESVs)

using the hazard quotient (HQ) approach to identify COPCs. Using this approach, sample-by-sample concentrations will be divided by the ESVs to calculate an HQ. Constituents with HQs greater than or equal to 1 in one or more samples will be identified as ecological COPCs, warranting further consideration. Although both total and dissolved metals groundwater data will be screened against ESVs, only dissolved metals data will be considered when selecting COPCs because chemicals in groundwater are most likely to travel dissolved in water rather than adhered to particles, as they must travel through soil pores or fractured rock. Similarly, when groundwater discharges to a water body (at which time ecological exposures become possible), the bulk of the discharged chemicals are likely to be dissolved in water since the discharge must pass through the pores in the underlying sediments. Thus, the dissolved concentrations are likely to be more representative of what would be transported via the groundwater than the total concentrations. Once discharged, the dissolved metal fraction in water (filtered samples) is more representative of the bioavailable fraction to aquatic receptors than the total metal fraction (unfiltered samples) (USEPA, 1996). This is reflected in how the most recent Ambient Water Quality Criteria have been developed for many metals; that is, they are based upon the dissolved fraction (USEPA, 2009).

What types of data are needed?

Groundwater data are required for this project. All analytical samples will be submitted to an offsite subcontracted laboratory for analysis of total and dissolved select metals comprising of RCRA 8 metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) plus antimony and manganese, 1,3,5-trinitrobenzene, and 2,3,7,8-TCDD. For completion of the human health risk screening assessment, if dissolved and total metals concentrations are similar (meaning if dissolved and total metals concentrations for samples collected from the same monitoring well are within one order of magnitude of each other), total metal results will be used for that monitoring well. If a notable disparity exists between dissolved and total metals concentrations collected from a monitoring well, as can be demonstrated by total metals concentrations that are over a magnitude greater than dissolved metals concentrations in mutual samples, dissolved metals data would be used for that well. For completion of the screening-level ecological risk assessment, only dissolved metals data are considered when selecting COPCs as previously described in the "What will the data be used for?" section. Refer to **Section 2.5** and **Section 3.0** for sample locations, numbers, rationale, and methodology. **Section 2.5** contains detailed information on the types of data needed for this project, including sample locations and sample depth intervals.

Are there any special data quality needs, field or laboratory, in order to support environmental decisions?

None

Where, when, and how should the data be collected or generated?

Detailed information on where, when, and how the data will be collected is provided in **Section 3.0**.

How will the data usability be documented?

The PM, PC, and other team members will be responsible for compiling the data. The data will then be presented to the Yorktown Partnering Team who, as a whole, will evaluate the data usability according to project objectives. Any qualifications made to the data during validation will be included for consideration; possible qualifications that may be applied to the data during validation are as follows:

- When major QC deficiencies are encountered, data will be qualified with an "R" and in most cases are not considered usable for project decisions. If R-qualified data are used in evaluations and, ultimately, project decisions, the rationale for their use will be included in the RI Report. The R-qualifier is defined as follows:
  - R = Rejected result. Result not reliable.
- For minor QC deficiencies that will not affect the usability of the data, data may be qualified as estimated with the following qualifiers: J, UJ, K, L, or UL. These qualifiers are defined as follows:
  - J = Analyte present. Reported value may or may not be accurate or precise.
  - UJ = Analyte not detected. Quantitation limit (QL) may be inaccurate or imprecise.

  - K = Analyte present. Reported value may be biased high. Actual value is expected to be lower.
  - L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
  - UL = Analyte not detected. QL is probably higher.
- Additional qualifiers that may be applied to data by the DV are:
  - B = Not detected substantially above the level reported in laboratory or field blanks. This detection is attributed to blank contamination and is to be treated as a non-detect.
  - N = Tentative identification. The analyte is considered present, though special methods may be needed to confirm its presence or absence in future sampling efforts.
  - NJ = Qualitative identification is questionable due to poor resolution. Presumptively present at approximate quantity.
  - U = Not detected.

Results will be evaluated through trend analysis and direct comparison against the PALs. Specific data verification and validation steps are detailed in **Section 4, Table 4-11**, *Data Verification and Validation (Steps I and IIa/IIb) Process Table*. In general:

- Samples in which constituent concentrations are not detected will be evaluated to ensure that project quantitation limit (PQL) goals in *Reference Limits and Evaluation Table* (**Section 4, Tables 4-1** through **4-4**) were achieved. If PQLs were achieved and the verification and validation steps yielded acceptable data, then the data are considered usable.
- To assess whether a sufficient quantity of acceptable data are available for decision making, the data will be reconciled with Measurement Performance Criteria (MPC) following validation and review of data quality indicators (DQIs).
- Deviations from the SAP will be reviewed to assess whether CA is warranted and to assess impacts to the achievement of project objectives.

Data usability will be documented in data tables and discussed in the data quality evaluation, both of which will be provided as part of the LTM report. Data tables will reflect the reported concentration of analytes, whether the analyte was detected, and what, if any, data qualifiers accompany the result. The data quality evaluation will discuss the use of specific data qualifiers and their impact on decision-making, the overall quality of the data set, and any data usability limitations determined by the Yorktown Partnering Team.

List the Data Quality Objectives in the form of if/then qualitative and quantitative statements

Quantifiable analytical results will be the primary basis for project decisions. The limit of quantitation (LOQ), which is defined as the minimum concentration or quantity of a target analyte that can be reported with accurate quantitation, will be the metric to define whether an analytical result is quantifiable. The data quality objectives (DQOs) are presented on **Figure 5** in the form of a decision tree.

2.4 Field Quality Control Samples

Details regarding the types, frequency, and evaluation of field QC samples are provided in the *Measurement Performance Criteria Table for Field QC Samples* (**Tables 2-3 through 2-5**).

TABLE 2-3
Measurement Performance Criteria Table for Field Quality Control Samples

Matrix: Groundwater

Analytical Group: Total and Dissolved Metals[1]

Analytical Method: SW846 6020A and 7470A

QC Sample	Analytical Group	Frequency	DQIs	MPC	QC Sample Assesses Error for Sampling (S) or Analytical (A)
Field Duplicate (FD)	Total and Dissolved Metals	One per 10 field samples	Precision	Relative Percent Difference (RPD) ≤ 20 percent	S & A
Equipment Blank (EB)		One per day of sampling for decontaminated equipment, one per lot for disposable equipment	Bias/ Contamination	Target analytes ≤ 1/2 LOQ	S & A
Cooler Temperature Indicator		One per cooler to the laboratory	Representativeness	Temperature ≤ 6 degrees Celsius (°C)	S

[1] Field QA/QC as described in this table will be collected and analyzed for each of the analytical groups listed.

TABLE 2-4
Measurement Performance Criteria Table for Field Quality Control Samples

Matrix: Groundwater

Analytical Group: 1,3,5-Trinitrobenzene

Analytical Method: SW846 8330A

QC Sample	Analytical Group	Frequency	DQIs	MPC	QC Sample Assesses Error for Sampling (S) or Analytical (A)
FD	1,3,5-Trinitrobenzene	1 per 10 field samples	Precision	RPD ≤ 30%	S & A
EB		1 per day of sampling for decontaminated equipment, 1 per lot for disposable equipment	Bias/ Contamination	Target analytes ≤ 1/2 LOQ	S & A
Cooler Temperature Indicator		1 per cooler to the laboratory	Representativeness	Temperature ≤ 6C	S

TABLE 2-5
Measurement Performance Criteria Table for Field Quality Control Samples

Matrix: Groundwater
Analytical Group: 2,3,7,8-Dioxin
Analytical Method: SW846 8290

QC Sample	Analytical Group	Frequency	DQIs	MPC	QC Sample Assesses Error for Sampling (S) or Analytical (A)
FD	2,3,7,8-Dioxin	One per 10 field samples	Precision	RPD ≤ 20 percent	S & A
EB		One per day of sampling for decontaminated equipment, one per lot for disposable equipment	Bias/ Contamination	Target analytes ≤ 1/2 LOQ	S & A
Cooler Temperature Indicator		One per cooler to the laboratory	Representativeness	Temperature ≤ 6C	S

2.5 Sampling Design and Rationale

The Yorktown Partnering Team discussed and agreed to the proposed sampling rationale for Site 12 (see **Section 2.2**). **Figure 4** presents the proposed sample locations. One new monitoring well (12GW28) will be installed in the Cornwallis Cave aquifer immediately downgradient of the Area A landfill to identify a potential future release from the landfill to groundwater. Once every 5 years, groundwater samples will be collected from the newly installed monitoring well, as well as from seven existing monitoring wells located upgradient of the Area A landfill boundary, for comparison against downgradient data to determine if a release to groundwater from the landfill has occurred. A summary of the monitoring wells to be sampled is provided in **Table 2-6**.

TABLE 2-6
Summary of Monitoring Wells

Sampling Point	Purpose/Location	Total Depth (feet bgs)	Screened Interval (feet bgs)
YS12-GW04	Upgradient	52.5	37.5-52.5
YS12-GW05	Upgradient	49.5	34.5-49.5
YS12-GW06	Upgradient	54	44-54
YS12-GW08	Upgradient	53	43-53
YS12-GW13	Upgradient	64	44-64
YS12-GW18	Downgradient	15	5-15
YS12-GW19	Upgradient	55	45-55
YS12-GW28	Downgradient	TBD	TBD

If a release has occurred, data collected from the downgradient well will also be used to evaluate potential unacceptable risks to human health and the environment. Because 2,3,7,8-TCDD, arsenic, barium, chromium, mercury, selenium, and silver are not ROD-identified COCs, they will be evaluated during the first round of LTM sampling. If they are not detected, or are detected but at levels that do not pose a potential risk to human health or ecological receptors, future monitoring of these constituents will not be necessary to ensure protectiveness of the remedy, and they will be removed from future rounds of LTM sampling (**Figure 5b**). Samples will be collected from each monitoring well at the mid-point of the screened interval. **Section 3.0** provides a detailed outline of the field methods to be performed.

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3 Field Project Implementation

3.1 Project Logistics

Work will be performed in Level D personal protective equipment (PPE), which includes safety glasses, safety-toed boots, and impermeable gloves. Upgrades to higher levels of PPE, if necessary, will be presented in the HSP. Sampling efforts will be coordinated with WPNSTA Yorktown to minimize impacts to the installation.

3.2 Field Project Tasks

Applicable Standard Operating Procedures (SOPs) for project tasks outlined in this section are listed in **Table 3-1** (**Section 3.3**) and provided in **Appendix C**. There are no specialized SOPs or modifications to the standard SOPs required for this project. A temporary staging area (location TBD in the field) will be located onsite to store equipment, if necessary.

3.2.1 Base Passes

WPNSTA Yorktown is currently enrolled in the RAPIDGate Program.

3.2.2 Mobilization

Following approval of the SAP, CH2M HILL will begin mobilization activities. Before mobilization, all field team members will review this SAP and the project-specific HSP. A field team kickoff meeting will be held to ensure that personnel and subcontractors are familiar with the scope of field activities and discuss any safety issues. Mobilization activities include coordination with base personnel and subcontractors and preparation of field equipment.

3.2.3 Monitoring Well Installation

One Cornwallis Cave aquifer monitoring well will be installed using hollow stem auger drilling methods as described in the SOPs. The approximate location of the proposed monitoring well (12GW28) is shown on **Figure 4**. During monitoring well installation, continuous macrocore samples will be collected to the depth of the top of the Yorktown confining unit. Soil descriptions that include grain size, color, moisture content, consistency, soil structure, mineralogy, and other relevant information concerning contamination will be recorded. Consistent with existing site monitoring wells, the monitoring well will be installed to the depth of the top of the Yorktown confining unit with 2-inch nominal-diameter Schedule 40 polyvinyl chloride (PVC) screen and riser. The monitoring well screen will be machine-slotted, 0.010 inch, and 10 feet long. A silica filter pack will be placed around the annular space of the well screen from the bottom of the boring extending to a depth of 2 feet above the top of the screen. A 2-foot bentonite layer will be placed above the top of the sand pack. After the bentonite has been hydrated, a cement-bentonite grout will be placed in the remaining annular space. The monitoring well will be completed with stick-up steel casing and water-tight cap. Following installation, the monitoring well will be developed as described in the SOPs. Development information, including turbidity, pH, specific conductivity, temperature, and gallons removed, will be recorded in the field logbook.

3.2.4 Groundwater Sampling

Groundwater sampling will be performed once every 5 years at eight monitoring wells (including the newly installed 12GW28), as presented on **Figure 4**. Groundwater samples will be collected using a peristaltic pump following low-flow sampling protocol as described in the SOPs. Water quality parameters will be measured and stabilization readings recorded and consistency protocol met before samples are collected. All relevant site-specific observations, onsite conditions, and sampling activities will be recorded in the field logbook, as described in the SOPs. All samples will be collected in laboratory-prepared sampling containers, packed on ice, and shipped overnight to an offsite laboratory every evening. Dissolved metal samples will be field-filtered.

3.2.5 Water-Level Survey

A round of water levels will be collected from 16 site monitoring wells (**Figure 4**) either prior to or at least 24 hours following the groundwater sampling event in order to allow the water table to equilibrate. An electronic water-level meter will be used to measure depth to water from the top of the PVC casing (either at marked point or at the highest point along the PVC). All water levels will be recorded in the field logbook.

3.2.6 Equipment Decontamination

All non-disposable sampling equipment will be decontaminated before use and immediately after each use as described in the SOPs. The water-level indicator will be scrubbed with deionized water between each measurement. Disposable equipment, such as tubing for low-flow sampling, will be disposed of immediately following use.

3.2.7 Investigation-Derived Waste Handling

Investigation-derived waste (IDW) generated during well installation may include soil cuttings, development purge water, and solutions used to decontaminate drilling equipment. IDW generated during groundwater sampling will include purge water and solutions used to decontaminate non-disposable sampling equipment. All IDW will be containerized in approved 55-gallon drums and stored on secondary containment at an approved staging area (location TBD). IDW will be characterized for appropriate offsite disposal (Navy-approved) and will be removed from the site within 90 days from the first day of generation.

3.2.8 Quality Control

QC samples will be collected as outlined in **Table 3-2**. Field activities will be implemented following the applicable SOPs listed in **Table 3-1** (**Section 3.3**) and provided in **Appendix C**. Laboratory activities will be implemented following the applicable SOPs listed in the *Analytical SOP References Table* (**Section 4.2**, **Tables 4-5 and 4-6**).

3.3 Field Standard Operating Procedures References

TABLE 3-1
Field Standard Operating Procedures Reference Table

SOP Reference Number	Title/Author	Revision Date or Version Number	Location of SOP	Any planned deviation for Project Work	Comments
001_BlankPrep	EB and Field Blank Preparation	8/2012	Appendix C	Not Applicable (N/A)	N/A
002_COC	Chain-of-Custody	8/2012	Appendix C	N/A	N/A
003_Log Books	Preparing Field Log Books	8/2012	Appendix C	N/A	N/A
004_WaterQual-Horiba_YSI	Field Measurement of pH, Specific Conductance, Turbidity, Dissolved Oxygen, Oxidation-Reduction Potential (ORP), and Temperature Using the Horiba or YSI Water Quality Parameter Meter with Flow-through Cell	8/2012	Appendix C	N/A	N/A
005_LowFlow – USEPA Region I &III	Low-flow Groundwater Sampling from Monitoring Wells – USEPA Regions 1 and 3	8/2012	Appendix C	N/A	N/A
006_DrumSample	Sampling Contents of Tanks and Drums	8/2012	Appendix C	N/A	N/A
007_Dispose	Disposal of Waste Fluids and Solids	8/2012	Appendix C	N/A	N/A
008_Decon	Decontamination of Equipment and Personnel	8/2012	Appendix C	N/A	N/A
009_DeconRig	Decontamination of Drilling Rigs and Equipment	8/2012	Appendix C	N/A	N/A
010_WaterLevels	Water-level Measurements	8/2012	Appendix C	N/A	N/A
011_MWInstal	General Guidance for Monitoring Well Installation	8/2012	Appendix C	N/A	N/A
012_MWShall	Installation of Shallow Monitoring Wells	8/2012	Appendix C	N/A	N/A
013_SBLog	Logging of Soil Borings	8/2012	Appendix C	N/A	N/A

3.4 Sample Details Table

Table 3-2 includes details regarding sample nomenclature, sampling, and analysis that will be conducted as part of this SAP.

TABLE 3-2
Sample Details Table

Contract Task Order (CTO)-WE42 WPNSTA Yorktown Site 12 Groundwater LTM Sampling Fall 2013, tentative Main Laboratory ChemTech 284 Sheffield Street Mountainside, NJ 07092 Kurt Hummler – (908) 728-3143 Dioxin Laboratory ALS-Houston 19408 Park Row Suite 320 Houston, TX 77084 USA Arthi Kodur - (713) 266-1599		**Analysis Group**		Total Select Metals, including mercury	Dissolved Select Metals, including mercury	Select Explosives	Select Dioxins
		Preparation and Analytical Method		SW-846 3010A, 6020A, 7470A	SW-846 3010A, 6020A, 7470A	SW-846 3535A, 8330A	SW-846 8290 (prep and analysis)
		Analytical Laboratory/ Preparation and Analytical SOP Reference[1]		Chemtech / M3010A-Digestion-11, M6020/6020A-Metals ICPMS-15, M7470A-Mercury-13		Chemtech / M3535-HPLC EXP prep-01, M8330-A-Nitroaromatics-11	ALS-Houston / HE-EXT001, HE-EXT003, HMS-PCDD/F
		Data Package Turnaround Time		28 calendar days			
		Container Type/ Minimum Volume required		1, 250-milliliter (ml) Plastic/100 ml	1, 250-ml Plastic/100 ml	2, 1-liter (L) amber/1 L	2, 1-L amber/1 L
		Preservative		HNO_3, Cool to <6°C	Field Filter; HNO_3; Cool to <6°C	Cool to <6°C	Cool to <6°C
		Holding Time (Preparation/ Analysis)[2]		28 days for Mercury, 180 days others		7 days to extraction / 40 days from extraction to analysis	30 days
Matrix	**Station Identification**	**Sample identification**	**Sampling Depth**				
Groundwater Samples							
GW	YS12-GW04	YS12-GW04-MMYY	Middle of Screen	1	1	1	1
	YS12-GW05	YS12-GW05-MMYY	Middle of Screen	1	1	1	1
	YS12-GW06	YS12-GW06-MMYY	Middle of Screen	1	1	1	1
	YS12-GW08	YS12-GW08-MMYY	Middle of Screen	1	1	1	1
	YS12-GW13	YS12-GW13-MMYY	Middle of Screen	1	1	1	1
	YS12-GW18	YS12-GW18-MMYY	Middle of Screen	1	1	1	1
	YS12-GW19	YS12-GW19-MMYY	Middle of Screen	1	1	1	1
	YS12-GW28	YS12-GW19-MMYY	Middle of Screen	1	1	1	1
Groundwater QA/QC Samples[3]							
FD	YS12-GW06	YS12-GW06P-MMYY	same as parent	1	1	1	1
Matrix Spike (MS)	YS12-GW04	YS12-GW04-MMYY-MS	same as parent	1	1	1	1
Matrix Spike Duplicate (MSD)	YS12-GW04	YS12-GW04-MMYY-SD	same as parent	1	1	1	1
EB	YS12-QC	YS12-EBMMDDYY	N/A	1	1	1	1
		Total Number of Samples to the Laboratory:		12	12	12	12

Notes follow on the next page

Notes for Table 3-2 on preceding page:
[1] For a complete reference of laboratory SOPs, see the Analytical SOP References Table in **Appendix A**.
[2] Maximum holding time is calculated from the time the sample is collected to the time the sample is prepared/analyzed.
[3] Field QC counts may change depending on the duration of field event. Frequency of QA/QC sample collection is noted on the MPC Table in Section 2.4 of the UFP-SAP and is as follows :
FD - One per 10 field samples
MS/MSD - One pair per 20 field samples of similar matrix (including FDs)
EB- For disposable equipment, one per week of sampling; for decontaminated equipment, one per type of sampling equipment, per day of sampling
Field Blank - No field blanks will be collected for this project
Trip Blank - No trip blanks will be collected for this project

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4 Sample Analysis and Data Validation Details

4.1 Reference Limits and Evaluation Tables

Samples will be collected and analyzed for the analytical groups and methods detailed in **Section 3.4**, *Sample Details Table* (**Table 3-2**). The PALs and laboratory reporting limits for each analyte from these samples are provided in the *Reference Limits and Evaluation Tables* (**Tables 4-1** through **4-4**).

TABLE 4-1
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: Total Select Metals

Analyte Name	CAS[a] No.	PALs[1]					PQL Goal[3] (µg/L)	Laboratory Limits (µg/L)			LCS[c] and MS/MSD Recovery and RPD Limits[4] (%)		
		Adjusted Tap-water RSL, May 2013 (µg/L)[b]	Surface Water Quality Criteria (µg/L)	Yorktown Cornwallis Cave Aquifer Background[2] (µg/L)	MCL (µg/L)	BTAG Region 3 Freshwater ESV (µg/L)		LOQ	LOD[d]	DL[e]	LCL[f]	UCL[g]	RPD
Antimony	7440-36-0	0.6	30	***18.8***	6	30	0.3	2	1	0.14	80	120	20
Arsenic	7440-38-2	0.045	150	2.28	10	5.00	0.0225	1	0.5	0.18			
Barium	7440-39-3	290	4	118	2000	4.00	2	10	5	0.1			
Cadmium	7440-43-9	0.69	0.27	0.6	5	NC	0.135	1	0.5	0.13			
Chromium	7440-47-3	0.031	11.4	15.1	100	NC	0.0155	2	1	0.04			
Lead	7439-92-1	15	3.18	***21.3***	15	NC	1.59	1	0.5	0.04			
Manganese	7439-96-5	32	120	57.9	NC	120	16	1	0.5	0.05			
Mercury	7439-97-6	0.43	0.91	***0.081***	2	0.026	0.013	0.2	0.1	0.09			
Selenium	7782-49-2	7.8	5	NC	50	1.00	0.5	5	2.5	0.7			
Silver	7440-22-4	7.1	0.36	NC	NC	NC	0.18	1	0.5	0.03			

Notes:
[1] Refer to **Section 2.3.2** for a detailed discussion on the development of PALs.
[2] The background values are 95 percent UTL values, except in cases where 95 percent UTLs were not evaluated, the max detection in a background sample is shown; max background values are bolded and italicized.
[3] PQL goals are equal to half of the minimum applicable PAL.
[4] Department of Defense (DoD) Quality Systems Manual (QSM) v.4.1 is the basis for LCS and MS/MSD limits.
Shading indicates instances where the PAL is lower than the LOD. Non-detects will not be treated as exceedances, though they will be reported at a value greater than the PAL.
NC indicates that no criterion exists.
[a] CAS = Chemical Abstract Service
[b] µg/L = micrograms per liter
[c] LCS = Laboratory Control Sample
[d] LOD = limit of detection
[e] DL = detection limit
[f] LCL = lower control limit
[g] UCL = upper control limit

TABLE 4-2
Reference Limits and Evaluation Table

Matrix: Groundwater

Analytical Group: Dissolved Select Metals

Analyte Name	CAS No.	PALs[1]					PQL Goal[3] (µg/L)	Laboratory Limits (µg/L)			LCS and MS/MSD Recovery and RPD Limits[4] (%)		
		Adjusted Tap-water RSL, May 2013 (µg/L)	Surface Water Quality Criteria (µg/L)	Yorktown Cornwallis Cave Aquifer Background (µg/L)	MCL (µg/L)	BTAG Region 3 Freshwater ESV (µg/L)		LOQ	LOD	DL	LCL	UCL	RPD
Antimony	7440-36-0	0.6	30	***9.7***	6	NC	0.3	2	1	0.14	80	120	20
Arsenic	7440-38-2	0.045	150	1.37	10	NC	0.0225	1	0.5	0.18			
Barium	7440-39-3	290	4	127	2000	NC	2	10	5	0.1			
Cadmium	7440-43-9	0.69	0.25	0.2	5	0.25	0.0885	1	0.5	0.13			
Chromium	7440-47-3	0.031	11	6.04	100	11.0	0.0155	2	1	0.04			
Lead	7439-92-1	15.0	2.52	***1.7***	15	2.52	0.85	1	0.5	0.04			
Manganese	7439-96-5	32	120	49.5	NC	NC	16	1	0.5	0.05			
Mercury	7439-97-6	0.43	0.77	***0.1***	2	NC	0.05	0.2	0.1	0.09			
Selenium	7782-49-2	7.8	4.61	***9.1***	50	NC	0.215	5	2.5	0.7			
Silver	7440-22-4	7.1	0.36	NC	NC	3.22	0.18	1	0.5	0.03			

Notes:

[1] Refer to **Section 2.3.2** for a detailed discussion on the development of PALs.

[2] The background values are 95 percent UTL values, except in cases where 95 percent UTLs were not evaluated, the max detection in a background sample is shown; max background values are bolded and italicized.

[3] PQL goals are equal to half of the minimum applicable PAL.

[4] DoD QSM v.4.1 is the basis for LCS and MS/MSD limits.

Shading indicates instances where the PAL is lower than the LOD. Non-detects will not be treated as exceedances, though they will be reported at a value greater than the PAL.

NC indicates that no criterion exists.

TABLE 4-3
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: Select Explosives

		PALs[1]						Laboratory Limits (µg/L)			LCS and MS/MSD Recovery and RPD Limits[4] (%)		
Analyte Name	**CAS No.**	**Adjusted Tap-water RSL, May 2013 (µg/L)**	**MCL (µg/L)**	**Yorktown Cornwallis Cave Aquifer Background[2] (µg/L)**	**Surface Water Quality Criteria (µg/L)**	**BTAG Region 3 Freshwater ESV (µg/L)**	**PQL Goal[3] (µg/L)**	**LOQ**	**LOD**	**DL**	**LCL**	**UCL**	**RPD**
1,3,5-Trinitrobenzene	99-35-4	46	NC	NC	11	NC	5.5	0.5	0.25	0.09	65	140	30

Notes:

[1] Refer to **Section 2.3.2** for a detailed discussion on the development of PALs.
[2] The background values are 95 percent UTL values, except in cases where 95 percent UTLs were not evaluated, the max detection in a background sample is shown; max background values are bolded and italicized.

[3] PQL goals are equal to half of the minimum applicable PAL.

[4] DoD QSM v.4.2 is the basis for LCS and MS/MSD limits.

Shading indicates instances where the PAL is lower than the LOD. Non-detects will not be treated as exceedances, though they will be reported at a value greater than the PAL.
NC indicates that no criterion exists.

TABLE 4-4
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: Select Dioxins

		PALs[1]						Laboratory Limits (pg/L)			LCS and MS/MSD Recovery and RPD Limits[4] (%)		
Analyte Name	**CAS No.**	**Adjusted Tap-water RSL, May 2013 (pg/L)**	**MCL (pg/L)**	**Yorktown Cornwallis Cave Aquifer Background (pg/L)**	**Surface Water Quality Criteria (pg/L)**	**BTAG Region 3 Freshwater ESV (pg/L)**	**PQL Goal[3] (µg/L)**	**LOQ**	**LOD**	**DL**	**LCL**	**UCL**	**RPD**
2,3,7,8-TCDD (dioxin)	1746-01-6	0.52	30	NC	2	0.0031	0.0015	5	1.5	0.813	**67**	**158**	20

Notes:

[1] Refer to **Section 2.3.2** for a detailed discussion on the development of PALs.
[2] The background values are 95 percent UTL values, except in cases where 95 percent UTLs were not evaluated, the max detection in a background sample is shown; max background values are bolded and italicized.
[3] PQL goals are equal to half of the minimum applicable PAL.
[4] DoD QSM v.4.2 is the basis for LCS and MS/MSD limits. Bolded limits are in-house limits when no limits are specified in DoD QSM.
Shading indicates instances where the PAL is lower than the LOD. Non-detects will not be treated as exceedances, though they will be reported at a value greater than the PAL.
NC indicates that no criterion exists.
pg/L =picograms per liter

4.2 Analytical SOPs Reference Table

Information regarding the laboratory SOPs and to be used for the handling and analysis of samples is provided in *Analytical SOP References Table*, **Tables 4-5 and 4-6.**

TABLE 4-5
Analytical SOP References Table

Laboratory Name and Address: CHEMTECH Consulting Group, 284 Sheffield Street, Mountainside, NJ 07092

POC: Kurt Hummler

Phone Number: (908) 728-3143

Lab SOP Number	Title, Revision Date, and Number	Date reviewed if not revised	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Variance to QSM	Modified for Project Work?
M3010A-Digestion-11	Acid Digestion of Aqueous Samples and Extracts for Total Metals (Revision 11, 03/08/2013)	N/A	Definitive	Groundwater, Metals	N/A - Digestion	None	No
M3535A-HPLC EXP prep 02	Sample Preparation for the Determination of Explosives by High Performance Liquid Chromatography (HPLC) (Revision 2, 9/30/2009)	5/29/2013	Definitive	Groundwater, Select Explosives	N/A – Preparation	None	No
M6020/6020A-Metals ICPMS-15	Trace Elemental Analysis by Inductively Coupled Plasma-Mass Spectrometric Method (Revision 15, 03/08/2013)	N/A	Definitive	Groundwater, Metals	Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS)	None	No
M7470A-Mercury-13	Mercury Analysis in Liquid Waste by Cold Vapor Technique (Revision 12, 7/25/11)	In review	Definitive	Groundwater, Metals	Cold Vapor Atomic Absorption	None	No
M8330-A-Nitroaromatics-11	Determination of Nitroaromatics and Nitramines by HPLC using SW-846 Method 8330/8330A. (Revision 11, 03/29/2013)	N/A	Definitive	Groundwater, Select Explosives	HPLC/ ultraviolet-visible spectrometer (UV-vis)	None	No
P205-Waste Disposal-07	Waste Disposal (Revision 7, 7/25/11)	7/9/2012	Screening	All	N/A	None	No
P250-Login Procedure-16	Sample Receipt, Sample Acceptance Policy, Sample Login, Sample Identification, and Sample Storage (Revision 16, 1/23/12)	5/21/2013	Screening	All	N/A	None	No

Notes:

Required Laboratory Accreditation: DoD Environmental Laboratory Accreditation Program (ELAP)

Valid through: 10/20/2015

TABLE 4-6
Analytical Standard Operating Procedures References Table

Laboratory Name and Address: ALS-Houston, 19408 Park Row Suite 320, Houston, TX 77084

POC: Ms. Arthi Kodur

Phone Number: (713) 266-1599

Lab SOP Number	Title, Revision Date, and Number	Date reviewed if not revised	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Variance to QSM	Modified for Project Work?
HE-EXT001	Extraction of Liquid Sample for Analysis of PCB and polychlorinated dibenzodioxin/furan (PCDD/F) Compounds by High Resolution Mass Spectrometry; Rev. 0.0, 2/13/2013	N/A	Definitive	Groundwater, Select Dioxin	N/A (Preparation)	None	No
HE-EXT003	Clean-up Processing of Sample Extracts Containing Polychlorinated Dibenzo-p-dioxins, Polychlorinated Dibenzofurans, and PCBs; Rev.0.0, 1/21/2013	N/A	Definitive	Groundwater, Select Dioxin	N/A (Preparation)	None	No
HMS-PCDD/F	Analysis of Polychlorinated Dibenzo-p-dioxins and Polychlorinated Dibenzofurans by High-Resolution Gas Chromatography/High-Resolution Mass Spectrometry (HRGC/HRMS); August 27, 2012; Rev. 0	N/A	Definitive	Groundwater, Select Dioxin	HRGC/HRMS	None	No
SMO-WET	Sample Receiving; December 5, 2012; Rev. 09.	N/A	N/A (Receiving)	N/A	N/A (Receiving)	N/A	No

Notes:

Required Laboratory Accreditation: DoD ELAP

Valid through: 12/22/2015

4.3 Laboratory QC Samples Tables

Laboratories analyzing samples in support of this work will perform laboratory QC samples at the frequency required by the DoD QSM v. 4.1. Details regarding each laboratory QC sample are provided in *Laboratory QC Samples Tables*, **Tables 4-7 through 4-10**.

TABLE 4-7
Laboratory Quality Control Samples Table

Matrix: Groundwater
Analytical Group: Total and Dissolved Metals (except mercury)
Analytical Method/SOP Reference: SW-846 6020A/CHEMTECH M6020/6020A-Metals ICPMS-15

QC Sample[1]	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per batch of 20 or fewer samples per matrix.	No target analytes > 1/2 LOQ and 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank results do not otherwise affect sample results.	Correct problem; then repeat. If the method blank still fails; redigest and reanalyze all affected samples.	Analyst, Supervisor	Bias/ Contamination	Same as Method/ SOP QC Acceptance Limits.
LCS		See *Reference Limits and Evaluation Table*, **Tables 4-1** and **4-2**.	Investigate source of problem. Redigest and reanalyze all associated samples.		Accuracy/Bias	
MS/MSD		Same as LCS and RPD specified in *Reference Limits and Evaluation Table,* **Tables 4-1** and **4-2**.	Dilute and re-spike and re-analyze to determine if interferences can be overcome by sample dilution. Prepare post-digestion spike (PS) for analytes outside limits. Flag data as possible matrix interference.		Accuracy/Bias	
Duplicate Sample	One per batch of 20 or fewer samples per matrix (if MSD is not included).	RPD between duplicate samples should be ≤20 percent, if both results are >5x LOQ.	Evaluate sample homogeneity and flag as necessary.		Precision	
Serial Dilution	One per batch of 20 or fewer samples per matrix on failure of MS/MSD.	The five-fold dilution result must agree within ± 10 percent difference (%D) of the original sample result.	Flag result or dilute and reanalyze sample to eliminate interference. Applicable when the concentration is >50x the LOQ. If the %D is >10 percent, then perform PS solution.		Precision	

TABLE 4-7 (CONTINUED)
Laboratory Quality Control Samples Table

Matrix: Groundwater

Analytical Group: Total and Dissolved Metals (except mercury)

Analytical Method/SOP Reference: SW-846 6020A/CHEMTECH M6020/6020A-Metals ICPMS-15

QC Sample[1]	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
PS	When dilution test fails or analyte concentration for all samples < 50x LOD.	Recovery within ±25 percent of true value.	If dilution test recovers outside of QC acceptance limits but PS meets QC acceptance criteria, matrix effects are not confirmed, re-prepare and reanalyze sample.	Analyst, Supervisor	Precision and Accuracy/Bias	Same as Method/ SOP QC Acceptance Limits.
Internal Standard (IS)	Spiked in every sample.	IS intensity within 30-120 percent of intensity of IS in initial calibration (ICAL).	Re-analyze sample at 5x dilution with the addition of appropriate amounts of IS.		Precision and Accuracy	

Note:

[1] The specifications in this table are from DoD QSM Version 4.1

TABLE 4-8
Laboratory Quality Control Samples Table

Matrix: Groundwater

Analytical Group: Total and Dissolved Mercury

Analytical Method/SOP Reference: SW-846 7470A CHEMTECH SOP M7470A-Mercury-13

QC Sample[1]	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per batch of 20 or fewer samples per matrix.	No target analytes > 1/2 LOQ and 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank results do not otherwise affect sample results.	Correct problem; then repeat. If the method blank still fails; redigest and reanalyze all affected samples.	Analyst, Supervisor	Bias / Contamination	Same as Method/ SOP QC Acceptance Limits.
LCS		See *Reference Limits and Evaluation Table*, **Tables 4-1** and **4-2**.	Investigate source of problem. Redigest and reanalyze all associated samples.		Accuracy / Bias	
MS/MSD		Same as LCS and RPD specified in *Reference Limits and Evaluation Table*, **Tables 4-1** and **4-2**.	Dilute and re-spike and re-analyze to determine if interferences can be overcome by sample dilution. Prepare PS for analytes outside limits. Flag data as possible matrix interference.		Accuracy / Bias	
Duplicate Sample	One per batch of 20 or fewer samples per matrix (if MSD is not included).	RPD between duplicate samples should be ≤20 percent, if both results are >5x LOQ.	Evaluate sample homogeneity and flag as necessary.		Precision	

Note:

[1] The specifications in this table are from DoD QSM Version 4.1

TABLE 4-9
Laboratory Quality Control Samples Table

Matrix: Groundwater
Analytical Group: Select Explosives
Analytical Method/SOP Reference: SW-846 8330A / CHEMTECH SOP M8330-A-Nitroaromatics-11

QC Sample[1]	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per every 20 or less samples of the same matrix per extraction day	No target compounds detected above ½ laboratory reporting limit	Correct problem. If required, reprep and reanalyze method blank and all samples processed with the contaminated blank.	Analyst, Supervisor	Contamination	Same as Method / SOP QC Acceptance Limits.
LCS		See **Table 4-3**.	Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient material is available.		Accuracy/Bias	
MS/MSD	One per every 20 samples of the same matrix per extraction day. For Water Matrix if no MS/MSD is provided from client then use LCSD	Same as LCS, and RPD of ≤ 20%.	CA will not be taken for samples when recoveries are outside limits and surrogate and LCS criteria are met unless RPDs indicate obvious extraction/ analysis difficulties, then re-prepare and reanalyze MS/MSD.		Accuracy/Bias/ Precision	
Surrogates	All field and QCs samples.	*Surrogate recovery within 30%-150%*	For QC and field samples, correct problem then reprep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient material is available. If obvious chromatographic interference with surrogate is present, then reanalysis will be sufficient instead of re-extraction.		Accuracy/Bias	
Confirmation of positive results (second Colum or second detector)	All positive results must be confirmed.	Calibration and QC criteria same as for initial or primary column analysis. Results between primary and secondary column RPD ≤ 40%.	Qualify data and discuss in narrative.		Precision	

Note:
[1] The specifications in this table are from DoD QSM Version 4.2.

TABLE 4-10
Laboratory Quality Control Samples Table

Matrix: Groundwater

Analytical Group: Select Dioxins

Analytical Method/SOP Reference: SW-846 8290 / ALS-Houston SOP HMS-PCDD/F

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per each batch of 20 field samples	No analytes detected ≥ LOD for the analyte or ≥ 5% of the associated regulatory limit for the analyte or ≥5% of the sample result for the analyte, whichever is greater, per method.	Identify and correct the problem, evaluate whether affected samples require re-extraction/re-analysis.	Analyst/Supervisor	Bias/Contamination	Same as Method/SOP QC Acceptance Limits
LCS	One per each batch of 20 field samples	See **Table 4-4**	Identify and correct the problem, if possible re-extract and re-analyze QC and related samples.		Accuracy/Bias	
MS	One per each batch of 20 field samples	Same as LCS	Evaluate parent sample, and determine whether re-extraction is warranted			
MSD	One per each batch of 20 field samples	Same as LCS and refer to **Table 4-4**				
IS	Every field sample, standard, and QC sample	%Recovery 40-135%	Identify and correct the problem, if possible re-extract and re-analyze field samples with a smaller sample size.			
Second Column Confirmation (2,3,7,8-TCDD)	Required for all positive detections	Positive identification	Report results from confirmation column			

Notes:
The specifications in this table meet the requirements of DoD QSM 4.2.

4.4 Data Verification and Validation (Steps I and IIa/IIb) Process Table

TABLE 4-11
Data Verification and Validation (Steps I and IIa/IIb)[1] Process Table

Data Review Input	Description	Responsible for Verification and/or Validation[2]	Internal/External[3]
Field Notebooks	Field notebooks will be reviewed internally and placed into the project file for archival at project closeout.	FTL/CH2M HILL	Internal
Chains-of-Custody and Shipping Forms	Chain-of-custody forms and shipping documentation will be reviewed internally upon their completion and verified against the packed sample coolers they represent. The shipper's signature on the chain-of-custody will be initialed by the reviewer, a copy of the chain-of-custody retained in the site file, and the original and remaining copies taped inside the cooler for shipment. Chains-of-custody will also be reviewed for adherence to the SAP by the PC.	FTL/CH2M HILL PC/CH2M HILL	Internal and External
Sample Condition upon Receipt	Any discrepancies, missing, or broken containers will be communicated to the PC in the form of laboratory logins.	PC/CH2M HILL	External
Documentation of Laboratory Method Deviations	Laboratory Method Deviations will be discussed and approved by the PC. Documentation will be incorporated into the case narrative, which becomes part of the final hardcopy data package.	PC/CH2M HILL	External
Electronic Data Deliverables	Electronic Data Deliverables will be compared against hardcopy laboratory results (10 percent check).	PC/CH2M HILL	External
Case Narrative	Case narratives will be reviewed by the DV during the data validation process. This is verification that they were generated and applicable to the data packages.	DV/CH2M HILL	External
Laboratory Data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal.	Respective Laboratory QAO	Internal
Laboratory Data	The data will be verified for completeness by the PC.	PC/CH2M HILL	External
Audit Reports	Upon report completion, a copy of all audit reports will be placed in the site file. If CAs are required, a copy of the documented CA taken will be attached to the appropriate audit report in the QA site file. Periodically, and at the completion of site work, site file audit reports and CA forms will be reviewed internally to ensure that all appropriate CAs have been taken and that CA reports are attached. If CAs have not been taken, the site manager will be notified to ensure action is taken.	PM/CH2M HILL PC/CH2M HILL	Internal
CA Reports	CA reports will be reviewed by the PC or PM and placed into the project file for archival at project closeout.	PM/CH2M HILL PC/CH2M HILL	External
Laboratory Methods	Ensure the laboratory analyzed samples using the correct methods.	PC/CH2M HILL	External
Target Compound List and Target Analyte List	Ensure the laboratory reported all analytes from each analysis group.	PC/CH2M HILL	External

TABLE 4-11 (CONTINUED)
Data Verification and Validation (Steps I and IIa/IIb)[1] Process Table

Data Review Input	Description	Responsible for Verification and/or Validation[2]	Internal/External3
Reporting Limits	Ensure the laboratory met the project-designated QLs. If QLs were not met, the reason will be determined and documented.	PC/CH2M HILL	External
Field SOPs	Ensure that all field SOPs were followed.	FTL/CH2M HILL	Internal
Laboratory SOPs	Ensure that approved analytical laboratory SOPs were followed.	Respective Laboratory QAO	Internal
Raw Data	10 percent review of raw data to confirm laboratory calculations.	DV/CH2M HILL	External
Onsite Screening	All non-analytical field data will be reviewed against SAP requirements for completeness and accuracy based on the field calibration records.	FTL/CH2M HILL	Internal
Documentation of Method QC Results	Establish that all required QC samples were run.	DV/CH2M HILL	External
Documentation of Field QC Sample Results	Establish that all required QC samples were run.	PC/CH2M HILL	Internal
DoD ELAP Evaluation	Ensure that each laboratory is DoD ELAP-certified for the analyses they are to perform. Ensure evaluation timeframe does not expire.	PC/CH2M HILL	External
Data for Total and Dissolved Metals, Select Explosives and/or Select Dioxins in Groundwater	Analytical methods and laboratory SOPs as presented in this SAP will be used to evaluate compliance against QA/QC criteria presented in this SAP. Should adherence to QA/QC criteria yield deficiencies, data may be qualified. The data qualifiers used are those presented in *Region III Modifications to the Laboratory Data Validation Guidelines for Inorganic Data Review* (USEPA, 1993). National Functional Guidelines may be used for data validation, and the specific qualifiers listed therein may be applied to data should non-conformances against the QA/QC criteria as presented in this SAP be identified.	DV/CH2M HILL	External

Notes:

[1] Verification (Step I) is a completeness check that is performed before the data review process continues in order to determine whether the required information (complete data package) is available for further review. Validation (Step IIa) is a review that the data generated are in compliance with analytical methods, procedures, and contracts. Validation (Step IIb) is a comparison of generated data against MPC in the SAP (both sampling and analytical).

[2] Should CH2M HILL find discrepancies during the verification or validation procedures above, an e-mail documenting the issue will be circulated to the internal project team, and a Corrections to File Memorandum will be prepared identifying the issues and the CA needed. This Memorandum will be sent to the laboratory, or applicable party, and maintained in the project file.

[3] Internal/External is with respect to the entity that generated the data.

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5 References

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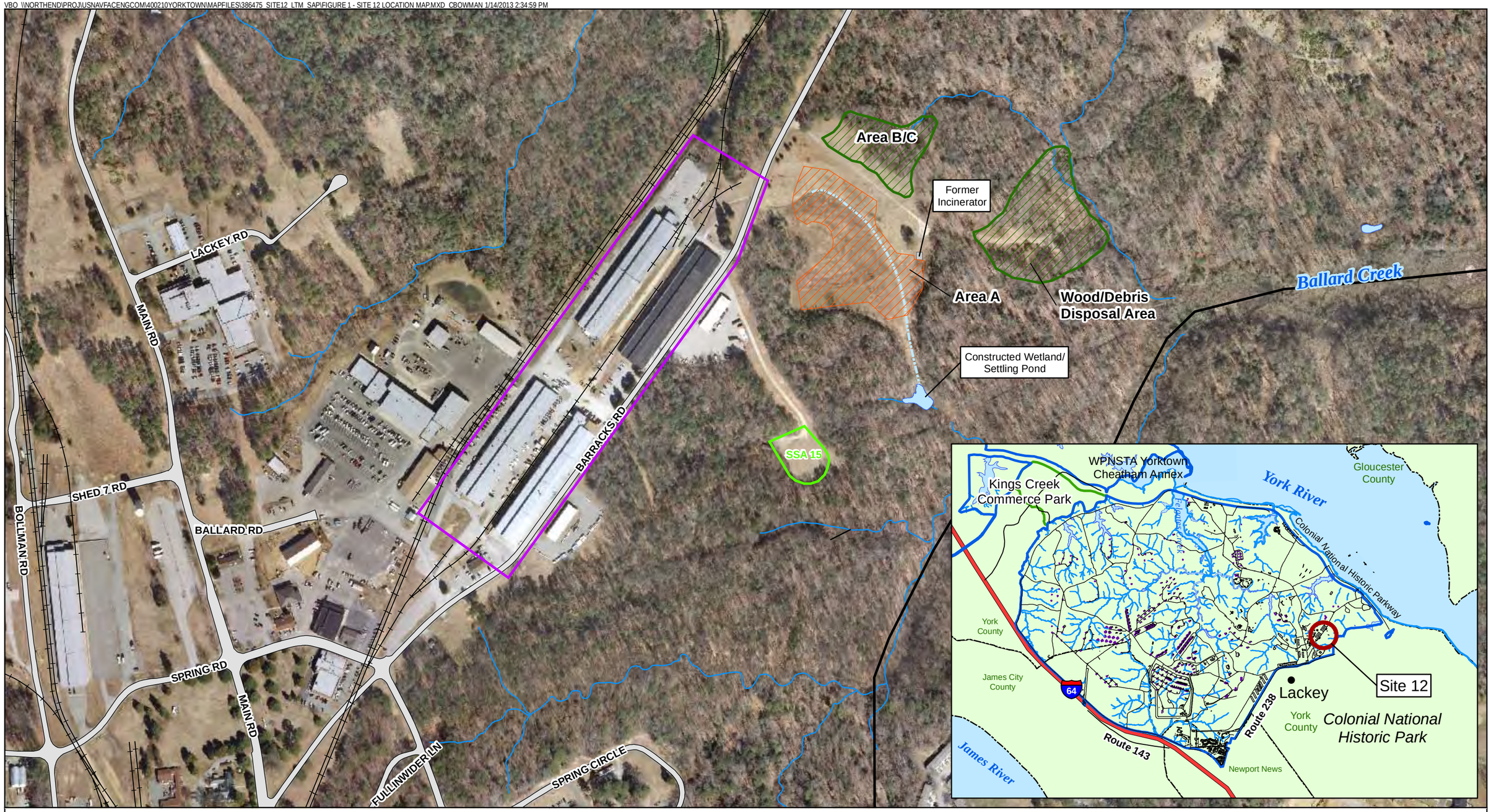
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USEPA. 2009. *National recommended water quality criteria - 2009.*

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Figures

VBO \\NORTHEND\PROJ\USNAVFACENGCOM\400210YORKTOWN\MAPFILES\386475_SITE12_LTM_SAP\FIGURE 1 - SITE 12 LOCATION MAP.MXD CBOWMAN 1/14/2013 2:34:59 PM



Legend

- Former Railroad
- Trilock Block Drainage Ditch
- Site 12 NFA Areas
- IR Site 31 Boundary
- Site 12 Area A Landfill Cap
- SSA 15 Boundary
- NWS Yorktown Boundary

N
W E
S

0 350 700
Feet

Figure 1
Site Location and Layout
Site 12 LTM Sampling and Analysis Plan
Naval Weapon Station Yorktown
Yorktown, Virginia

CH2MHILL

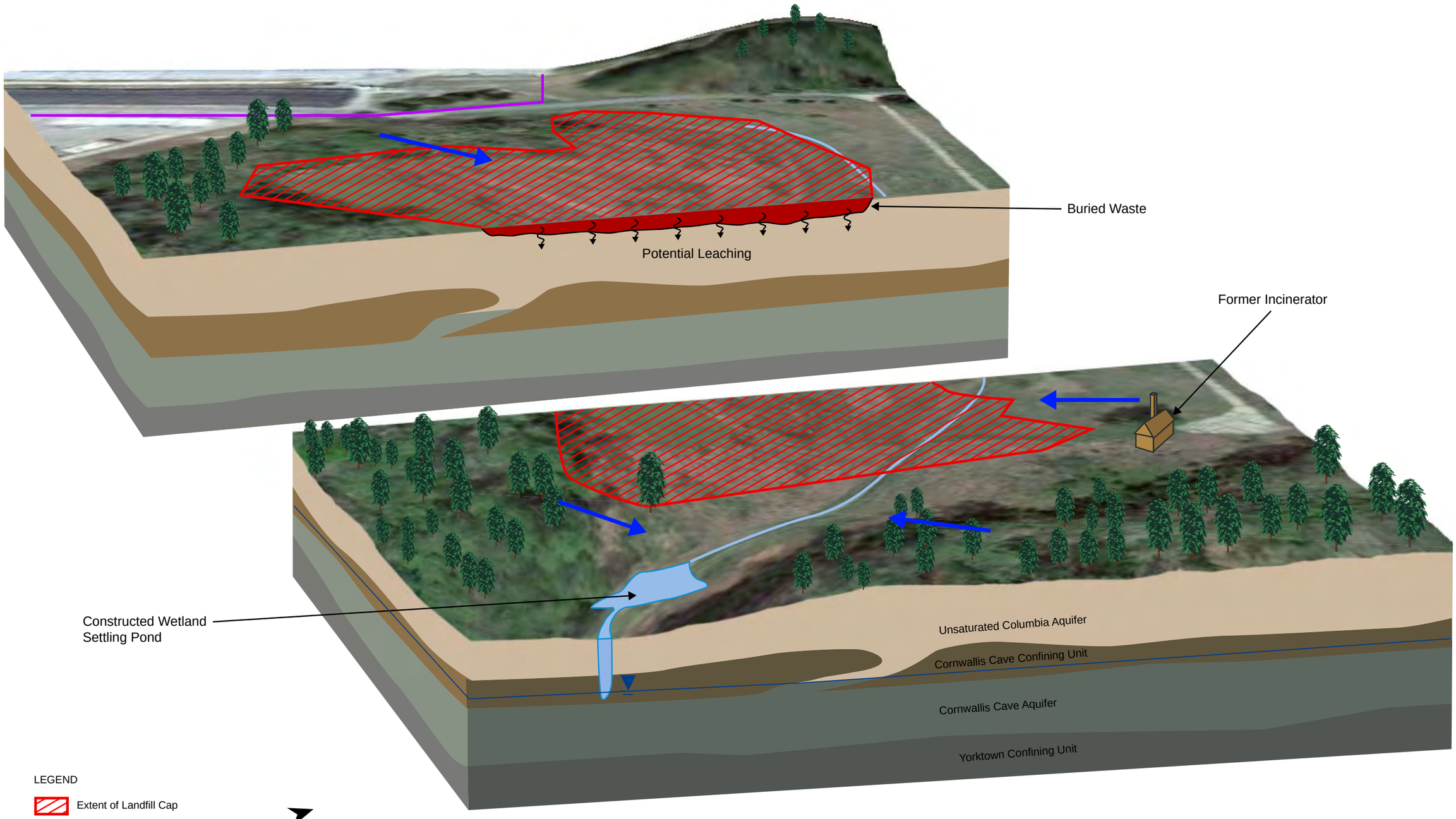
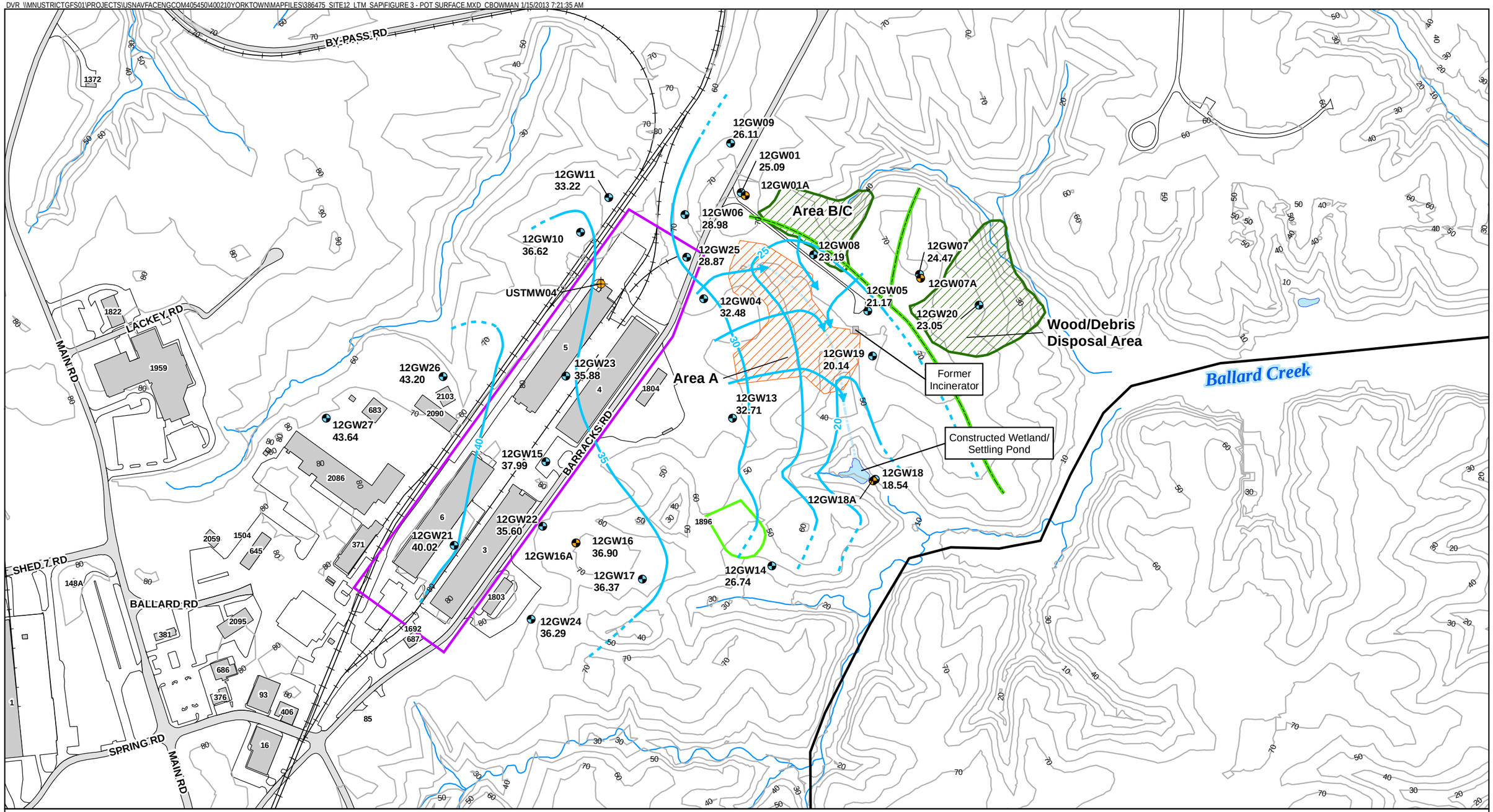


FIGURE 2
Groundwater LTM Conceptual Site Model
Site 12 LTM Sampling and Analysis Plan
Naval Weapon Station Yorktown
Yorktown, Virginia

CH2MHILL

DVR \\MNUSTRICTGFS01\PROJECTS\USNAVFACENGCOM405450\400210YORKTOWN\MAPFILES\386475_SITE12_LTM_SAP\FIGURE 3 - POT SURFACE.MXD CBOWMAN 1/15/2013 7:21:35 AM



Legend

- Yorktown-Eastover Aquifer Monitoring Well
- Cornwallis Cave Aquifer Monitoring Well
- Former Railroad
- Trilock Block Drainage Ditch
- Site 12 Area A Landfill Cap
- Site 12 NFA Areas
- IR Site 31 Boundary
- Approximate Location of Groundwater Divide
- SSA 15 Boundary
- NWS Yorktown Boundary
- Groundwater Potentiometric Surface
- Groundwater Potentiometric Surface (inferred)
- Groundwater Flow Direction

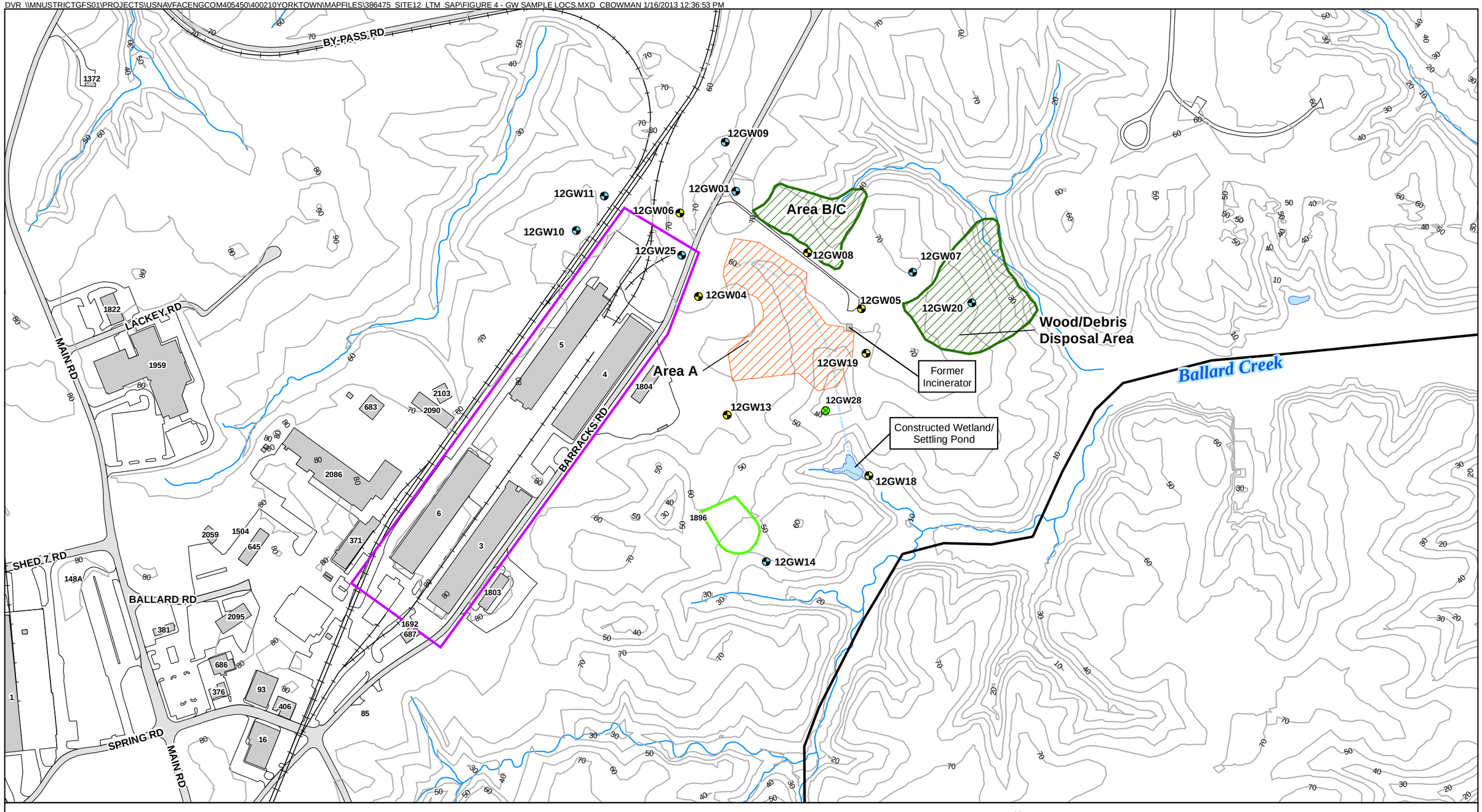
N W E S

0 350 700 Feet

Figure 3
Potentiometric Surface Map: Cornwallis Cave Aquifer
Site 12 LTM Sampling and Analysis Plan
Naval Weapon Station Yorktown
Yorktown, Virginia

CH2MHILL

DVR \\MNUSTRICTGFS01\PROJECTS\USNAVFACENGCOM405450\400210YORKTOWN\MAPFILES\386475_SITE12_LTM_SAP\FIGURE 4 - GW SAMPLE LOCS.MXD CBOWMAN 1/16/2013 12:36:53 PM



Legend

- Cornwallis Cave Aquifer Monitoring Well to be Sampled
- Cornwallis Cave Aquifer Monitoring Well for inclusion in groundwater elevation survey
- New Cornwallis Cave Aquifer Monitoring Well to be Sampled
- Former Railroad
- Trilock Block Drainage Ditch
- IR Site 31 Boundary
- Site 12 NFA Areas
- Site 12 Area A Landfill Cap
- SSA 15 Boundary
- NWS Yorktown Boundary

N
W E
S

0 350 700
Feet

Figure 4
Groundwater Sample Locations
Site 12 LTM Sampling and Analysis Plan
Naval Weapon Station Yorktown
Yorktown, Virginia

CH2MHILL

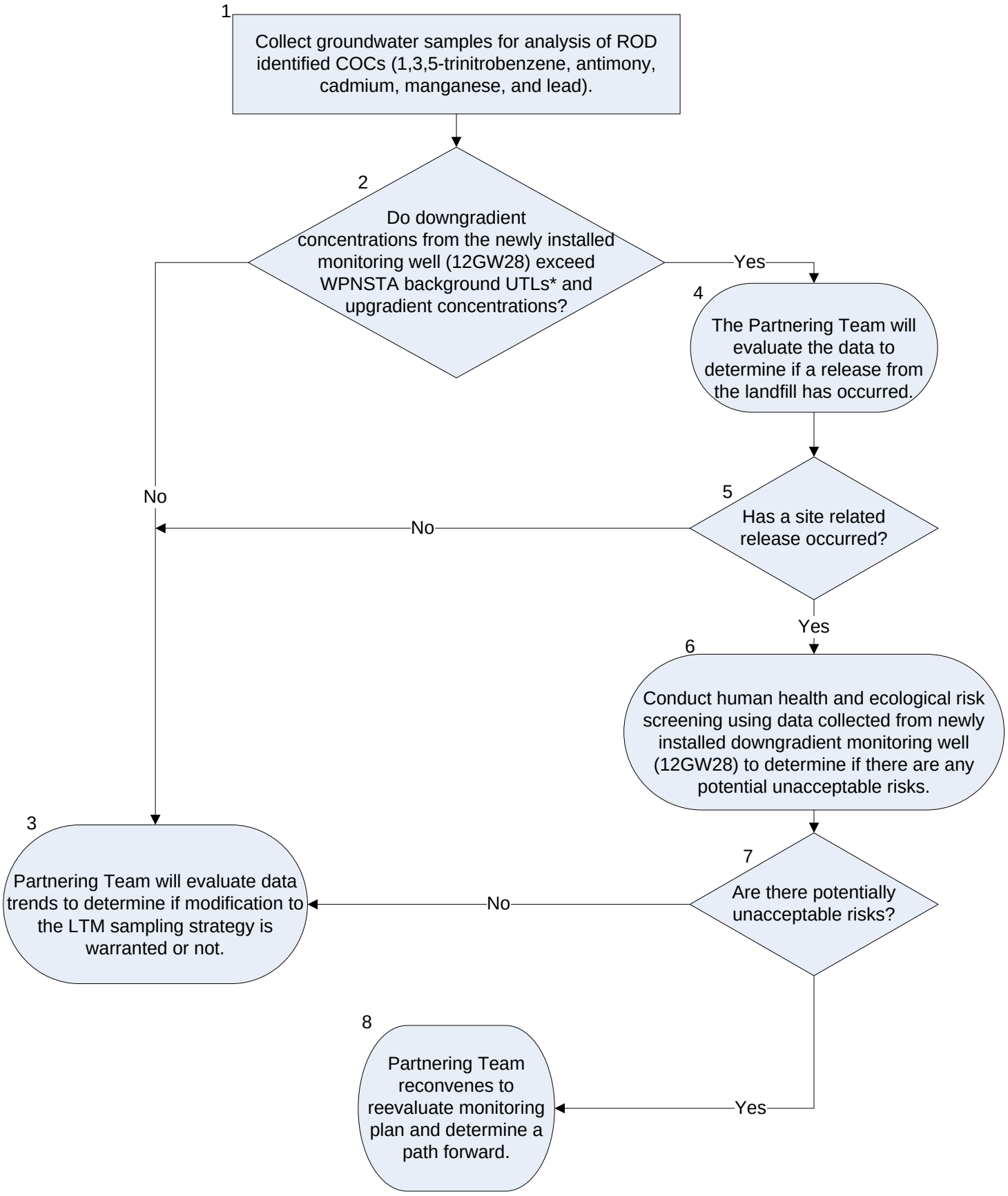


Figure 5a
Decision Tree – ROD Identified COCs
Site 12 LTM Sampling and Analysis Plan
Naval Weapon Station Yorktown
Yorktown, Virginia

*Because 1,3,5-trinitrobenzene is not naturally occurring, a comparison to basewide background UTLs will not be made for this constituent. A comparison to upgradient results will be performed.

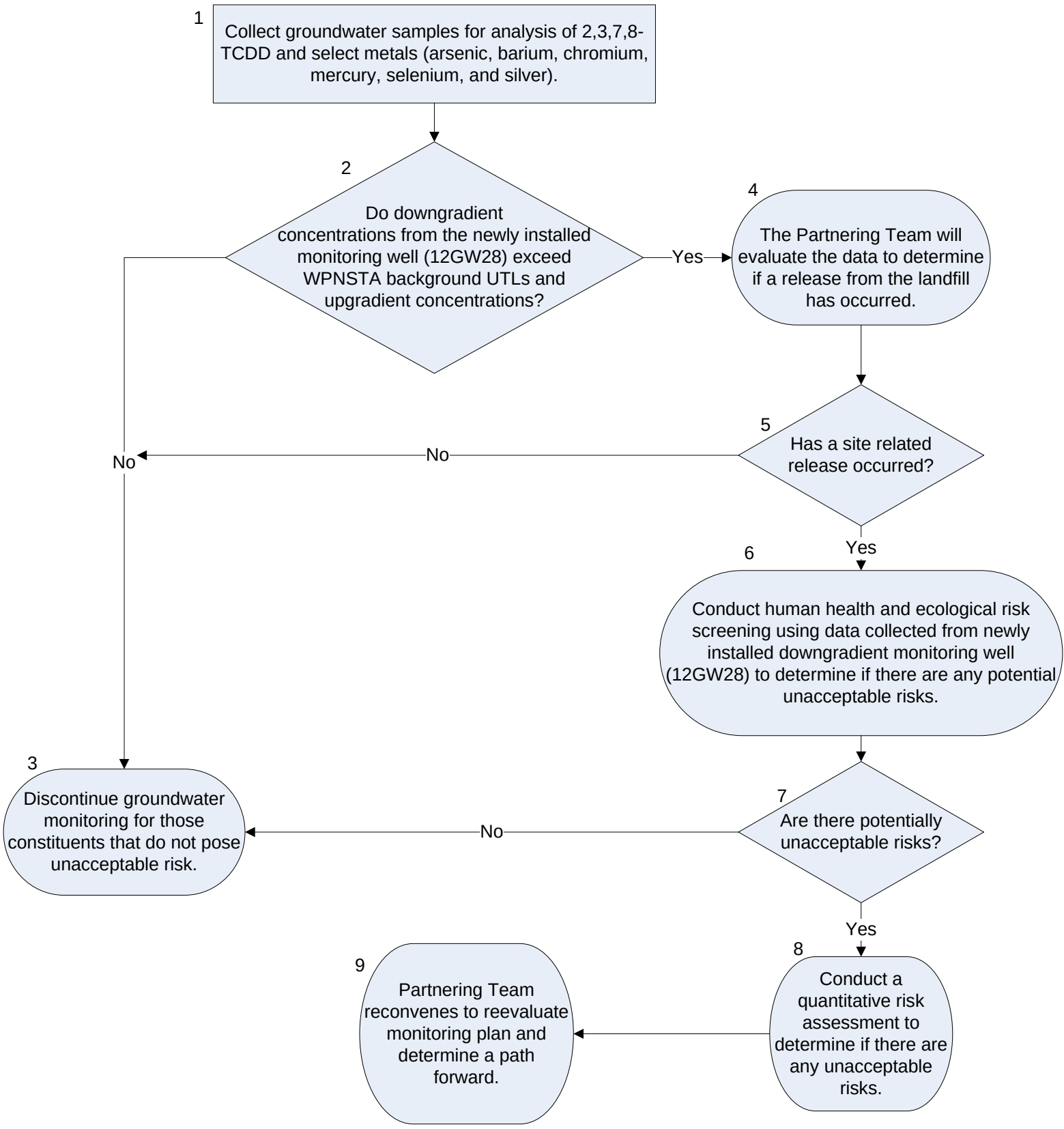


Figure 5b
Decision Tree – 2,3,7,8-TCDD and Select Metals
Site 12 LTM Sampling and Analysis Plan
Naval Weapon Station Yorktown
Yorktown, Virginia

Appendix A
Laboratory DoD ELAP Accreditation

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

ALS GROUP USA CORP. DBA ALS ENVIRONMENTAL
19408 Park Row, Suite 320
Houston, Texas 77084
Rebecca Pierrot Phone: (713) 266 1599
rpierrot@caslab.com

ENVIRONMENTAL

Valid To: November 30, 2013 Certificate Number: 2897.01

In recognition of the successful completion of the A2LA evaluation process, (including an assessment of the laboratory's compliance with ISO IEC 17025:2005, the 2003 NELAC Chapter 5 Standard, and the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 4.2 of the DoD Quality Systems Manual for Environmental Laboratories) accreditation is granted to this laboratory to perform recognized EPA methods using the following testing technologies and in the analyte categories identified below:

Testing Technologies

High Resolution Gas Chromatography/High Resolution Mass Spectrometry

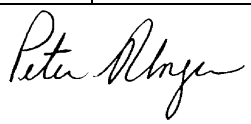
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PCBs			
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PCB 2	EPA 1668A	EPA 1668A	EPA 1668A
PCB 3	EPA 1668A	EPA 1668A	EPA 1668A
PCB 4	EPA 1668A	EPA 1668A	EPA 1668A
PCB 5	EPA 1668A	EPA 1668A	EPA 1668A
PCB 6	EPA 1668A	EPA 1668A	EPA 1668A
PCB 7	EPA 1668A	EPA 1668A	EPA 1668A
PCB 8	EPA 1668A	EPA 1668A	EPA 1668A
PCB 9	EPA 1668A	EPA 1668A	EPA 1668A
PCB 10	EPA 1668A	EPA 1668A	EPA 1668A
PCB 11	EPA 1668A	EPA 1668A	EPA 1668A
PCB 12	EPA 1668A	EPA 1668A	EPA 1668A
PCB 13	EPA 1668A	EPA 1668A	EPA 1668A
PCB 14	EPA 1668A	EPA 1668A	EPA 1668A
PCB 15	EPA 1668A	EPA 1668A	EPA 1668A
PCB 16	EPA 1668A	EPA 1668A	EPA 1668A
PCB 17	EPA 1668A	EPA 1668A	EPA 1668A

5301 Buckeystown Pike, Suite 350 | Frederick, Maryland 21704-8373 | Phone: 301 644 3248 | Fax: 301 662 2974 | www.A2LA.org

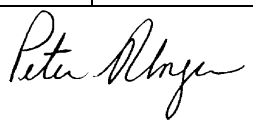
Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste	Tissue
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PCB 21	EPA 1668A	EPA 1668A	EPA 1668A
PCB 22	EPA 1668A	EPA 1668A	EPA 1668A
PCB 23	EPA 1668A	EPA 1668A	EPA 1668A
PCB 24	EPA 1668A	EPA 1668A	EPA 1668A
PCB 25	EPA 1668A	EPA 1668A	EPA 1668A
PCB 26	EPA 1668A	EPA 1668A	EPA 1668A
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PCB 52	EPA 1668A	EPA 1668A	EPA 1668A
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PCB 54	EPA 1668A	EPA 1668A	EPA 1668A
PCB 55	EPA 1668A	EPA 1668A	EPA 1668A
PCB 56	EPA 1668A	EPA 1668A	EPA 1668A
PCB 57	EPA 1668A	EPA 1668A	EPA 1668A
PCB 58	EPA 1668A	EPA 1668A	EPA 1668A
PCB 59	EPA 1668A	EPA 1668A	EPA 1668A
PCB 60	EPA 1668A	EPA 1668A	EPA 1668A



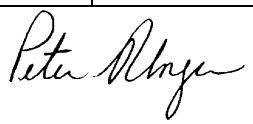
Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste	Tissue
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PCB 64	EPA 1668A	EPA 1668A	EPA 1668A
PCB 65	EPA 1668A	EPA 1668A	EPA 1668A
PCB 66	EPA 1668A	EPA 1668A	EPA 1668A
PCB 67	EPA 1668A	EPA 1668A	EPA 1668A
PCB 68	EPA 1668A	EPA 1668A	EPA 1668A
PCB 69	EPA 1668A	EPA 1668A	EPA 1668A
PCB 70	EPA 1668A	EPA 1668A	EPA 1668A
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PCB 72	EPA 1668A	EPA 1668A	EPA 1668A
PCB 73	EPA 1668A	EPA 1668A	EPA 1668A
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PCB 90	EPA 1668A	EPA 1668A	EPA 1668A
PCB 91	EPA 1668A	EPA 1668A	EPA 1668A
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PCB 95	EPA 1668A	EPA 1668A	EPA 1668A
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Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste	Tissue
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Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste	Tissue
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PCB 191	EPA 1668A	EPA 1668A	EPA 1668A
PCB 192	EPA 1668A	EPA 1668A	EPA 1668A



Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste	Tissue
PCB 193	EPA 1668A	EPA 1668A	EPA 1668A
PCB 194	EPA 1668A	EPA 1668A	EPA 1668A
PCB 195	EPA 1668A	EPA 1668A	EPA 1668A
PCB 196	EPA 1668A	EPA 1668A	EPA 1668A
PCB 197	EPA 1668A	EPA 1668A	EPA 1668A
PCB 198	EPA 1668A	EPA 1668A	EPA 1668A
PCB 199	EPA 1668A	EPA 1668A	EPA 1668A
PCB 200	EPA 1668A	EPA 1668A	EPA 1668A
PCB 201	EPA 1668A	EPA 1668A	EPA 1668A
PCB 202	EPA 1668A	EPA 1668A	EPA 1668A
PCB 203	EPA 1668A	EPA 1668A	EPA 1668A
PCB 204	EPA 1668A	EPA 1668A	EPA 1668A
PCB 205	EPA 1668A	EPA 1668A	EPA 1668A
PCB 206	EPA 1668A	EPA 1668A	EPA 1668A
PCB 207	EPA 1668A	EPA 1668A	EPA 1668A
PCB 208	EPA 1668A	EPA 1668A	EPA 1668A
PCB 209	EPA 1668A	EPA 1668A	EPA 1668A
Sample Preparation	Liquid Liquid Extraction	Liquid Extraction, ASE, Soxhlet	Soxhlet
Dioxins/Furans			
2,3,7,8-TCDD	EPA 8290	EPA 8290	EPA 8290
1,2,3,7,8-PeCDD	EPA 8290	EPA 8290	EPA 8290
1,2,3,4,7,8-HxCDD	EPA 8290	EPA 8290	EPA 8290
1,2,3,6,7,8-HxCDD	EPA 8290	EPA 8290	EPA 8290
1,2,3,7,8,9-HxCDD	EPA 8290	EPA 8290	EPA 8290
1,2,3,4,6,7,8-HpCDD	EPA 8290	EPA 8290	EPA 8290
OCDD	EPA 8290	EPA 8290	EPA 8290
2,3,7,8-TCDF	EPA 8290	EPA 8290	EPA 8290
1,2,3,7,8-PeCDF	EPA 8290	EPA 8290	EPA 8290
2,3,4,7,8-PeCDF	EPA 8290	EPA 8290	EPA 8290
1,2,3,4,7,8-HxCDF	EPA 8290	EPA 8290	EPA 8290
1,2,3,6,7,8-HxCDF	EPA 8290	EPA 8290	EPA 8290
1,2,3,7,8,9-HxCDF	EPA 8290	EPA 8290	EPA 8290
2,3,4,6,7,8-HxCDF	EPA 8290	EPA 8290	EPA 8290
1,2,3,4,6,7,8-HpCDF	EPA 8290	EPA 8290	EPA 8290
1,2,3,4,7,8,9-HpCDF	EPA 8290	EPA 8290	EPA 8290
OCDF	EPA 8290	EPA 8290	EPA 8290
Sample Preparation	Liquid Liquid Extraction	Liquid Extraction, ASE, Soxhlet	Soxhlet



In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform recognized EPA methods using the following testing technologies and in the analyte categories identified below, and for the test methods applicable to NELAC Chapter 5:

Parameter/Analyte	Potable Water	Nonpotable Water	Solid Hazardous Waste	Foods
Dioxins/Furans				
2,3,7,8-TCDD	EPA 1613B	EPA 1613B	EPA 1613B	EPA 1613B
1,2,3,7,8-PeCDD	EPA 1613B	EPA 1613B	EPA 1613B	EPA 1613B
1,2,3,4,7,8-HxCDD	EPA 1613B	EPA 1613B	EPA 1613B	EPA 1613B
1,2,3,6,7,8-HxCDD	EPA 1613B	EPA 1613B	EPA 1613B	EPA 1613B
1,2,3,7,8,9-HxCDD	EPA 1613B	EPA 1613B	EPA 1613B	EPA 1613B
1,2,3,4,6,7,8-HpCDD	EPA 1613B	EPA 1613B	EPA 1613B	EPA 1613B
OCDD	EPA 1613B	EPA 1613B	EPA 1613B	EPA 1613B
2,3,7,8-TCDF	EPA 1613B	EPA 1613B	EPA 1613B	EPA 1613B
1,2,3,7,8-PeCDF	EPA 1613B	EPA 1613B	EPA 1613B	EPA 1613B
2,3,4,7,8-PeCDF	EPA 1613B	EPA 1613B	EPA 1613B	EPA 1613B
1,2,3,4,7,8-HxCDF	EPA 1613B	EPA 1613B	EPA 1613B	EPA 1613B
1,2,3,6,7,8-HxCDF	EPA 1613B	EPA 1613B	EPA 1613B	EPA 1613B
1,2,3,7,8,9-HxCDF	EPA 1613B	EPA 1613B	EPA 1613B	EPA 1613B
2,3,4,6,7,8-HxCDF	EPA 1613B	EPA 1613B	EPA 1613B	EPA 1613B
1,2,3,4,6,7,8-HpCDF	EPA 1613B	EPA 1613B	EPA 1613B	EPA 1613B
1,2,3,4,7,8,9-HpCDF	EPA 1613B	EPA 1613B	EPA 1613B	EPA 1613B
OCDF	EPA 1613B	EPA 1613B	EPA 1613B	EPA 1613B
Sample Preparation	Liquid/Liquid	Liquid/liquid	Soxhlet, ASE	Soxhlet, ASE

ASE=accelerated solvent extraction



The American Association for Laboratory Accreditation

World Class Accreditation

Accredited DoD ELAP Laboratory

A2LA has accredited

ALS Group USA Corp. dba ALS Environmental

Houston, TX

for technical competence in the field of

Environmental Testing

In recognition of the successful completion of the A2LA evaluation process that includes an assessment of the laboratory's compliance with ISO/IEC 17025:2005, the 2003 NELAC Chapter 5 Standard, and the requirements of the Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 4.2 of the DoD Quality System Manual for Environmental Laboratories (QSM); accreditation is granted to this laboratory to perform recognized EPA methods as defined on the associated A2LA Environmental Scope of Accreditation. This accreditation demonstrates technical competence for this defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009*).

Presented this 21st day of November 2011.

President & CEO
For the Accreditation Council
Certificate Number 2897.01
Valid to November 30, 2013
Revised April 2, 2013

For the tests or types of tests to which this accreditation applies, please refer to the laboratory's Environmental Scope of Accreditation.

Scope of Accreditation
For
CHEMTECH

284 Sheffield Street
Mountainside, NJ 07092
Divyajit Mehta
908-789-8900

In recognition of a successful assessment to ISO/IEC 17025:2005 and the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in the DoD Quality Systems Manual for Environmental Laboratories (DoD QSM v4.2) based on the National Environmental Laboratory Accreditation Conference Chapter 5 Quality Systems Standard (NELAC Voted Revision June 5, 2003), accreditation is granted to CHEMTECH to perform the following tests:

Accreditation granted through: October 20, 2015

Testing – Environmental

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8081A,B	4,4`-DDD
GC/ECD	EPA 8081A,B	4,4`-DDE
GC/ECD	EPA 8081A,B	4,4`-DDT
GC/ECD	EPA 8081A,B	Aldrin
GC/ECD	EPA 8081A,B	alpha-BHC (alpha-Hexachlorocyclohexane)
GC/ECD	EPA 8081A,B	alpha Chlordane
GC/ECD	EPA 8081A,B	beta-BHC (beta-Hexachlorocyclohexane)
GC/ECD	EPA 8081A,B	Chlordane (tech.)
GC/ECD	EPA 8081A,B	delta-BHC
GC/ECD	EPA 8081A,B	Dieldrin
GC/ECD	EPA 8081A,B	Endosulfan I
GC/ECD	EPA 8081A,B	Endosulfan II
GC/ECD	EPA 8081A,B	Endosulfan sulfate
GC/ECD	EPA 8081A,B	Endrin aldehyde
GC/ECD	EPA 8081A,B	Endrin ketone
GC/ECD	EPA 8081A,B	Endrin
GC/ECD	EPA 8081A,B	gamma-BHC (Lindane gamma-Hexachlorocyclohexane)

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8081A,B	gamma Chlordane
GC/ECD	EPA 8081A,B	Heptachlor epoxide
GC/ECD	EPA 8081A,B	Heptachlor
GC/ECD	EPA 8081A,B	Methoxychlor
GC/ECD	EPA 8081A,B	Toxaphene (Chlorinated camphene)
GC/ECD	EPA 8082/8082A	Aroclor-1016 (PCB-1016)
GC/ECD	EPA 8082/8082A	Aroclor-1221 (PCB-1221)
GC/ECD	EPA 8082/8082A	Aroclor-1232 (PCB-1232)
GC/ECD	EPA 8082/8082A	Aroclor-1242 (PCB-1242)
GC/ECD	EPA 8082/8082A	Aroclor-1248 (PCB-1248)
GC/ECD	EPA 8082/8082A	Aroclor-1254 (PCB-1254)
GC/ECD	EPA 8082/8082A	Aroclor-1260 (PCB-1260)
GC/ECD	EPA 8151A	2,4,5-T
GC/ECD	EPA 8151A	2,4-D
GC/ECD	EPA 8151A	Dalapon
GC/ECD	EPA 8151A	Dicamba
GC/ECD	EPA 8151A	Dinoseb
GC/ECD	EPA 8151A	Picloram
GC/ECD	EPA 8151A	Silvex (2,4,5-TP)
GC/FID	EPA 8015B/D	Diesel range organics (DRO)
GC/FID	EPA 8015B/D	Gasoline range organics (GRO)
GC/MS	EPA 8260B,C	1,1,1,2-Tetrachloroethane
GC/MS	EPA 8260B,C	1,1,1-Trichloroethane
GC/MS	EPA 8260B,C	1,1,2,2-Tetrachloroethane
GC/MS	EPA 8260B,C	1,1,2-Trichloroethane
GC/MS	EPA 8260B,C	1,1-Dichloroethane
GC/MS	EPA 8260B,C	1,1-Dichloroethylene
GC/MS	EPA 8260B,C	1,1-Dichloropropene
GC/MS	EPA 8260B,C	1,2,3-Trichlorobenzene
GC/MS	EPA 8260B,C	1,2,3-Trichloropropane
GC/MS	EPA 8260B,C	1,2,4-Trichlorobenzene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B,C	1,2,4-Trimethylbenzene
GC/MS	EPA 8260B,C	1,2-Dibromo-3-chloropropane (DBCP)
GC/MS	EPA 8260B,C	1,2-Dibromoethane (EDB Ethylene dibromide)
GC/MS	EPA 8260B,C	1,2-Dichlorobenzene
GC/MS	EPA 8260B,C	1,2-Dichloroethane
GC/MS	EPA 8260B,C	1,2-Dichloropropane
GC/MS	EPA 8260B,C	1,3,5-Trimethylbenzene
GC/MS	EPA 8260B,C	1,3-Dichlorobenzene
GC/MS	EPA 8260B,C	1,3-Dichloropropane
GC/MS	EPA 8260B,C	1,4-Dichlorobenzene
GC/MS	EPA 8260B,C	2,2-Dichloropropane
GC/MS	EPA 8260B,C	2-Butanone (Methyl ethyl ketone MEK)
GC/MS	EPA 8260B,C	2-Chloroethyl vinyl ether
GC/MS	EPA 8260B,C	2-Chlorotoluene
GC/MS	EPA 8260B,C	2-Hexanone
GC/MS	EPA 8260B,C	4-Chlorotoluene
GC/MS	EPA 8260B,C	4-Methyl-2-pentanone (MIBK)
GC/MS	EPA 8260B,C	Acetone
GC/MS	EPA 8260B,C	Acrolein (Propenal)
GC/MS	EPA 8260B,C	Acrylonitrile
GC/MS	EPA 8260B,C	1,1,2-Trichlorotrifluoroethane
GC/MS	EPA 8260B,C	Allyl chloride (3-Chloropropene)
GC/MS	EPA 8260B,C	Benzene
GC/MS	EPA 8260B,C	Bromobenzene
GC/MS	EPA 8260B,C	Bromochloromethane
GC/MS	EPA 8260B,C	Bromodichloromethane
GC/MS	EPA 8260B,C	Bromoform
GC/MS	EPA 8260B,C	Carbon disulfide
GC/MS	EPA 8260B,C	Carbon tetrachloride
GC/MS	EPA 8260B,C	Chlorobenzene
GC/MS	EPA 8260B,C	Chloroethane

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B,C	Chloroform
GC/MS	EPA 8260B,C	cis-1,2-Dichloroethylene
GC/MS	EPA 8260B,C	cis-1,3-Dichloropropene
GC/MS	EPA 8260B,C	Dibromochloromethane
GC/MS	EPA 8260B,C	Dibromomethane
GC/MS	EPA 8260B,C	Dichlorodifluoromethane
GC/MS	EPA 8260B,C	Ethyl acetate
GC/MS	EPA 8260B,C	Ethyl methacrylate
GC/MS	EPA 8260B,C	Ethylbenzene
GC/MS	EPA 8260B,C	Hexachlorobutadiene
GC/MS	EPA 8260B,C	Isopropylbenzene
GC/MS	EPA 8260B,C	m+p-Xylenes
GC/MS	EPA 8260B,C	Methacrylonitrile
GC/MS	EPA 8260B,C	Methyl bromide (Bromomethane)
GC/MS	EPA 8260B,C	Methyl chloride (Chloromethane)
GC/MS	EPA 8260B,C	Methyl tert-butyl ether (MTBE)
GC/MS	EPA 8260B,C	Methylene chloride
GC/MS	EPA 8260B,C	Naphthalene
GC/MS	EPA 8260B,C	n-Butylbenzene
GC/MS	EPA 8260B,C	n-Propylbenzene
GC/MS	EPA 8260B,C	o-Xylene
GC/MS	EPA 8260B,C	p-Dioxane
GC/MS	EPA 8260B,C	p-Isopropyltoluene
GC/MS	EPA 8260B,C	sec-Butylbenzene
GC/MS	EPA 8260B,C	Styrene
GS/MS	EPA 8260B,C	Tert-butyl alcohol
GC/MS	EPA 8260B,C	tert-Butylbenzene
GC/MS	EPA 8260B,C	Tetrachloroethylene (Perchloroethylene)
GC/MS	EPA 8260B,C	Toluene
GC/MS	EPA 8260B,C	trans-1,2-Dichloroethylene
GC/MS	EPA 8260B,C	trans-1,3-Dichloropropylene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B,C	trans-1,4-Dichloro-2-butene
GC/MS	EPA 8260B,C	Trichloroethene (Trichloroethylene)
GC/MS	EPA 8260B,C	Trichlorofluoromethane
GC/MS	EPA 8260B,C	Vinyl acetate
GC/MS	EPA 8260B,C	Vinyl chloride
GC/MS	EPA 8260B,C	Xylene (total)
GC/MS	EPA 8270C,D	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 8270C,D	1,2,4-Trichlorobenzene
GC/MS	EPA 8270C,D	1,2-Dichlorobenzene
GC/MS	EPA 8270C,D	1,2-Diphenylhydrazine
GC/MS	EPA 8270C,D	1,3-Dichlorobenzene
GC/MS	EPA 8270C,D	1,4-Dichlorobenzene
GC/MS	EPA 8270C,D	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 8270C,D	2,4,5-Trichlorophenol
GC/MS	EPA 8270C,D	2,4,6-Trichlorophenol
GC/MS	EPA 8270C,D	2,4-Dichlorophenol
GC/MS	EPA 8270C,D	2,4-Dimethylphenol
GC/MS	EPA 8270C,D	2,4-Dinitrophenol
GC/MS	EPA 8270C,D	2,4-Dinitrotoluene (2,4-DNT)
GC/MS	EPA 8270C,D	2,6-Dinitrotoluene (2,6-DNT)
GC/MS	EPA 8270C,D	2-Chloronaphthalene
GC/MS	EPA 8270C,D	2-Chlorophenol
GC/MS	EPA 8270C,D	2-Methyl-4,6-dinitrophenol
GC/MS	EPA 8270C,D	2-Methylnaphthalene
GC/MS	EPA 8270C,D	2-Methylphenol (o-Cresol)
GC/MS	EPA 8270C,D	2-Nitroaniline
GC/MS	EPA 8270C,D	2-Nitrophenol
GC/MS	EPA 8270C,D	3,3`-Dichlorobenzidine
GC/MS	EPA 8270C,D	3+4-Methylphenol
GC/MS	EPA 8270C,D	3-Nitroaniline
GC/MS	EPA 8270C,D	4-Bromophenyl phenyl ether

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C,D	4-Chloro-3-methylphenol
GC/MS	EPA 8270C,D	4-Chloroaniline
GC/MS	EPA 8270C,D	4-Chlorophenyl phenylether
GC/MS	EPA 8270C,D	4-Nitroaniline
GC/MS	EPA 8270C,D	4-Nitrophenol
GC/MS	EPA 8270C,D	Acenaphthene
GC/MS	EPA 8270C,D	Acenaphthylene
GC/MS	EPA 8270C,D	Acetophenone
GC/MS	EPA 8270C,D	Aniline
GC/MS	EPA 8270C,D	Anthracene
GC/MS	EPA 8270C,D	Benzidine
GC/MS	EPA 8270C,D	Benzo(a)anthracene
GC/MS	EPA 8270C,D	Benzo(a)pyrene
GC/MS	EPA 8270C,D	Benzo(b)fluoranthene
GC/MS	EPA 8270C,D	Benzo(g,h,i)perylene
GC/MS	EPA 8270C,D	Benzo(k)fluoranthene
GC/MS	EPA 8270C,D	Benzoic acid
GC/MS	EPA 8270C,D	Benzyl alcohol
GC/MS	EPA 8270C,D	bis(2-Chloroethoxy)methane
GC/MS	EPA 8270C,D	bis(2-Chloroethyl) ether
GC/MS	EPA 8270C,D	bis(2-Chloroisopropyl) ether (2,2`-Oxybis(1-chloropropane))
GC/MS	EPA 8270C,D	bis(2-Ethylhexyl) phthalate (DEHP)
GC/MS	EPA 8270C,D	Butyl benzyl phthalate
GC/MS	EPA 8270C,D	Carbazole
GC/MS	EPA 8270C,D	Chrysene
GC/MS	EPA 8270C,D	Dibenz(a,h)anthracene
GC/MS	EPA 8270C,D	Dibenzofuran
GC/MS	EPA 8270C,D	Diethyl phthalate
GC/MS	EPA 8270C,D	Dimethyl phthalate
GC/MS	EPA 8270C,D	Di-n-butyl phthalate
GC/MS	EPA 8270C,D	Di-n-octyl phthalate

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C,D	Diphenylamine
GC/MS	EPA 8270C,D	Fluoranthene
GC/MS	EPA 8270C,D	Fluorene
GC/MS	EPA 8270C,D	Hexachlorobenzene
GC/MS	EPA 8270C,D	Hexachlorobutadiene
GC/MS	EPA 8270C,D	Hexachlorocyclopentadiene
GC/MS	EPA 8270C,D	Hexachloroethane
GC/MS	EPA 8270C,D	Indeno(1,2,3-cd)pyrene
GC/MS	EPA 8270C,D	Isophorone
GC/MS	EPA 8270C,D	Naphthalene
GC/MS	EPA 8270C,D	Nitrobenzene
GC/MS	EPA 8270C,D	n-Nitrosodimethylamine
GC/MS	EPA 8270C,D	n-Nitrosodi-n-propylamine
GC/MS	EPA 8270C,D	n-Nitrosodiphenylamine
GC/MS	EPA 8270C,D	Pentachlorophenol
GC/MS	EPA 8270C,D	Phenanthrene
GC/MS	EPA 8270C,D	Phenol
GC/MS	EPA 8270C,D	Pyrene
GC/MS	EPA 8270C,D	Pyridine
GC/MS	Chemtech SOP M.5	White Phosphorus
IC	Chemtech SOP J.21	Nitrocellulose
HPLC	EPA 8330/8330A	1,3,5-Trinitrobenzene
HPLC	EPA 8330/8330A	1,3-Dinitrobenzene
HPLC	EPA 8330/8330A	2,4,6-Trinitrotoluene
HPLC	EPA 8330/8330A	2,4-Dinitrotoluene
HPLC	EPA 8330/8330A	2,6-Dinitrotoluene
HPLC	EPA 8330/8330A	2-Amino-4,6-Dinitrotoluene
HPLC	EPA 8330/8330A	2-Nitrotoluene
HPLC	EPA 8330/8330A	3-Nitrotoluene
HPLC	EPA 8330/8330A	4-Amino-2,6-Dinitrotoluene
HPLC	EPA 8330/8330A	4-Nitrotoluene

Non-Potable Water		
Technology	**Method**	**Analyte**
HPLC	EPA 8330/8330A	HMX
HPLC	EPA 8330/8330A	Nitrobenzene
HPLC	EPA 8330/8330A	RDX
HPLC	EPA 8330/8330A	Tetryl
HPLC	EPA 8330B	1,3,5-TNB
HPLC	EPA 8330B	1,3-DNB
HPLC	EPA 8330B	2,4,6-TNT
HPLC	EPA 8330B	2,4-DNT
HPLC	EPA 8330B	2,6-DNT
HPLC	EPA 8330B	2-Amino-4,6-DNT
HPLC	EPA 8330B	2-NT
HPLC	EPA 8330B	3,5-Dinitroaniline
HPLC	EPA 8330B	3-NT
HPLC	EPA 8330B	4-Amino-2,6-DNT
HPLC	EPA 8330B	4-NT
HPLC	EPA 8330B	Nitrobenzene
HPLC	EPA 8330B	Nitroglycerin
HPLC	EPA 8330B	HMX
HPLC	EPA 8330B	Pentaerythritoltetranitrate
HPLC	EPA 8330B	RDX
HPLC	EPA 8330B	Tetryl
Gravimetric	EPA 1664A	Oil & Grease
Gravimetric	EPA 1664A	Total Petroleum Hydrocarbons (TPH)
IC	EPA 9056/9056A	Bromide
IC	EPA 9056/9056A	Chloride
IC	EPA 9056/9056A	Fluoride
IC	EPA 9056/9056A	Nitrate
IC	EPA 9056/9056A	Nitrite
IC	EPA 9056/9056A	O-phosphate
IC	EPA 9056/9056A	Sulfate
CVAA	EPA 7470A	Mercury

Non-Potable Water		
Technology	**Method**	**Analyte**
ICP	EPA 6010B,C	Aluminum
ICP	EPA 6010B,C	Antimony
ICP	EPA 6010B,C	Arsenic
ICP	EPA 6010B,C	Barium
ICP	EPA 6010B,C	Beryllium
ICP	EPA 6010B,C	Boron
ICP	EPA 6010B,C	Cadmium
ICP	EPA 6010B,C	Calcium
ICP	EPA 6010B,C	Chromium
ICP	EPA 6010B,C	Cobalt
ICP	EPA 6010B,C	Copper
ICP	EPA 6010B,C	Iron
ICP	EPA 6010B,C	Lead
ICP	EPA 6010B,C	Magnesium
ICP	EPA 6010B,C	Manganese
ICP	EPA 6010B,C	Molybdenum
ICP	EPA 6010B,C	Nickel
ICP	EPA 6010B,C	Potassium
ICP	EPA 6010B,C	Selenium
ICP	EPA 6010B,C	Silicon
ICP	EPA 6010B,C	Silver
ICP	EPA 6010B,C	Sodium
ICP	EPA 6010B,C	Thallium
ICP	EPA 6010B,C	Tin
ICP	EPA 6010B,C	Titanium
ICP	EPA 6010B,C	Vanadium
ICP	EPA 6010B,C	Zinc
ICP-MS	EPA 6020/6020A	Aluminum
ICP-MS	EPA 6020/6020A	Antimony
ICP-MS	EPA 6020/6020A	Arsenic
ICP-MS	EPA 6020/6020A	Barium

Non-Potable Water		
Technology	**Method**	**Analyte**
ICP-MS	EPA 6020/6020A	Beryllium
ICP-MS	EPA 6020/6020A	Boron
ICP-MS	EPA 6020/6020A	Cadmium
ICP-MS	EPA 6020/6020A	Calcium
ICP-MS	EPA 6020/6020A	Chromium
ICP-MS	EPA 6020/6020A	Cobalt
ICP-MS	EPA 6020/6020A	Copper
ICP-MS	EPA 6020/6020A	Iron
ICP-MS	EPA 6020/6020A	Lead
ICP-MS	EPA 6020/6020A	Magnesium
ICP-MS	EPA 6020/6020A	Manganese
ICP-MS	EPA 6020/6020A	Molybdenum
ICP-MS	EPA 6020/6020A	Nickel
ICP-MS	EPA 6020/6020A	Potassium
ICP-MS	EPA 6020/6020A	Selenium
ICP-MS	EPA 6020/6020A	Silicon
ICP-MS	EPA 6020/6020A	Silver
ICP-MS	EPA 6020/6020A	Sodium
ICP-MS	EPA 6020/6020A	Thallium
ICP-MS	EPA 6020/6020A	Tin
ICP-MS	EPA 6020/6020A	Titanium
ICP-MS	EPA 6020/6020A	Vanadium
ICP-MS	EPA 6020/6020A	Zinc
Preparation	**Method**	**Type**
ISE	EPA 9040C	Corrosivity (pH)
ISE	EPA 9040C	pH
pH Paper	EPA 9041A	pH
ISE	EPA 9050A	Conductivity
Physical	EPA 1010A	Ignitability
Titrimetric	EPA 9034	Sulfide
Probe21	EPA 9040C	pH

Non-Potable Water		
Technology	**Method**	**Analyte**
TOC	EPA 9060/9060A	Total organic carbon
Turbidimetric	EPA 9038	Sulfate
UV/VIS	EPA 7196A	Chromium VI
Distillation	EPA 9010C	Total cyanide
UV/VIS	EPA 9012B	Total cyanide
UV/VIS	EPA 9065	Total phenolics
Organic Preparation	3510C	Separatory Funnel
Organic Preparation	3541	Automated Soxhlet Extraction
Clean Up	3620C	Florisil Cleanup
Clean Up	3630C	Silica Gel Cleanup
Clean Up	3640A	Gel-Permeation Cleanup
Clean Up	3660	Sulfur Cleanup
Inorganic Preparation	3050B	Hotblock
Inorganic Preparation	3010A	Hotblock
Volatile Organic Preparation	5030B	Purge and Trap
Distillation	9030B	Sulfide
Extraction/Titrimetric	9031	Sulfide
Extraction	Chemtech SOP O.20	Extraction of White Phosphorous from Aqueous Samples by Separatory Funnel
Colorimetric	Chemtech SOP J.21	Nitrocellulose

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8081A,B	4,4`-DDD
GC/ECD	EPA 8081A,B	4,4`-DDE
GC/ECD	EPA 8081A,B	4,4`-DDT
GC/ECD	EPA 8081A,B	Aldrin
GC/ECD	EPA 8081A,B	alpha-BHC (alpha-Hexachlorocyclohexane)
GC/ECD	EPA 8081A,B	alpha Chlordane
GC/ECD	EPA 8081A,B	beta-BHC (beta-Hexachlorocyclohexane)

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8081A,B	Chlordane (tech.)
GC/ECD	EPA 8081A,B	delta-BHC
GC/ECD	EPA 8081A,B	Dieldrin
GC/ECD	EPA 8081A,B	Endosulfan I
GC/ECD	EPA 8081A,B	Endosulfan II
GC/ECD	EPA 8081A,B	Endosulfan sulfate
GC/ECD	EPA 8081A,B	Endrin aldehyde
GC/ECD	EPA 8081A,B	Endrin ketone
GC/ECD	EPA 8081A,B	Endrin
GC/ECD	EPA 8081A,B	gamma-BHC (Lindane gamma-Hexachlorocyclohexane)
GC/ECD	EPA 8081A,B	gamma Chlordane
GC/ECD	EPA 8081A,B	Heptachlor epoxide
GC/ECD	EPA 8081A,B	Heptachlor
GC/ECD	EPA 8081A,B	Methoxychlor
GC/ECD	EPA 8081A,B	Toxaphene (Chlorinated camphene)
GC/ECD	EPA 8082/8082A	Aroclor-1016 (PCB-1016)
GC/ECD	EPA 8082/8082A	Aroclor-1221 (PCB-1221)
GC/ECD	EPA 8082/8082A	Aroclor-1232 (PCB-1232)
GC/ECD	EPA 8082/8082A	Aroclor-1242 (PCB-1242)
GC/ECD	EPA 8082/8082A	Aroclor-1248 (PCB-1248)
GC/ECD	EPA 8082/8082A	Aroclor-1254 (PCB-1254)
GC/ECD	EPA 8082/8082A	Aroclor-1260 (PCB-1260)
GC/ECD	EPA 8151A	2,4,5-T
GC/ECD	EPA 8151A	2,4-D
GC/ECD	EPA 8151A	Dalapon
GC/ECD	EPA 8151A	Dicamba
GC/ECD	EPA 8151A	Dinoseb
GC/ECD	EPA 8151A	Picloram
GC/ECD	EPA 8151A	Silvex (2,4,5-TP)
GC/FID	EPA 8015B/D	Diesel range organics (DRO)

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
GC/MS	EPA 8015B/D	GRO
GC/MS	EPA 8260B,C	1,1,1,2-Tetrachloroethane
GC/MS	EPA 8260B,C	1,1,1-Trichloroethane
GC/MS	EPA 8260B,C	1,1,2,2-Tetrachloroethane
GC/MS	EPA 8260B,C	1,1,2-Trichloroethane
GC/MS	EPA 8260B,C	1,1,2-Trichlorotrifluoroethane
GC/MS	EPA 8260B,C	1,1-Dichloroethane
GC/MS	EPA 8260B,C	1,1-Dichloroethylene
GC/MS	EPA 8260B,C	1,1-Dichloropropene
GC/MS	EPA 8260B,C	1,2,3-Trichlorobenzene
GC/MS	EPA 8260B,C	1,2,3-Trichloropropane
GC/MS	EPA 8260B,C	1,2,4-Trichlorobenzene
GC/MS	EPA 8260B,C	1,2,4-Trimethylbenzene
GC/MS	EPA 8260B,C	1,2-Dibromo-3-chloropropane (DBCP)
GC/MS	EPA 8260B,C	1,2-Dibromoethane (EDB Ethylene dibromide)
GC/MS	EPA 8260B,C	1,2-Dichlorobenzene
GC/MS	EPA 8260B,C	1,2-Dichloroethane
GC/MS	EPA 8260B,C	1,2-Dichloropropane
GC/MS	EPA 8260B,C	1,3,5-Trimethylbenzene
GC/MS	EPA 8260B,C	1,3-Dichlorobenzene
GC/MS	EPA 8260B,C	1,3-Dichloropropane
GC/MS	EPA 8260B,C	1,4-Dichlorobenzene
GC/MS	EPA 8260B,C	2,2-Dichloropropane
GC/MS	EPA 8260B,C	2-Butanone (Methyl ethyl ketone MEK)
GC/MS	EPA 8260B,C	2-Chloroethyl vinyl ether
GC/MS	EPA 8260B,C	2-Chlorotoluene
GC/MS	EPA 8260B,C	2-Hexanone
GC/MS	EPA 8260B,C	4-Chlorotoluene
GC/MS	EPA 8260B,C	4-Methyl-2-pentanone (MIBK)
GC/MS	EPA 8260B,C	Acetone

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B,C	Acrolein (Propenal)
GC/MS	EPA 8260B,C	Acrylonitrile
GC/MS	EPA 8260B,C	Allyl chloride (3-Chloropropene)
GC/MS	EPA 8260B,C	Benzene
GC/MS	EPA 8260B,C	Bromobenzene
GC/MS	EPA 8260B,C	Bromochloromethane
GC/MS	EPA 8260B,C	Bromodichloromethane
GC/MS	EPA 8260B,C	Bromoform
GC/MS	EPA 8260B,C	Carbon disulfide
GC/MS	EPA 8260B,C	Carbon tetrachloride
GC/MS	EPA 8260B,C	Chlorobenzene
GC/MS	EPA 8260B,C	Chloroethane
GC/MS	EPA 8260B,C	Chloroform
GC/MS	EPA 8260B,C	Methylcyclohexane
GC/MS	EPA 8260B,C	m+p-xylene
GC/MS	EPA 8260B,C	o-xylene
GC/MS	EPA 8260B,C	cis-1,2-Dichloroethylene
GC/MS	EPA 8260B,C	cis-1,3-Dichloropropene
GC/MS	EPA 8260B,C	Dibromochloromethane
GC/MS	EPA 8260B,C	Dibromomethane
GC/MS	EPA 8260B,C	Dichlorodifluoromethane
GC/MS	EPA 8260B,C	Ethyl methacrylate
GC/MS	EPA 8260B,C	Ethylbenzene
GC/MS	EPA 8260B,C	Hexachlorobutadiene
GC/MS	EPA 8260B,C	Isopropylbenzene
GC/MS	EPA 8260B,C	Methacrylonitrile
GC/MS	EPA 8260B,C	Methyl bromide (Bromomethane)
GC/MS	EPA 8260B,C	Methyl chloride (Chloromethane)
GC/MS	EPA 8260B,C	Methyl tert-butyl ether (MTBE)
GC/MS	EPA 8260B,C	Methylene chloride

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B,C	Naphthalene
GC/MS	EPA 8260B,C	n-Butylbenzene
GC/MS	EPA 8260B,C	n-Propylbenzene
GC/MS	EPA 8260B,C	p-Dioxane
GC/MS	EPA 8260B,C	p-Isopropyltoluene
GC/MS	EPA 8260B,C	sec-Butylbenzene
GC/MS	EPA 8260B,C	Styrene
GC/MS	EPA 8260B,C	tert-butyl alcohol
GC/MS	EPA 8260B,C	tert-Butylbenzene
GC/MS	EPA 8260B,C	Tetrachloroethylene (Perchloroethylene)
GC/MS	EPA 8260B,C	Toluene
GC/MS	EPA 8260B,C	trans-1,2-Dichloroethylene
GC/MS	EPA 8260B,C	trans-1,3-Dichloropropylene
GC/MS	EPA 8260B,C	trans-1,4-Dichloro-2-butene
GC/MS	EPA 8260B,C	Trichloroethene (Trichloroethylene)
GC/MS	EPA 8260B,C	Trichlorofluoromethane
GC/MS	EPA 8260B,C	Vinyl acetate
GC/MS	EPA 8260B,C	Vinyl chloride
GC/MS	EPA 8260B,C	Xylene (total)
GC/MS	EPA 8270C,D	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 8270C,D	1,2,4-Trichlorobenzene
GC/MS	EPA 8270C,D	1,2-Dichlorobenzene
GC/MS	EPA 8270C,D	1,2-Diphenylhydrazine
GC/MS	EPA 8270C,D	1,3-Dichlorobenzene
GC/MS	EPA 8270C,D	1,4-Dichlorobenzene
GC/MS	EPA 8270C,D	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 8270C,D	2,4,5-Trichlorophenol
GC/MS	EPA 8270C,D	2,4,6-Trichlorophenol
GC/MS	EPA 8270C,D	2,4-Dichlorophenol
GC/MS	EPA 8270C,D	2,4-Dimethylphenol

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C,D	2,4-Dinitrophenol
GC/MS	EPA 8270C,D	2,4-Dinitrotoluene (2,4-DNT)
GC/MS	EPA 8270C,D	2,6-Dinitrotoluene (2,6-DNT)
GC/MS	EPA 8270C,D	2-Chloronaphthalene
GC/MS	EPA 8270C,D	2-Chlorophenol
GC/MS	EPA 8270C,D	2-Methyl-4,6-dinitrophenol
GC/MS	EPA 8270C,D	2-Methylnaphthalene
GC/MS	EPA 8270C,D	2-Methylphenol (o-Cresol)
GC/MS	EPA 8270C,D	2-Nitroaniline
GC/MS	EPA 8270C,D	2-Nitrophenol
GC/MS	EPA 8270C,D	3,3`-Dichlorobenzidine
GC/MS	EPA 8270C,D	3+4-Methylphenol
GC/MS	EPA 8270C,D	3-Nitroaniline
GC/MS	EPA 8270C,D	4-Bromophenyl phenyl ether
GC/MS	EPA 8270C,D	4-Chloro-3-methylphenol
GC/MS	EPA 8270C,D	4-Chloroaniline
GC/MS	EPA 8270C,D	4-Chlorophenyl phenylether
GC/MS	EPA 8270C,D	4-Nitroaniline
GC/MS	EPA 8270C,D	4-Nitrophenol
GC/MS	EPA 8270C,D	Acenaphthene
GC/MS	EPA 8270C,D	Acenaphthylene
GC/MS	EPA 8270C,D	Acetophenone
GC/MS	EPA 8270C,D	Aniline
GC/MS	EPA 8270C,D	Anthracene
GC/MS	EPA 8270C,D	Aramite
GC/MS	EPA 8270C,D	Benzidine
GC/MS	EPA 8270C,D	Benzo(a)anthracene
GC/MS	EPA 8270C,D	Benzo(a)pyrene
GC/MS	EPA 8270C,D	Benzo(b)fluoranthene
GC/MS	EPA 8270C,D	Benzo(g,h,i)perylene

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C,D	Benzo(k)fluoranthene
GC/MS	EPA 8270C,D	Benzoic acid
GC/MS	EPA 8270C,D	Benzyl alcohol
GC/MS	EPA 8270C,D	bis(2-Chloroethoxy)methane
GC/MS	EPA 8270C,D	bis(2-Chloroethyl) ether
GC/MS	EPA 8270C,D	bis(2-Chloroisopropyl) ether (2,2`-Oxybis(1-chloropropane))
GC/MS	EPA 8270C,D	bis(2-Ethylhexyl) phthalate (DEHP)
GC/MS	EPA 8270C,D	Butyl benzyl phthalate
GC/MS	EPA 8270C,D	Carbazole
GC/MS	EPA 8270C,D	Chrysene
GC/MS	EPA 8270C,D	Dibenz(a,h)anthracene
GC/MS	EPA 8270C,D	Dibenzofuran
GC/MS	EPA 8270C,D	Diethyl phthalate
GC/MS	EPA 8270C,D	Dimethyl phthalate
GC/MS	EPA 8270C,D	Di-n-butyl phthalate
GC/MS	EPA 8270C,D	Di-n-octyl phthalate
GC/MS	EPA 8270C,D	Diphenylamine
GC/MS	EPA 8270C,D	Fluoranthene
GC/MS	EPA 8270C,D	Fluorene
GC/MS	EPA 8270C,D	Hexachlorobenzene
GC/MS	EPA 8270C,D	Hexachlorobutadiene
GC/MS	EPA 8270C,D	Hexachlorocyclopentadiene
GC/MS	EPA 8270C,D	Hexachloroethane
GC/MS	EPA 8270C,D	Indeno(1,2,3-cd)pyrene
GC/MS	EPA 8270C,D	Isophorone
GC/MS	EPA 8270C,D	Naphthalene
GC/MS	EPA 8270C,D	Nitrobenzene
GC/MS	EPA 8270C,D	n-Nitrosodimethylamine
GC/MS	EPA 8270C,D	n-Nitroso-di-n-butylamine
GC/MS	EPA 8270C,D	n-Nitrosodi-n-propylamine

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C,D	n-Nitrosodiphenylamine
GC/MS	EPA 8270C,D	Pentachlorophenol
GC/MS	EPA 8270C,D	Phenanthrene
GC/MS	EPA 8270C,D	Phenol
GC/MS	EPA 8270C,D	Pyrene
GC/MS	EPA 8270C,D	Pyridine
GC/MS	Chemtech SOP M.5	White Phosphorus
IC	Chemtech SOP J.21	Nitrocellulose
HPLC	EPA 8330/8330A	1,3,5-Trinitrobenzene
HPLC	EPA 8330/8330A	1,3-Dinitrobenzene
HPLC	EPA 8330/8330A	2,4,6-Trinitrotoluene
HPLC	EPA 8330/8330A	2,4-Dinitrotoluene
HPLC	EPA 8330/8330A	2,6-Dinitrotoluene
HPLC	EPA 8330/8330A	2-Nitrotoluene
HPLC	EPA 8330/8330A	3-Nitrotoluene
HPLC	EPA 8330/8330A	4-Amino-2,6-Dinitrotoluene
HPLC	EPA 8330/8330A	2-Amino-4,6-Dinitrotoluene
HPLC	EPA 8330/8330A	4-Nitrotoluene
HPLC	EPA 8330/8330A	HMX
HPLC	EPA 8330/8330A	Nitrobenzene
HPLC	EPA 8330/8330A	RDX
HPLC	EPA 8330/8330A	Tetryl
HPLC	EPA 8330B	1,3,5-Trinitrobenzene
HPLC	EPA 8330B	1,3-Dinitrobenzene
HPLC	EPA 8330B	2,4,6-Trinitrotoluene
HPLC	EPA 8330B	2,4-Dinitrotoluene
HPLC	EPA 8330B	2,6-Dinitrotoluene
HPLC	EPA 8330B	2-Amino-4,6-Dinitrotoluene
HPLC	EPA 8330B	2-Nitrotoluene
HPLC	EPA 8330B	3-Nitrotoluene

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
HPLC	EPA 8330B	4-Amino-2,6-Dinitrotoluene
HPLC	EPA 8330B	4-Nitrotoluene
HPLC	EPA 8330B	HMX
HPLC	EPA 8330B	Nitrobenzene
HPLC	EPA 8330B	RDX
HPLC	EPA 8330B	Tetryl
HPLC	EPA 8330B	3,5-Dinitroaniline
HPLC	EPA 8330B	Nitroglycerin
HPLC	EPA 8330B	Pentaerythritoltetranitrate
Colorimetric	EPA 9012B	Total cyanide
CVAA	EPA 7471A,B	Mercury
Gravimetric	EPA 9071B	Oil & Grease
IC	EPA 9056/9056A	Nitrite
IC	EPA 9056/9056A	Nitrate
IC	EPA 9056/9056A	Bromide
IC	EPA 9056/9056A	Chloride
IC	EPA 9056/9056A	Fluoride
IC	EPA 9056/9056A	O-phosphate
ICP	EPA 6010B,C	Aluminum
ICP	EPA 6010B,C	Antimony
ICP	EPA 6010B,C	Arsenic
ICP	EPA 6010B,C	Barium
ICP	EPA 6010B,C	Beryllium
ICP	EPA 6010B,C	Boron
ICP	EPA 6010B,C	Cadmium
ICP	EPA 6010B,C	Calcium
ICP	EPA 6010B,C	Chromium
ICP	EPA 6010B,C	Cobalt
ICP	EPA 6010B,C	Copper
ICP	EPA 6010B,C	Iron

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
ICP	EPA 6010B,C	Lead
ICP	EPA 6010B,C	Magnesium
ICP	EPA 6010B,C	Manganese
ICP	EPA 6010B,C	Molybdenum
ICP	EPA 6010B,C	Nickel
ICP	EPA 6010B,C	Potassium
ICP	EPA 6010B,C	Selenium
ICP	EPA 6010B,C	Silicon
ICP	EPA 6010B,C	Silver
ICP	EPA 6010B,C	Sodium
ICP	EPA 6010B,C	Thallium
ICP	EPA 6010B,C	Tin
ICP	EPA 6010B,C	Titanium
ICP	EPA 6010B,C	Vanadium
ICP	EPA 6010B,C	Zinc
ICP-MS	EPA 6020/6020A	Aluminum
ICP-MS	EPA 6020/6020A	Antimony
ICP-MS	EPA 6020/6020A	Arsenic
ICP-MS	EPA 6020/6020A	Barium
ICP-MS	EPA 6020/6020A	Beryllium
ICP-MS	EPA 6020/6020A	Boron
ICP-MS	EPA 6020/6020A	Cadmium
ICP-MS	EPA 6020/6020A	Calcium
ICP-MS	EPA 6020/6020A	Chromium
ICP-MS	EPA 6020/6020A	Cobalt
ICP-MS	EPA 6020/6020A	Copper
ICP-MS	EPA 6020/6020A	Iron
ICP-MS	EPA 6020/6020A	Lead
ICP-MS	EPA 6020/6020A	Magnesium
ICP-MS	EPA 6020/6020A	Manganese

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
ICP-MS	EPA 6020/6020A	Molybdenum
ICP-MS	EPA 6020/6020A	Nickel
ICP-MS	EPA 6020/6020A	Potassium
ICP-MS	EPA 6020/6020A	Selenium
ICP-MS	EPA 6020/6020A	Silicon
ICP-MS	EPA 6020/6020A	Silver
ICP-MS	EPA 6020/6020A	Sodium
ICP-MS	EPA 6020/6020A	Thallium
ICP-MS	EPA 6020/6020A	Tin
ICP-MS	EPA 6020/6020A	Titanium
ICP-MS	EPA 6020/6020A	Vanadium
ICP-MS	EPA 6020/6020A	Zinc
Solid and Chemical Waste		
Preparation	**Method**	**Type**
pH Paper	EPA 9041A	pH
Probe	EPA 9045C	pH
ISE	EPA 9040C	pH/Corrosivity
TOC	EPA 9060 Mod/ 9060A Mod	Total organic carbon
Physical	EPA 1010A	Ignitability
Titrimetric	EPA 9034	Sulfide
Turbidimetric	EPA 9038	Sulfate
Physical	EPA 9095A,B	Paint Filter Liquids Test
Preparation	EPA 3060A	Chromium VI
UV/VIS	EPA 7196A	Chromium VI
Distillation	EPA 9010C	Total cyanide
UV/VIS	EPA 9012B	Total cyanide
Distillation	EPA 9013	Total cyanide
UV/VIS	EPA 9065	Total phenolics
Preparation	EPA 1311	Toxicity Characteristic Leaching Procedure

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
Preparation	EPA 1312	SPLP
Organic Preparation	3541	Automated Soxhlet Extraction
Clean Up	3620C	Florisil Cleanup
Clean Up	3630C	Silica Gel Cleanup
Clean Up	3640A	Gel-Permeation Cleanup
Clean Up	3660	Sulfur Cleanup
Inorganics Preparation	3050B	Hotblock
Volatile Organics Preparation	5035A	Closed System Purge and Trap
Organic Preparation	3580A	Waste dilution
Distillation	9030B	Sulfide
Extraction/Titrimetric	9031	Sulfide
Extraction	Chemtech SOP O.19	Extraction of White Phosphorous from Soil and Sediment Sample by Sonication
Sonication	EPA 3550B	Extraction Preparation Method
Soxhlet	EPA 3540C	Extraction Preparation Method
Colorimetric	Chemtech SOP J.21	Nitrocellulose

Air		
Technology	**Method**	**Analyte**
GC/MS	TO-15	1,1,1-Trichloroethane
GC/MS	TO-15	1,1,2,2-Tetrachloroethane
GC/MS	TO-15	1,1,2-Trichloroethane
GC/MS	TO-15	1,1,2-Trichlorotrifluoroethane
GC/MS	TO-15	1,1-Dichloroethane
GC/MS	TO-15	1,1-Dichloroethene
GC/MS	TO-15	1,2,4-Trichlorobenzene
GC/MS	TO-15	1,2,4-Trimethylbenzene
GC/MS	TO-15	1,2-Dibromoethane
GC/MS	TO-15	1,2-Dichlorobenzene
GC/MS	TO-15	1,2-Dichloroethane

Air		
Technology	**Method**	**Analyte**
GC/MS	TO-15	1,2-Dichloropropane
GC/MS	TO-15	1,3,5-Trimethylbenzene
GC/MS	TO-15	1,3-Butadiene
GC/MS	TO-15	1,3-Dichlorobenzene
GC/MS	TO-15	1,4-Dichlorobenzene
GC/MS	TO-15	1,4-Dioxane
GC/MS	TO-15	2,2,4-Trimethylpentane
GC/MS	TO-15	2-Butanone
GC/MS	TO-15	2-Chlorotoluene
GC/MS	TO-15	2-Hexanone
GC/MS	TO-15	4-Ethyltoluene
GC/MS	TO-15	4-Methyl-2-Pentanone
GC/MS	TO-15	Acetone
GC/MS	TO-15	Allyl Chloride
GC/MS	TO-15	Benzene
GC/MS	TO-15	Benzyl Chloride
GC/MS	TO-15	Bromodichloromethane
GC/MS	TO-15	Bromoethene
GC/MS	TO-15	Bromoform
GC/MS	TO-15	Bromomethane
GC/MS	TO-15	Carbon Disulfide
GC/MS	TO-15	Carbon Tetrachloride
GC/MS	TO-15	Chlorobenzene
GC/MS	TO-15	Chloroethane
GC/MS	TO-15	Chloroform
GC/MS	TO-15	Chloromethane
GC/MS	TO-15	cis-1,2-Dichloroethene
GC/MS	TO-15	cis-1,3-Dichloropropene
GC/MS	TO-15	Cyclohexane
GC/MS	TO-15	Dibromochloromethane
GC/MS	TO-15	Dichlorodifluoromethane

Air		
Technology	**Method**	**Analyte**
GC/MS	TO-15	Dichlorotetrafluoroethane
GC/MS	TO-15	Ethanol
GC/MS	TO-15	Ethyl Acetate
GC/MS	TO-15	Ethyl Benzene
GC/MS	TO-15	Heptane
GC/MS	TO-15	Hexachloro-1,3-Butadiene
GC/MS	TO-15	Hexane
GC/MS	TO-15	Isopropyl Alcohol
GC/MS	TO-15	m/p-Xylene
GC/MS	TO-15	Methyl methacrylate
GC/MS	TO-15	Methyl tert-Butyl Ether
GC/MS	TO-15	Methylene Chloride
GC/MS	TO-15	Naphthalene
GC/MS	TO-15	o-Xylene
GC/MS	TO-15	Propene
GC/MS	TO-15	Styrene
GC/MS	TO-15	t-1,3-Dichloropropene
GC/MS	TO-15	tert-butyl alcohol
GC/MS	TO-15	Tetrachloroethene
GC/MS	TO-15	Tetrahydrofuran
GC/MS	TO-15	Toluene
GC/MS	TO-15	trans-1,2-Dichloroethene
GC/MS	TO-15	Trichloroethene
GC/MS	TO-15	Trichlorofluoromethane
GC/MS	TO-15	Vinyl Acetate
GC/MS	TO-15	Vinyl Chloride

Notes:

1.) This laboratory offers commercial testing service.

Approved by: _____ Date: April 23, 2013

R. Douglas Leonard
Chief Technical Officer

Re-issued: 12/20/12 Revised: 3/15/13 Revised: 4/23/13

Appendix B
Responses to Comments

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January 18, 2013

Mr. Moshood Oduwole
Federal Facility Remediation (3HS11)
United States Environmental Protection Agency Region 3
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

Subject: Response to Comments
Draft Tier II Sampling and Analysis Plan, Site 12 Long-term Monitoring
Naval Weapons Station Yorktown
Yorktown, Virginia

Dear Mr. Oduwole,

This letter is in response to your comments on the subject document provided in your comment letter dated November 5, 2012. Comments are presented below followed by responses in italics.

GENERAL COMMENTS

1. The SAP includes a proposal to analyze groundwater samples from Site 12 monitoring wells for Resource Conservation and Recovery Act (RCRA) 8 metals. However, it is unclear if this limited analytical suite will allow for the stated objective of the sampling to be achieved, which is "to determine if concentrations of chemical constituents increase downgradient of the landfill from their current, acceptable levels to levels that indicate a release may have occurred that might adversely impact human health and the environment." According to the *Draft Third Five-Year Review Report, Naval Weapons Station, Yorktown Virginia,* dated July 2012 (Third Five Year Review), Section 7.2.4, History of Contamination, "waste materials including incinerator ash, explosives-contaminated packaging, possibly solvents, and construction debris were disposed of at the Area A landfill at Site 12." Additionally, the Third Five-Year Review notes, "[volatile organic compounds] VOCs, explosives, and metals were observed in groundwater." Due to the materials disposed of at the Area A landfill and the chemicals previously detected in site groundwater, an expanded analytical suite appears warranted. The analytical suite should include at a minimum, VOCs, semi-volatile organic compounds (SVOCs), explosives, metals, and dioxins/furans in order to determine whether a release may have occurred. Please revise the SAP to expand the analyses proposed for groundwater samples at the Site 12 monitoring wells, or provide significant justification for limiting the proposed analyses to RCRA 8 metals. Additionally, if specific chemicals of concern (COC) were identified in the Record of Decision (ROD), these COCs should be identified in the SAP so that they can be included in the long-term monitoring program.

Response: VOCs, SVOCs, pesticides, PCBs, explosives, and full TAL metals were analyzed in the Round 1 and 2 Remedial Investigations and were included in the risk assessments which formed the basis of the response action outlined in the 1997 ROD. The FS determined that only the contaminated soil in Area A required remediation. COCs for Area A soils were 1,3,5-trinitrobenzene, antimony, cadmium, manganese, and lead. COCs identified in other media were trichloroethene (TCE) in groundwater and surface water, and PAHs, PCBs, cadmium, manganese, silver, antimony, and beryllium in sediment. However, risks were determined to be limited and no remediation was determined to be necessary for groundwater, surface water, or sediment. Instead, the ROD implemented a monitoring program "to ensure that groundwater quality and surface water/sediment quality do not further deteriorate."

The details of the monitoring program were developed and optimized via work plans and partnering consensus statements as uncertainties were satisfied with additional data generated through the LTM program. As a result, the 2008 LTM report recommended continued LTM of groundwater and sediment for RCRA 8 metals once every 5 years. Based on comment letters, the LTM report was approved by the WPNSTA Yorktown Partnering Team on the contingency that an ESD was completed for the site. The Final 2012 ESD modified the remedy outlined in the 1997 ROD to establish that "LTM will be performed only to confirm that the cover in Area A remains protective of human health and the environment, and that downgradient areas are not adversely impacted by potential future releases from this area." As a result of this conclusion, sediment sampling is no longer required as potential impacts to sediment and surface water will be identified through regular landfill inspections and groundwater sampling of COCs nearest the landfill limits of waste. This results in a monitoring requirement for only RCRA 8 metals in groundwater, as outlined in the SAP. However, because the RCRA 8 metals are not representative of all COCs at the site, and because the site was not previously sampled for dioxins, it is recommended that the groundwater monitoring approach for this round, currently included in the SAP be modified to comprise 1,3,5-trinitrobenzene, antimony, cadmium, manganese, lead and 2,3,7,8- tetrachlorodibenzo para dioxin (TCDD). Dioxin sampling will not be completed in future rounds if concentrations are at levels less than screening values. The remaining four RCRA metals will not be analyzed because they were not identified as COCs. Additionally, seven rounds of LTM sampling have occurred between May 2000 and December 2007, during which time the concentrations of these dissolved RCRA metals not identified as COCs (arsenic, barium, chromium, and mercury), were all less than risk-based screening values.

2. Seven monitoring wells have been proposed for inclusion in the Site 12 long-term monitoring program, but specific rationale for each of the wells selected has not been provided. The SAP should describe the logic used to determine each of the sample locations, including the depth at which the sample will be collected. Please revise the SAP to provide specific rationale for the selection of each of the seven monitoring wells proposed for inclusion in the long-term monitoring program.

   Response: 12GW06 is upgradient of Site 12; 12GW05, 12GW08, and 12GW19 are in the vicinity of Area A to the east; and 12GW04 and 12GW13 are in the vicinity of the Area A to the west. 12GW18 is a downgradient well. While this well was not included in the

original SAP, the SAP will be revised to include this well as a monitoring point (see Figure 4 included as an attachment to these RTCs). The new well, 12GW28, will be installed immediately downgradient of the Area A landfill to identify a potential future release from the landfill to groundwater. The table shown below will be added to the SAP summarizing the depths of each well and location/purpose. Well 12GW28 will be screened in the Cornwallis Cave aquifer at an anticipated depth of 20 to 40 feet below ground surface, however, the final depth of the well will be dependent on observations made in the field during installation.

Sampling Point	Purpose/Location	Total Depth (ft bgs)	Screened Interval (ft bgs)
YS12-GW04	Landfill Area	52.5	37.5-52.5
YS12-GW05	Landfill Area	49.5	34.5-49.5
YS12-GW06	Upgradient	54	44-54
YS12-GW08	Landfill Area	53	43-53
YS12-GW13	Landfill Area	64	44-64
YS12-GW18	Downgradient	15	5-15
YS12-GW19	Landfill Area	55	45-55
YS12-GW28	Downgradient	TBD	TBD

3. The SAP does not provide the rationale for the proposed sampling schedule. The SAP proposes to collect groundwater samples once every five years, but it is unclear if this proposed schedule will be able to meet the objective of detecting potential releases to groundwater, at the waste boundary, of COCs in landfill material. The average groundwater flow velocity in the Cornwallis Cave aquifer was reported to be 0.23 feet per day, or 84 feet a year. A release, if one occurs, has the potential to travel over 400 feet within five years. If there are any receptors that could be affected within this distance, it may be beneficial to sample on a more frequent schedule. Please revise the SAP to provide the rationale for sampling groundwater once every five years, in consideration of the sampling objective, groundwater flow velocity at the site and potential receptors in the near vicinity.

   Response: The proposed sampling frequency is based on the recommendations outlined in the 2008 LTM report which evaluated the historic remedial investigation and LTM data. The team will reevaluate the monitoring plan and determine a path forward if the data from the wells in the vicinity of and directly downgradient of Area A indicate the potential for a release. This could include an increase in sample frequency.

4. Site 12 is located within 700 feet of the Naval Weapons Station (NWS) property boundary, but no wells appear to be located along the property boundary to determine if groundwater contamination extends off-property. NWS should consider installing a sentinel well at the property boundary for inclusion in the long-term monitoring program to monitor potential groundwater contamination migrating off-site. Please revise the SAP to address this recommendation, or clarify why a sentinel well is not warranted at this time.

Response: Previous investigations have not indicated a release from the landfill. Therefore, additional wells further downgradient, along the property boundary, are not currently warranted. Groundwater from the site migrates southeast and discharges to Ballard Creek. If contamination is detected at levels of concern in samples from GW18 and GW28, additional sampling in Ballard Creek may be warranted.

SPECIFIC COMMENTS

1. Section 2.1.2, Project Scoping Session 2, Page 16: This section indicates that monitoring well 12GW18 will not be included in the long-term monitoring program for Site 12, but it will be retained as a contingency monitoring well and will only be sampled if a potentially unacceptable release from the landfill is identified. The SAP does not address this contingency sampling anywhere else in the document. The SAP needs to specifically state the decision criteria that will be applied to determine when monitoring well 12GW18 will be sampled. Revise the SAP to present the decision criteria that will be applied to determine when monitoring well 12GW18 will be sampled.

   Response: In accordance with the response to General Comment 2, 12GW18 will be included in the initial LTM sampling strategy, and the SAP will be revised to reflect this change.

2. Section 2.3.2: What are the environmental questions being answered?, Page 19: This section states, "the determination of whether a release has occurred will be made if metals are detected in the newly installed monitoring well immediately downgradient of the landfill boundary above the basewide background upper tolerance limits (UTLs) and upgradient and sidegradient concentrations." The newly installed monitoring well is identified in the referenced sentence as a downgradient monitoring well, but Figure 3, Potentiometric Surface Map: Cornwallis Cave Aquifer does not appear to support this assessment. Figure 3 shows groundwater flow direction at the Area A landfill flowing east. Figure 4, Groundwater Sample Locations, shows the newly proposed monitoring well south of the Area A landfill, which would appear to be a sidegradient location, relative to the Area A landfill. Please revise the SAP to address this observation, and clarify how the newly proposed well is considered downgradient based on the potentiometric contours presented on Figure 3. A determination of a potential release should be based on detected concentrations in downgradient wells.

   Response: As depicted on Figure 3, groundwater at the site flows from the East and West, converging along the drainage ditch. Because groundwater across the Area A watershed reaches its most downgradient point beneath the landfill (at the meeting of the landfill cover and constructed tri-lock drainage ditch), a downgradient location cannot be installed in those areas immediately east of the landfill. However, as groundwater converges from both the south-west and north-east areas at the drainage ditch, the direction of groundwater flow will migrate to the south-east direction, toward the proposed new well and constructed wetland settling pond where 12GW18 is located. Consistent with the response to General Comment 2, 12GW18 will now be included in the sampling strategy. Therefore, 12GW18 and the proposed new monitoring well (12GW28) will serve as sentinel locations for downgradient migration. A site visit with USEPA and VDEQ was completed on November 28, 2012 to approve the location of the

new downgradient well. Figure 3 has been modified to better define the components of groundwater flow and is included as an attachment to these RTCs. Additionally, near-landfill monitoring well data will also be compared with upgradient data to better assess any landfill impacts.

3. Section 2.3.2, What are the environmental questions being answered?, Page 19: This section states, "Synoptic water level measurements will be collected from 16 Cornwallis Cave aquifer monitoring wells during each sampling event, seven wells proposed for sampling and 18 additional monitoring wells, as depicted on Figure 4." However, seven wells proposed for sampling plus 18 additional monitoring wells does not equal 16 wells. Figure 4 appears to show 16 total wells, seven of which will be sampled and another nine which will be monitored for groundwater elevations only. Please revise the above referenced sentence of Section 2.3.2 to address the discrepancy regarding the number of wells included in the groundwater elevation surveys.

   Response: The sentence will be updated to state "Synoptic water level measurements will be collected from the 16 Cornwallis Cave aquifer monitoring wells (15 existing and 1 new) during each sampling event, as depicted on Figure 4." Figure 4 has been updated to indicate 12GW18 will be sampled and gauged, in accordance with the response to General Comment 2 and is included as an attachment to these RTCs.

4. Section 3.4, Sample Details Table, Page 25: The summary table in this section identifies the wells that will be sampled as part of the long-term monitoring program. One of the wells identified, YS12-GW28, could not be located on Figure 4, Groundwater Sample Locations. It appears that YS12-GW28 may be the newly proposed monitoring well, but it is not labeled on Figure 4. Revise Figure 4 to identify the location of YSI2-GW28.

   Response: Correct, YS12-GW28 refers to the new well. Figure 4 has been updated to include the station identification and is included as an attachment to these RTCs.

5. Table 4-2, Reference Limits and Evaluation Table: The adjusted tapwater Regional Screening Levels (RSLs) for several metals are not consistent with those presented in the May 2012 RSL Table. For example, Table 4-2 identifies a lead RSL of 7.8 micrograms per liter (ug/1), but the May 2012 RSL Table does not include an established tapwater RSL for lead. Additionally, the values presented for mercury, selenium, and silver are not consistent with the values presented in the May 2012 RSL table for these chemicals. Revise Table 4-2 to provide the correct RSLs for mercury, selenium, and silver. For lead, EPA's action level of 15 ug/l could be used as a preliminary screening criterion since a tapwater RSL has not been established.

   Response: The table will be corrected to reflect the November 2012 RSL table and EPA's 15 ug/L action level will be used for lead; all other values will be confirmed. However, please note, that depending upon the date at which data are received a more updated version of the RSL table may be used for comparison.

USEPA TECHNICAL SUPPORT COMMENTS

BTAG

1. Section 2.1.1 on page 15 indicates that the sediment LTM data from 2007 had elevated levels of arsenic and selenium. The text states "... LTM data over time indicate an overall decreasing trend in metals concentrations in sediment." This overall decreasing trend does not necessarily mean that all contaminant concentrations are decreasing. Both of these points do not support the stated conclusion that "... the landfill cap is functioning as intended and preventing surface runoff of contaminants to sediment." Therefore, the sediment LTM needs to continue to ensure the surface runoff migration pathway to sediment is not active.

   Response: The 2012 ESD, signed by EPA and the Navy, was developed to appropriately focus the response actions on media potential impacted by historical releases from the Site 12 Landfill Area A. Consequently, sediment sampling that previously encompassed the Ballard Creek watershed is no longer a component of the remedy. Although the landfill is 50+ years post closure and no current or future releases are likely to occur, to ensure protection of surface water and sediment, groundwater downgradient of the Area A landfill will be monitored and regular landfill inspections will be conducted to ensure cap integrity and monitor surface runoff conditions. The sediment location with elevated arsenic and selenium data from 2007 is not located downgradient of Area A. The other sediment location where elevated arsenic was detected is over 1500 feet downgradient from Area A and there are three sediment sample locations between Area A and this location with sample results less than screening values. The results of previous sediment samples support that there is no complete pathway between Area A and these locations. Based on the 2012 ESD and historical sediment data indicating no pathway, sediment will not be included as part of the LTM Program for Site 12.

2. Section 2.2 on page 18 indicates that groundwater flow directions are shown on Figure 3. According to Figure 3, groundwater flow is toward the constructed wetland/settling pond. This wetland/pond needs to be included in the LTM for Site 12 to ensure that the remedial action is protective of ecological receptors. Discharge from this wetland/pond flows approximately 300 feet and enters Ballard Creek. This additional sediment area (approximately 300 feet and Ballard Creek) should also be sampled to ensure the remedial action continues to be protective of ecological receptors.

   Response: The Navy respectfully disagrees with this recommendation. Shallow groundwater will be monitored to determine the potential for a release from the landfill. If concentrations identified in downgradient groundwater indicate the potential for a release to surface water bodies, surface water and sediment sampling may be considered.

3. Section 2.3.2 on page 19 states that based on the recommendation in the 2008 long-term monitoring report and the nature of the waste disposed of in Area A (scrap metal, charred wood, burnt cloth, and glass) samples will be analyzed for total and dissolved Resource Conservation and Recovery Act (RCRA) 8 metals. Section 2.2 on page 17 states that wastes also included nitramine-contaminated packaging and incinerator ash. Based on these types of waste, explosives (from nitramine waste), and polycyclic aromatic hydrocarbons and dioxins (from combustion waste) should also be considered for analysis. Additional justification should be provided for limiting analysis to only the 8 RCRA metals.

Response: Please see response to General Comment #1.

4. Section 2.3.2 on page 19 states that in accordance with the decision tree in Figure 5, the determination of whether a release has occurred will be made if metals concentrations detected in the newly installed monitoring well immediately downgradient of the landfill boundary are above the basewide background and upgradient and sidegradient concentrations. Based on the potentiometric surface map in Figure 3, it is unclear what wells are downgradient (12GW19 may also be downgradient). It would be more appropriate to compare concentrations in wells surrounding Area A with upgradient wells to document whether a release has occurred, particularly given the proximity of these wells to landfill waste.

   Response: Please see response to General Comment #2. Comparison of near-landfill and downgradient results to upgradient samples will be completed. Also, please note that comparisons to upgradient well 12GW06 are included in the sampling plan, as outlined in the SAP.

5. Section 2.3.2 on page 19 states that groundwater concentrations will be compared to ecological screening values for surface water quality to evaluate the potential for ecological risk. The ecological screening values are listed in Section 4.1. The basis for these values is not provided. BTAG screening levels for freshwater should be used to assess potential ecological risk from chemicals in groundwater.

   Response: References for each ecological screening value will be added. Screening values will come from USEPA's Ambient Water Quality Criteria (USEPA, 2009) or Suter and Tsao (1996), in cases where an Ambient Water Quality Criteria value is not available:

   U.S. Environmental Protection Agency (USEPA). 2009. National recommended water quality criteria – 2009.

   Suter, G.W. II and C.L. Tsao. 1996. Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota: 1996 revision. Environmental Restoration Division, ORNL Environmental Restoration Program, ES/ER/TM-96/R2.

6. Generally, from the information provided, it is not clear where groundwater discharges to surface water or if these areas have been previously sampled. If this information is not known, then this report needs to justify why this data gap has remained and how it will be resolved.

   Response: Please see response to General Comment #1.

TOXICOLOGIST

7. The proposed monitoring frequency for groundwater is once every five years. Typically, groundwater monitoring is conducted more frequently than that, at least initially, to capture seasonal variations. The Navy should either 1) provide solid justification for a five-year sampling frequency or 2) monitor more often than every five years.

Response: Please see response to General Comment #3. In addition to the RI sampling, historic LTM sampling was performed at Site 12 in August 1998, May 2000, August 2000, December 2000, February 2001, June 2001, December 2001, August 2002, April 2003, and December 2007. This data set sufficiently characterizes seasonal variations. The proposed sampling frequency is based on the recommendations outlined in the 2008 LTM report which evaluated the historic remedial investigation and LTM data. As depicted on the Decision Tree presented as Figure 5, the team will reevaluate the monitoring plan and determine a path forward if the data from the wells directly downgradient of Area A or immediately adjacent to the landfill indicate the potential for a release. This could include a more frequent sampling frequency.

8. Eight (8) RCRA metals are proposed in the report for analysis, but no explanation for this is provided. Do these metals represent Contaminants of Concern in groundwater at Site 12 (Area A)? The selection of these metals for analysis should be explained in the report.

   Response: Samples will be analyze for site-specific COCs and dioxins in accordance with the response to General Comment #1.

Please provide acceptance of these responses or additional comments by February 16, 2013. Please feel free to contact me should you have any additional questions.

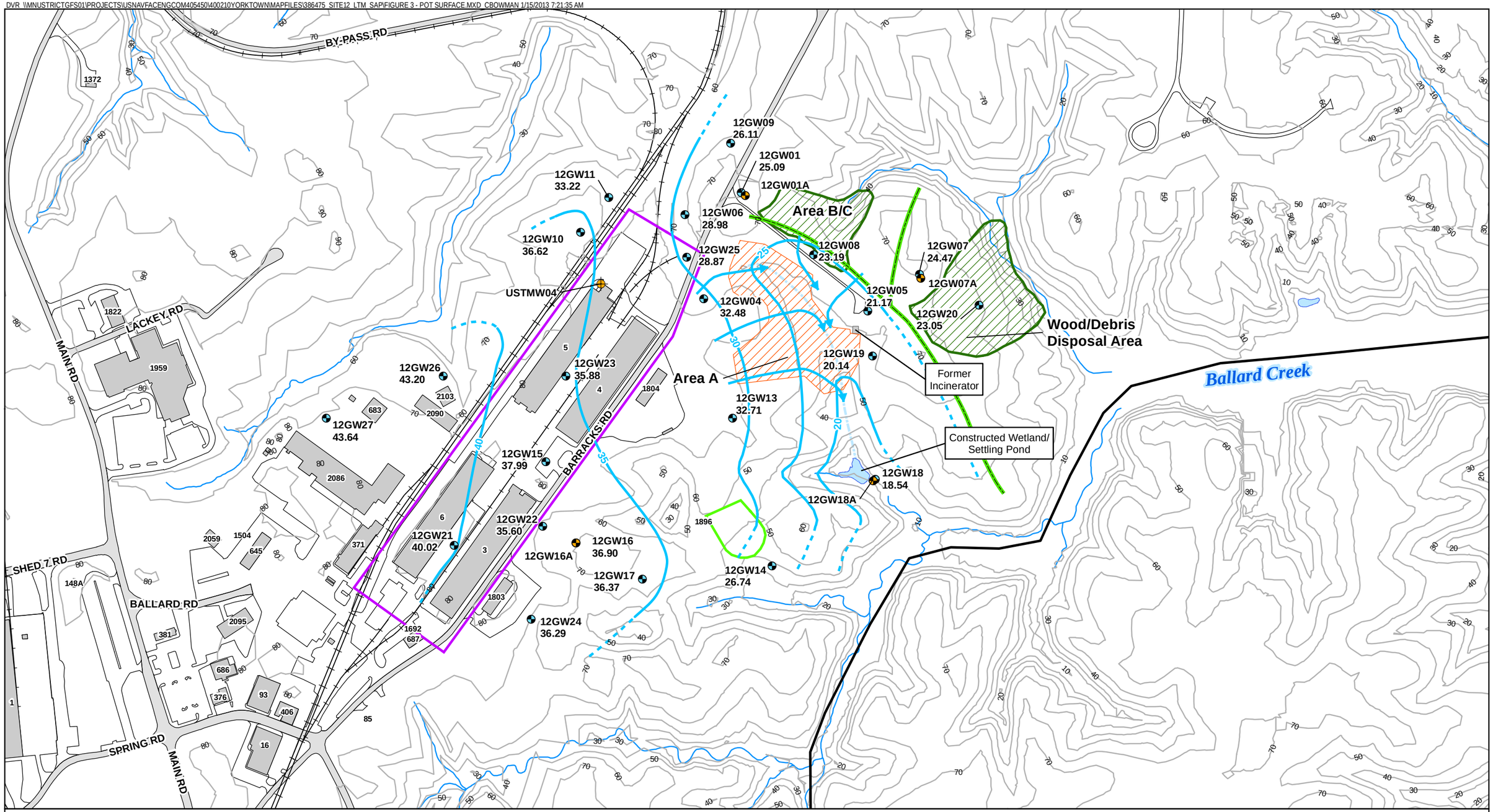
Sincerely,

CH2M HILL

FOR William J. Friedmann, Jr.
Activity Manager

cc: Mr. Wade Smith/VDEQ
Mr. James Gravette/NAVFAC MIDLANT
Mr. David Livingston/CH2M HILL

DVR \\MNUSTRICTGFS01\PROJECTS\USNAVFACENGCOM405450\400210YORKTOWN\MAPFILES\386475_SITE12_LTM_SAP\FIGURE 3 - POT SURFACE.MXD CBOWMAN 1/15/2013 7:21:35 AM



Legend

- Yorktown-Eastover Aquifer Monitoring Well
- Cornwallis Cave Aquifer Monitoring Well
- Former Railroad
- Trilock Block Drainage Ditch
- Site 12 Area A Landfill Cap
- Site 12 NFA Areas
- IR Site 31 Boundary
- Approximate Location of Groundwater Divide
- SSA 15 Boundary
- NWS Yorktown Boundary
- Groundwater Potentiometric Surface
- Groundwater Potentiometric Surface (inferred)
- Groundwater Flow Direction

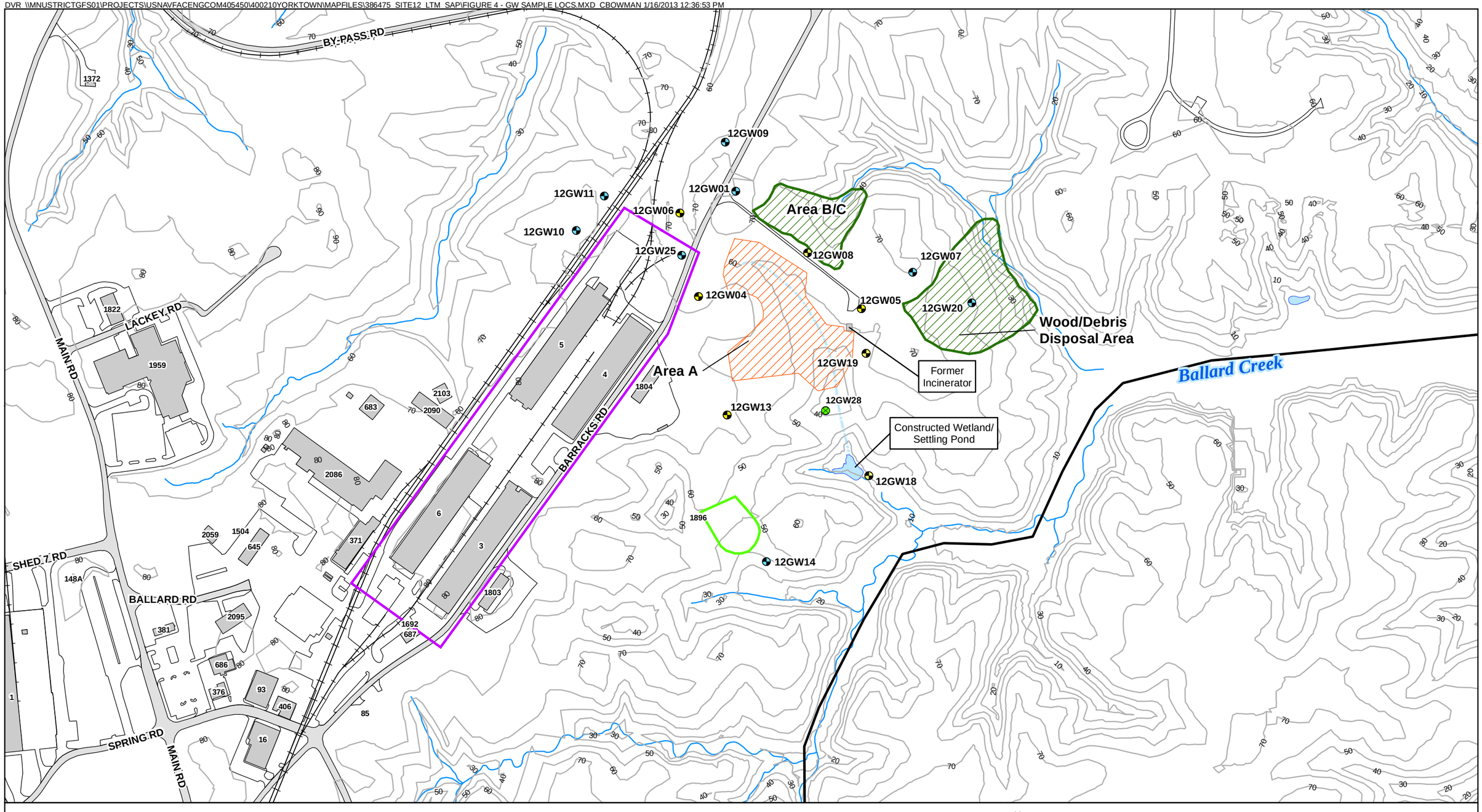
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Figure 3
Potentiometric Surface Map: Cornwallis Cave Aquifer
Site 12 LTM Sampling and Analysis Plan
Naval Weapon Station Yorktown
Yorktown, Virginia

CH2MHILL

DVR \\MNUSTRICTGFS01\PROJECTS\USNAVFACENGCOM405450\400210YORKTOWN\MAPFILES\386475_SITE12_LTM_SAP\FIGURE 4 - GW SAMPLE LOCS.MXD CBOWMAN 1/16/2013 12:36:53 PM



Legend

- Cornwallis Cave Aquifer Monitoring Well to be Sampled
- Cornwallis Cave Aquifer Monitoring Well for inclusion in groundwater elevation survey
- New Cornwallis Cave Aquifer Monitoring Well to be Sampled
- Former Railroad
- Trilock Block Drainage Ditch
- IR Site 31 Boundary
- Site 12 NFA Areas
- Site 12 Area A Landfill Cap
- SSA 15 Boundary
- NWS Yorktown Boundary

N
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Feet

Figure 4
Groundwater Sample Locations
Site 12 LTM Sampling and Analysis Plan
Naval Weapon Station Yorktown
Yorktown, Virginia

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March 13, 2013

Mr. Moshood Oduwole
Federal Facility Remediation (3HS11)
United States Environmental Protection Agency Region 3
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

Subject: Response to EPA Comment Letter
Draft Tier II Sampling and Analysis Plan, Site 12 Long-term Monitoring
Naval Weapons Station Yorktown
Yorktown, Virginia

Dear Mr. Oduwole,

This letter is in response to the EPA comments on the subject document provided in your comment letter dated February 7, 2013. Two rounds of comments on the Site 12 UFP-SAP were received by the EPA: in November 2012 and February 2013. The Navy provided a Response to Comment (RTC) letter in January 2013. In addition, the WPNSTA Yorktown Partnering discussed these RTC letters during the February 2013 partnering meetings. Due to the multiple rounds of comments and RTCs on the Site 12 UFP-SAP, the RTC history only for the unresolved comments are provided for clarity of the issue to be resolved by this letter. All other comments from the November 2012 EPA comment letter have been resolved within the Navy's November 2012 letter and will be incorporated in the Site 12 UFP-SAP once all the remaining comments are resolved.

Source of February 2013 EPA Comment #1

November 2012 EPA General Comment #1:	January 2013 Navy Response:
The SAP includes a proposal to analyze groundwater samples from Site 12 monitoring wells for Resource Conservation and Recovery Act (RCRA) 8 metals. However, it is unclear if this limited analytical suite will allow for the stated objective of the sampling to be achieved, which is "to determine if concentrations of chemical constituents increase downgradient of the landfill from their current, acceptable levels to levels that indicate a release may have occurred that might adversely impact human health and the environment." According to the *Draft Third Five-Year Review Report, Naval Weapons Station, Yorktown Virginia,* dated July 2012 (Third Five Year Review), Section 7.2.4, History	*VOCs, SVOCs, pesticides, PCBs, explosives, and full TAL metals were analyzed in the Round 1 and 2 Remedial Investigations and were included in the risk assessments which formed the basis of the response action outlined in the 1997 ROD. The FS determined that only the contaminated soil in Area A required remediation. COCs for Area A soils were 1,3,5-trinitrobenzene, antimony, cadmium, manganese, and lead. COCs identified in other media were trichloroethene (TCE) in groundwater and surface water, and PAHs, PCBs, cadmium, manganese, silver, antimony, and beryllium in sediment. However, risks were determined to be limited and no remediation was determined to be necessary for*

of Contamination, "waste materials including incinerator ash, explosives-contaminated packaging, possibly solvents, and construction debris were disposed of at the Area A landfill at Site 12." Additionally, the Third Five-Year Review notes, "[volatile organic compounds] VOCs, explosives, and metals were observed in groundwater." Due to the materials disposed of at the Area A landfill and the chemicals previously detected in site groundwater, an expanded analytical suite appears warranted. The analytical suite should include at a minimum, VOCs, semi-volatile organic compounds (SVOCs), explosives, metals, and dioxins/furans in order to determine whether a release may have occurred. Please revise the SAP to expand the analyses proposed for groundwater samples at the Site 12 monitoring wells, or provide significant justification for limiting the proposed analyses to RCRA 8 metals. Additionally, if specific chemicals of concern (COC) were identified in the Record of Decision (ROD), these COCs should be identified in the SAP so that they can be included in the long-term monitoring program.	*groundwater, surface water, or sediment. Instead, the ROD implemented a monitoring program "to ensure that groundwater quality and surface water/sediment quality do not further deteriorate."* *The details of the monitoring program were developed and optimized via work plans and partnering consensus statements as uncertainties were satisfied with additional data generated through the LTM program. As a result, the 2008 LTM report recommended continued LTM of groundwater and sediment for RCRA 8 metals once every 5 years. Based on comment letters, the LTM report was approved by the WPNSTA Yorktown Partnering Team on the contingency that an ESD was completed for the site. The Final 2012 ESD modified the remedy outlined in the 1997 ROD to establish that "LTM will be performed only to confirm that the cover in Area A remains protective of human health and the environment, and that downgradient areas are not adversely impacted by potential future releases from this area." As a result of this conclusion, sediment sampling is no longer required as potential impacts to sediment and surface water will be identified through regular landfill inspections and groundwater sampling of COCs nearest the landfill limits of waste. This results in a monitoring requirement for only RCRA 8 metals in groundwater, as outlined in the SAP. However, because the RCRA 8 metals are not representative of all COCs at the site, and because the site was not previously sampled for dioxins, it is recommended that the groundwater monitoring approach for this round, currently included in the SAP be modified to comprise 1,3,5-trinitrobenzene, antimony, cadmium, manganese, lead and 2,3,7,8- tetrachlorodibenzo para dioxin (TCDD). Dioxin sampling will not be completed in future rounds if concentrations are at levels less than screening values. The remaining four RCRA metals will not be analyzed because they were not identified as COCs. Additionally, seven rounds of LTM sampling have occurred between May 2000 and December 2007, during which time the concentrations of these dissolved RCRA metals not identified as*

	COCs (arsenic, barium, chromium, and mercury), were all less than risk-based screening values.

1. February 2013 EPA General Comment#1: According to the response to General Comment 1, the final 2012 ESD stated that "LTM will be performed only to confirm that the cover in Area A remains protective of human health and the environment and that downgradient areas are not adversely impacted by potential future releases from this area." This final ESD (page 3, Sections 3 Basis for the ESD and Section 4 Description of Significant Difference), only references the source of TCE being the upgradient Site 31. Therefore, this would not affect portions of the selected remedy pertaining to OU III ("LTM of the soil cover and surface water") and OU V (implementing LTM of groundwater from shallow and deep well across the study area, and surface water and sediment from Ballard Creek and its tributaries"). This response to comments will need to change to reflect this information.

Navy Response: As discussed during the November 2012 and February 2013 partnering meetings, LTM is required to confirm that the engineered cap installed over the Area A landfill remains protective. No other areas at Site 12 require LTM since these other areas (Area B/C and the Wood/Debris Disposal Area) do not pose a potential risk. No potential releases are expected to site soils since the cap in place prevents infiltration and is being annually inspected and maintained. Groundwater is considered the only transport pathway for contaminants at the site and it is for that reason that the Navy is proposing groundwater monitoring. It is important to note that given the age of the landfill (50+ years since waste was last disposed), the Navy does not expect future releases are expected. Historical groundwater, surface water, and sediment data also supports the expectation that future releases are unlikely.

As shown on the attached 4-4 of the 2000 LTM Report and 4-2 of the 2008 LTM Report, no exceedences of the Region III Freshwater ESVs were identified in the samples immediately downgradient of Area A. The 2008 LTM groundwater results (Attached Figure 4-1) indicate limited exceedence of human health screening values (Tap Water RBCs and Federal MCL). It is acknowledged that the results of the 2008 groundwater data was not screened against the Region III BTAG ESVs, which was not required as part of the LTM sampling plan.

It is for these reasons that the SAP has been revised to indicate that only the groundwater will be sampled to determine if groundwater remains a media of concern. The Navy recognizes that a new well is needed immediately downgradient of the site to better characterize the downgradient groundwater. The location of this well has been discussed with and agreed to by the EPA and VDEQ during the November 28, 2012 site visit as shown on Figure 4 of the draft UFP-SAP. It is important to point out that while groundwater will be the only media sampled during the next LTM sampling event, based on that data the Navy, EPA and VDEQ may decide if other media should be include in follow-up LTM events. In other words, if the groundwater data when compared to screening values indicate a potential concern to other media, such as surface water, the stakeholders will discuss the need for future

action for these other media. However, if no potential release to other is identified the Navy will assume no other media need to be sampled in the future.

Source of February 2013 EPA Comment #2

November 2012 EPA General Comment #1:	January 2013 Navy Response:
Seven monitoring wells have been proposed for inclusion in the Site 12 long-term monitoring program, but specific rationale for each of the wells selected has not been provided. The SAP should describe the logic used to determine each of the sample locations, including the depth at which the sample will be collected. Please revise the SAP to provide specific rationale for the selection of each of the seven monitoring wells proposed for inclusion in the long-term monitoring program.	*Response: 12GW06 is upgradient of Site 12; 12GW05, 12GW08, and 12GW19 are in the vicinity of Area A to the east; and 12GW04 and 12GW13 are in the vicinity of the Area A to the west. 12GW18 is a downgradient well. While this well was not included in the original SAP, the SAP will be revised to include this well as a monitoring point (see Figure 4 included as an attachment to these RTCs). The new well, 12GW28, will be installed immediately downgradient of the Area A landfill to identify a potential future release from the landfill to groundwater. The table provided will be added to the SAP summarizing the depths of each well and location/purpose. Well 12GW28 will be screened in the Cornwallis Cave aquifer at an anticipated depth of 20 to 40 feet below ground surface, however, the final depth of the well will be dependent on observations made in the field during installation.*

2. The last sentence indicates that dissolved concentrations of RCRA metals not identified as COCs (arsenic, barium, chromium, and mercury) were all less than risk-based screening values. The response needs to state that appropriate BTAG (EPA Region III) ecological screening values used and included in this general description of risk based screening values. Please identify the specific screening values used.

   Navy Response: Screening criteria used in the 2008 LTM Report (Table 4-1) utilized the then current EPA Region III RBCs and the Federal MCLs for evaluated the latest round of groundwater data. No ESV were used in the evaluation of the groundwater LTM data. A comparison of the four remaining RCRA metals (arsenic, barium, chromium, and mercury) from the 2007 groundwater data to the then current Region III BTAG Freshwater screening levels identified arsenic (11.8 mg/L) as exceeding its BTAG screening value (9.8 mg/L) However, arsenic did not exceed the ecological screening value in the tributary leading from Area A.

   The Navy will analyze for all RCRA 8 metals as well as 1,3,5-trinitrobenzene and 2,3,7,8-tetrachlorodibenzo para dioxin (TCDD). Should the additional compounds (1,3,5-trinitrobenzene and TCDD) be reported at levels below the current Region III BTAG Freshwater ESVs or base background, then the LTM report will recommend that no future analysis of these compounds will be conducted.

Source of February 2013 EPA Comment #3

November 2012 EPA BTAG Comment #1:	January 2013 Navy Response:
Section 2.1.1 on page 15 indicates that the sediment LTM data from 2007 had elevated levels of arsenic and selenium. The text states "... LTM data over time indicate an overall decreasing trend in metals concentrations in sediment." This overall decreasing trend does not necessarily mean that all contaminant concentrations are decreasing. Both of these points do not support the stated conclusion that "... the landfill cap is functioning as intended and preventing surface runoff of contaminants to sediment." Therefore, the sediment LTM needs to continue to ensure the surface runoff migration pathway to sediment is not active.	*The 2012 ESD, signed by EPA and the Navy, was developed to appropriately focus the response actions on media potential impacted by historical releases from the Site 12 Landfill Area A. Consequently, sediment sampling that previously encompassed the Ballard Creek watershed is no longer a component of the remedy. Although the landfill is 50+ years post closure and no current or future releases are likely to occur, to ensure protection of surface water and sediment, groundwater downgradient of the Area A landfill will be monitored and regular landfill inspections will be conducted to ensure cap integrity and monitor surface runoff conditions. The sediment location with elevated arsenic and selenium data from 2007 is not located downgradient of Area A. The other sediment location where elevated arsenic was detected is over 1500 feet downgradient from Area A and there are three sediment sample locations between Area A and this location with sample results less than screening values. The results of previous sediment samples support that there is no complete pathway between Area A and these locations. Based on the 2012 ESD and historical sediment data indicating no pathway, sediment will not be included as part of the LTM Program for Site 12.*

3. The response to BTAG comment 1 states" ... sediment sampling that previously encompassed the Ballard Creek watershed is no longer a component of the remedy." Based on the final ESD (see comment 1 above), this is not the case. This entire response will need to show how LTM sampling will document that chemical concentrations in soil, groundwater, sediment, and surface water will continue to be protective of ecological receptors at and downgradient of Area A (Site 12).

Navy Response: Please see response to General Comment #1.

Source of February 2013 EPA Comment #4 November 2012 EPA BTAG Comment #2:	January 2013 Navy Response:
Section 2.2 on page 18 indicates that groundwater flow directions are shown on	*The Navy respectfully disagrees with this recommendation. Shallow groundwater will be monitored to determine the potential for a*

Figure 3. According to Figure 3, groundwater flow is toward the constructed wetland/settling pond. This wetland/pond needs to be included in the LTM for Site 12 to ensure that the remedial action is protective of ecological receptors. Discharge from this wetland/pond flows approximately 300 feet and enters Ballard Creek. This additional sediment area (approximately 300 feet and Ballard Creek) should also be sampled to ensure the remedial action continues to be protective of ecological receptors.	*release from the landfill. If concentrations identified in downgradient groundwater indicate the potential for a release to surface water bodies, surface water and sediment sampling may be considered.*

4. The response to BTAG comment 2 will need to change to reflect the information that is contained in the fInal ESD. This means the wetland/pond, the tributary to Ballard Creek, Ballard Creek, and soils downgradient of Area A (Site 12) will need to be included in LTM sampling and analysis.

   Navy Response: Please see response to General Comment #1.

Source of February 2013 EPA Comment #5

November 2012 EPA BTAG Comment #3:	January 2013 Navy Response:
Section 2.3.2 on page 19 states that based on the recommendation in the 2008 long-term monitoring report and the nature of the waste disposed of in Area A (scrap metal, charred wood, burnt cloth, and glass) samples will be analyzed for total and dissolved Resource Conservation and Recovery Act (RCRA) 8 metals. Section 2.2 on page 17 states that wastes also included nitramine-contaminated packaging and incinerator ash. Based on these types of waste, explosives (from nitramine waste), and polycyclic aromatic hydrocarbons and dioxins (from combustion waste) should also be considered for analysis. Additional justification should be provided for limiting analysis to only the 8 RCRA metals.	*Please see response to General Comment #1.*

5. BTAG comment 3 indicates that more than the eight RCRA metals (e.g., explosives, PAHs, and dioxins) need to be included in the analytical results of the samples. The response ("Please see response to General Comment # 1) is not adequate (please see comment 1 above). Additional analytes will need to be added to the eight RCRA metals in the LTM for Area A (Site 12).

Navy Response: Please see response to General Comment #2.

Source of February 2013 EPA Comment #6

November 2012 EPA BTAG Comment #5:	January 2013 Navy Response:
Section 2.3.2 on page 19 states that groundwater concentrations will be compared to ecological screening values for surface water quality to evaluate the potential for ecological risk. The ecological screening values are listed in Section 4.1. The basis for these values is not provided. BTAG screening levels for freshwater should be used to assess potential ecological risk from chemicals in groundwater.	*References for each ecological screening value will be added. Screening values will come from USEPA's Ambient Water Quality Criteria (USEPA, 2009) or Suter and Tsao (1996), in cases where an Ambient Water Quality Criteria value is not available:* *U.S. Environmental Protection Agency (USEPA). 2009. National recommended water quality criteria – 2009.* *Suter, G.W. II and C.L. Tsao. 1996. Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota: 1996 revision. Environmental Restoration Division, ORNL Environmental Restoration Program, ES/ER/TM-96/R2.*

6. BTAG comment 5 indicates that BTAG (EPA Region III) ecological screening values for freshwater need to be used to evaluate risk from contaminants in groundwater. The Navy needs to use BTAG (EPA Region III) screening values.

   Navy Response: To clarify, the Navy will compare groundwater results to the most current version of the BTAG (EPA Region III) ecological screening values for freshwater. Section 4.1 will be modified to reflect the current ESVs for all the compounds to be analyzed.

Source of February 2013 EPA Comment #7

November 2012 EPA BTAG Comment #6:	January 2013 Navy Response:
Generally, from the information provided, it is not clear where groundwater discharges to surface water or if these areas have been previously sampled. If this information is not known, then this report needs to justify why this data gap has remained and how it will be resolved.	*Response: Please see response to General Comment #1.*

7. BTAG comment 6 indicates there is confusion about where groundwater discharges to surface water and if these specific locations have been sampled in the past. The response to this comment ("Please see response to General Comment #1") does not address this issue.

   Navy Response: Based on previous investigations no seeps have been identified at Area A and groundwater elevations reflect groundwater discharging to the surface water impoundment. In addition to the existing monitoring well located at the impoundment (GW18), the newly installed well (GW28) will be sampled to indicate whether contaminants are migrating toward the impoundment.

To summarize the next steps the Navy intends to take with regards to the next round of LTM sampling for Site 12.

- In order to evaluate groundwater from a more appropriate downgradient location, one new monitoring well (GW28) will be installed downgradient between the edge of the landfill cap and the surface water pond.
- Collection and analysis of groundwater samples from the identified monitoring well network for the identified COCs and compounds that were identified as a potential data gap. The compounds will be analyzed for RCRA 8 metals, 1,3,5-trinitrobenzene and 2,3,7,8-tetrachlorodibenzo para dioxin (TCDD).
- Comparison of data to the most current version of following screening values; EPA Region 3 tap water RSLs, Federal MCLs, EPA Region III BTAG fresh water ESVs and base 95% UTLs.

Please provide acceptance of these responses or additional comments by March 29, 2013. Please feel free to contact me should you have any additional questions.

Sincerely,

CH2M HILL

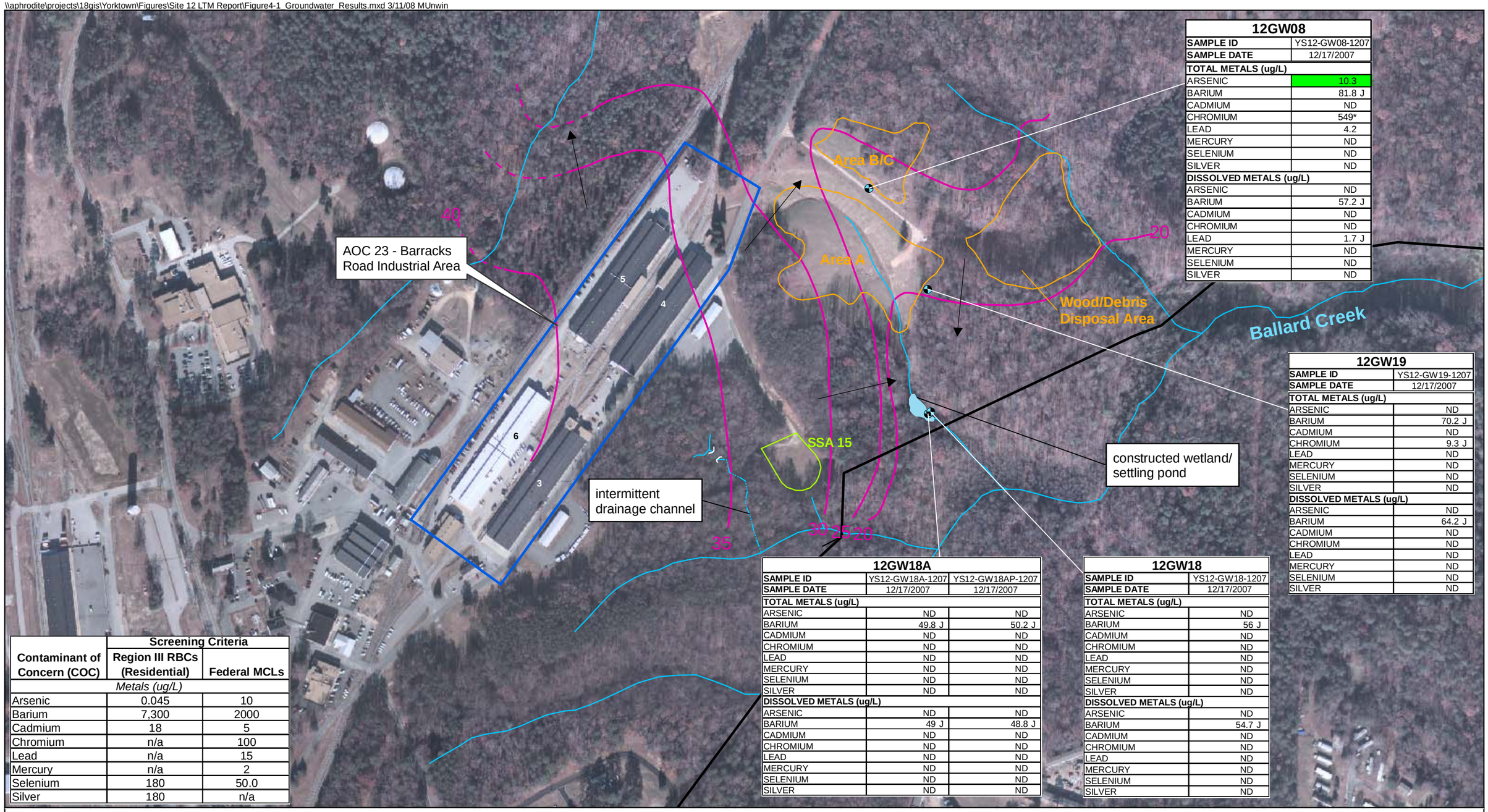
William J. Friedmann Jr.

William J. Friedmann, Jr.
Activity Manager

cc: Mr. Wade Smith/VDEQ
Mr. James Gravette/NAVFAC MIDLANT
Mr. David Livingston/CH2M HILL

Enclosed:
Attachments – Figures 4-1 & 4-2 of the 2008 LTM Report
Figure 4-4 of the 2000 LTM Report

\\aphrodite\projects\18gis\Yorktown\Figures\Site 12 LTM Report\Figure4-1_Groundwater_Results.mxd 3/11/08 MUnwin



12GW08	
SAMPLE ID	YS12-GW08-1207
SAMPLE DATE	12/17/2007
TOTAL METALS (ug/L)	
ARSENIC	10.3
BARIUM	81.8 J
CADMIUM	ND
CHROMIUM	549*
LEAD	4.2
MERCURY	ND
SELENIUM	ND
SILVER	ND
DISSOLVED METALS (ug/L)	
ARSENIC	ND
BARIUM	57.2 J
CADMIUM	ND
CHROMIUM	ND
LEAD	1.7 J
MERCURY	ND
SELENIUM	ND
SILVER	ND

12GW19	
SAMPLE ID	YS12-GW19-1207
SAMPLE DATE	12/17/2007
TOTAL METALS (ug/L)	
ARSENIC	ND
BARIUM	70.2 J
CADMIUM	ND
CHROMIUM	9.3 J
LEAD	ND
MERCURY	ND
SELENIUM	ND
SILVER	ND
DISSOLVED METALS (ug/L)	
ARSENIC	ND
BARIUM	64.2 J
CADMIUM	ND
CHROMIUM	ND
LEAD	ND
MERCURY	ND
SELENIUM	ND
SILVER	ND

12GW18A		
SAMPLE ID	YS12-GW18A-1207	YS12-GW18AP-1207
SAMPLE DATE	12/17/2007	12/17/2007
TOTAL METALS (ug/L)		
ARSENIC	ND	ND
BARIUM	49.8 J	50.2 J
CADMIUM	ND	ND
CHROMIUM	ND	ND
LEAD	ND	ND
MERCURY	ND	ND
SELENIUM	ND	ND
SILVER	ND	ND
DISSOLVED METALS (ug/L)		
ARSENIC	ND	ND
BARIUM	49 J	48.8 J
CADMIUM	ND	ND
CHROMIUM	ND	ND
LEAD	ND	ND
MERCURY	ND	ND
SELENIUM	ND	ND
SILVER	ND	ND

12GW18	
SAMPLE ID	YS12-GW18-1207
SAMPLE DATE	12/17/2007
TOTAL METALS (ug/L)	
ARSENIC	ND
BARIUM	56 J
CADMIUM	ND
CHROMIUM	ND
LEAD	ND
MERCURY	ND
SELENIUM	ND
SILVER	ND
DISSOLVED METALS (ug/L)	
ARSENIC	ND
BARIUM	54.7 J
CADMIUM	ND
CHROMIUM	ND
LEAD	ND
MERCURY	ND
SELENIUM	ND
SILVER	ND

Contaminant of Concern (COC)	Screening Criteria: Region III RBCs (Residential)	Screening Criteria: Federal MCLs
Metals (ug/L)		
Arsenic	0.045	10
Barium	7,300	2000
Cadmium	18	5
Chromium	n/a	100
Lead	n/a	15
Mercury	n/a	2
Selenium	180	50.0
Silver	180	n/a

Legend

- IRP Monitoring Wells
- Industrial Area
- Yorktown Boundary
- Approximate IR Site 12 Boundary
- SSA 15 Boundary
- Groundwater flow direction
- Estimated groundwater surface elevation contour - dashed where inferred (feet above mean sea level)

Notes:
*False positive due to high turbidity
ND - Not Detected
Boxes shaded blue exceed the Federal MCLs screening criteria
Boxes shaded yellow exceed the Region III RBCs screening criteria
Boxes shaded green exceed both the MCLs and RBCs screening criteria

N W E S

0 350 700 Feet

Figure 4-1
2007 Groundwater Sampling Results
Site 12 LTM Report
Naval Weapons Station, Yorktown
Yorktown, Virginia

CH2MHILL

\\aphrodite\proj\18gis\Yorktown\Figures\Site 12 LTM Report\Figure4-2_Sediment_Results.mxd 3/20/08 mrissing

Freshwater Stream Range of Background:
Arsenic - 0.27L - 5.4L mg/kg
Selenium - 0.86L - 0.86L mg/kg
* background data collected August 1994 from 0-4 and 4-8" bgs

AOC 23 - Barracks Road Industrial Area

constructed wetland/ settling pond

intermittent drainage channel

Area B/C

Area A

Wood/Debris Disposal Area

SSA 15

Ballard Creek

12SDCWL	
SAMPLE ID	YS12-SDCWL-1207
SAMPLE DATE	12/18/07
METALS (mg/kg)	
ARSENIC	1.1 J
BARIUM	15.7 J
CADMIUM	ND
CHROMIUM	7.4
LEAD	6.2
MERCURY	ND
SELENIUM	ND
SILVER	ND

12SD40	
SAMPLE ID	YS12-SD40-1207
SAMPLE DATE	12/18/07
METALS (mg/kg)	
ARSENIC	6.4 J
BARIUM	52.9 J
CADMIUM	ND
CHROMIUM	26.2
LEAD	31.5
MERCURY	0.14
SELENIUM	ND
SILVER	ND

12SD32	
SAMPLE ID	YS12-SD32-1207
SAMPLE DATE	12/18/07
METALS (mg/kg)	
ARSENIC	1.3 J
BARIUM	6.5 J
CADMIUM	ND
CHROMIUM	5.3
LEAD	6.3
MERCURY	ND
SELENIUM	ND
SILVER	ND

12SD34	
SAMPLE ID	YS12-SD34-1207
SAMPLE DATE	12/18/07
METALS (mg/kg)	
ARSENIC	0.96 J
BARIUM	7.6 J
CADMIUM	ND
CHROMIUM	3.4
LEAD	4.4
MERCURY	ND
SELENIUM	ND
SILVER	ND

12SD37		
SAMPLE ID	YS12-SD37-1207	YS12-SD37P-1207
SAMPLE DATE	12/18/07	12/18/07
METALS (mg/kg)		
ARSENIC	11.8	6.8 J
BARIUM	69.1 J	49.7 J
CADMIUM	ND	ND
CHROMIUM	13.9	11.5
LEAD	21.8	17.5
MERCURY	MD	ND
SELENIUM	3.6 J	ND
SILVER	ND	ND

Contaminant of Concern (COC)	Screening Criteria: Region III RBCs (Residential)*	Screening Criteria: Region III BTAGs (Freshwater)
Metals (mg/kg)		
Arsenic	4.3	9.8
Barium	160,000	500
Cadmium[1]	390	0.99
Chromium[2]	2300	43.4
Lead	n/a	35.8
Mercury[3]	230	0.18
Selenium	3900	2.0
Silver	3900	4.5

Legend
- Sediment Sample Location
- Industrial Area
- Yorktown Boundary
- Approximate IR Site 12 Boundary
- SSA 15 Boundary

Notes:
ND - Not Detected
Boxes shaded pink exceed the Region III RBC (Residential) screening criteria
Boxes shaded yellow exceed the Region III BTAGs (Freshwater) screening criteria
Boxes shaded dark orange exceed both the RBCs and BTAGs screening criteria
* The residential RBC is multiplied by 10 to reflect human health exposure to sediment
[1] The screening value for cadmium is based on the more conservative criteria for food
[2] No speciation analysis of chromium has been completed at the site. The screening value used is for the more conservative chromium VI
[3] The screening value for mercury is based on the residential RBC value of mercuric chloride

N W E S

0 350 700 Feet

Figure 4-2
2007 Sediment Sampling Results
Site 12 LTM Report
Naval Weapons Station, Yorktown
Yorktown, Virginia

CH2MHILL

386516LM

INTERMITTANT DRAINAGE WAY

12SD35

SAMPLE ID		12SD39-01
SAMPLE DATE		8/21/98
	SOW RESULTS	HIGH RES. RESULTS
Total PAHs	ND	627.7 (ug/kg)
Total cPAHs	ND	400.3 (ug/kg)

SAMPLE ID		12SD36-01
SAMPLE DATE		8/20/98
	SOW RESULTS	HIGH RES. RESULTS
Total PAHs	ND	1306.2 (ug/kg)
Total cPAHs	ND	1291.8 (ug/kg)

SEWAGE DISPOSAL PLANT No. 2 (A.I.P.)

12SD39

12SD38

12SD36

BALLARD CREEK

BEAVER POND

12SD37

CONSTRUCTED WETLAND/SEDIMENT POND

TRI-LOCK® DRAINAGE AREA

INTERMITTANT DRAINAGE WAY

12SD34

12SD32

12SD25

12SD33

12SD28

12SD26

12SD27

SAMPLE ID		12SD38-01
SAMPLE DATE		8/21/98
	SOW RESULTS	HIGH RES. RESULTS
Total PAHs	ND	559 (ug/kg)
Total cPAHs	ND	333 (ug/kg)

12SD30 BALLARD CREEK

12SD31

12SD29

BALLARD CREEK

COLONIAL NATIONAL HISTORICAL PARK

SAMPLE ID		12SD31-01
SAMPLE DATE		8/21/98
	SOW RESULTS	HIGH RES. RESULTS
Total PAHs	ND	52.5J (ug/kg)
Total cPAHs	ND	40.1J (ug/kg)

BARRACKS ROAD

BALLARD ROAD

MAIN ROAD

FULLINWIDER LANE

VA. STATE ROUTE 238

400 0 200 400

1 inch = 400 ft.

Baker

Baker Environmental, Inc.

LEGEND

- DRAINAGE
- EDGE OF PAVEMENT
- FENCE
- EXTENT OF SITE 12 COVER
- STRUCTURE
- APPROXIMATE LIMITS OF THE STUDY AREA
- 12SD25 SEDIMENT SAMPLE LOCATION

NOTES:
SOW – USEPA CONTRACT LABORATORY STATEMENT OF WORK METHOD.
HIGH RES. – SELECTIVE ION MONITORING METHOD

SOURCE OF BASE MAPPING: NAVAL WEAPONS STATION YORKTOWN, 1995.

FIGURE 4-4
POSITIVE DETECTIONS OF PAHs IN SEDIMENT
SITE 12 LONG-TERM MONITORING

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Appendix C
Field SOPs

STANDARD OPERATING PROCEDURE 001

Equipment Blank and Field Blank Preparation

I. Purpose

To prepare blanks to determine whether decontamination procedures are adequate and whether any cross-contamination is occurring during sampling due to contaminated air and dust.

II. Scope

The general protocols for preparing the blanks are outlined. The actual equipment to be rinsed will depend on the requirements of the specific sampling procedure.

III. Equipment and Materials

- Blank liquid (use ASTM Type II or lab grade water)
- Millipore™ deionized water
- Sample bottles as appropriate
- Gloves
- Preservatives as appropriate

IV. Procedures and Guidelines

A. Decontaminate all sampling equipment that has come in contact with sample according to SOP *Decontamination of Personnel and Equipment.*

B. To collect an equipment blank for volatile analysis from the surfaces of sampling equipment other than pumps, pour blank water over one piece of equipment and into two 40-ml vials until there is a positive meniscus, then seal the vials. Note the sample number and associated piece of equipment in the field notebook as well as the type and lot number of the water used.

For non-volatiles analyses, one aliquot is to be used for equipment. For example, if a pan and trowel are used, place trowel in pan and pour blank fluid in pan such that pan and trowel surfaces which contacted the sample are contacted by the blank fluid. Pour blank fluid from pan into appropriate sample bottles.

Do not let the blank fluid come in contact with any equipment that has not been decontaminated.

C. When collecting an equipment blank from a pump, run an extra gallon of deionized water through the pump while collecting the pump outflow into appropriate containers. Make sure the flow rate is low when sampling VOCs. If a Grundfos Redi-Flo2 pump with disposable tubing is used, remove the disposable tubing after sampling but before decon. When decon is complete, put a 3- to 5-foot segment of new tubing onto the pump to collect the equipment blank.

D. To collect a field blank, slowly pour ASTM Type II or lab grade water directly into sample containers.

E. Document and ship samples in accordance with the procedures for other samples.

F. Collect next field sample.

V. Attachments

None.

VI. Key Checks and Items

- Wear gloves.
- Do not use any non-decontaminated equipment to prepare blank.
- Use ASTM-Type II or lab grade water.

STANDARD OPERATING PROCEDURE 002

Chain-of-Custody

I Purpose

The purpose of this SOP is to provide information on chain-of-custody procedures to be used under the CLEAN Program.

II Scope

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities (except wellhead samples taken for measurement of field parameters). Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. This procedure identifies the necessary custody records and describes their completion. This procedure does not take precedence over region specific or site-specific requirements for chain-of-custody.

III Definitions

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. One copy of the form must be retained in the project file.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under one's custody if:

- It is in one's actual possession.
- It is in one's view, after being in one's physical possession.
- It was in one's physical possession and then he/she locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

IV. Procedures

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is valid. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom, as well as providing security for the evidence as it is moved and/or passed from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain-of-possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

Sample Identification

The method of identification of a sample depends on the type of measurement or analysis performed. When *in situ* measurements are made, the data are recorded directly in bound logbooks or other field data records with identifying information.

Information which shall be recorded in the field logbook, when in-situ measurements or samples for laboratory analysis are collected, includes:

- Field Sampler(s),
- Contract Task Order (CTO) Number,
- Project Sample Number,
- Sample location or sampling station number,
- Date and time of sample collection and/or measurement,
- Field observations,
- Equipment used to collect samples and measurements, and
- Calibration data for equipment used

Measurements and observations shall be recorded using waterproof ink.

Sample Label

Samples, other than for *in situ* measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling and Analysis Plan. Each sample container is identified by a sample label (see Attachment A). Sample labels are provided, along with sample containers, by the analytical laboratory. The information recorded on the sample label includes:

- Project - CTO Number.
- Station Location - The unique sample number identifying this sample.
- Date - A six-digit number indicating the day, month, and year of sample collection (e.g., 08/21/12).

- Time - A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- Medium - Water, soil, sediment, sludge, waste, etc.
- Sample Type - Grab or composite.
- Preservation - Type and quantity of preservation added.
- Analysis - VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- Sampled By - Printed name of the sampler.
- Remarks - Any pertinent additional information.

Using only the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing the analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site). The field team should always follow the sample ID system prepared by the project EIS and reviewed by the Project Manager.

Chain-of-Custody Procedures

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed.

Field Custody Procedures

- Samples are collected as described in the site Sampling and Analysis Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the Chain-of-Custody Record exactly.

- A Chain-of-Custody Record will be prepared for each individual cooler shipped and will include ***only*** the samples contained within that particular cooler. The Chain-of-Custody Record for that cooler will then be sealed in a zip-log bag and placed in the cooler prior to sealing. This ensures that the laboratory properly attributes trip blanks with the correct cooler and allows for easier tracking should a cooler become lost during transit.

- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once downloaded to the server or developed, the electronic files or photographic prints shall be serially numbered, corresponding to the logbook descriptions; photographic prints will be stored in the project files. To identify sample

locations in photographs, an easily read sign with the appropriate sample location number should be included.

- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions (e.g., a logbook notation would explain that a pencil was used to fill out the sample label if the pen would not function in freezing weather.)

Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. **A Chain-of-Custody Record Form must be completed for each cooler and should include only the samples contained within that cooler**. A Chain-of-Custody Record Form example is shown in Attachment B. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as given below:

- Enter header information (CTO number, samplers, and project name).

- Enter sample specific information (sample number, media, sample analysis required and analytical method grab or composite, number and type of sample containers, and date/time sample was collected).

- Sign, date, and enter the time under "Relinquished by" entry.

- Have the person receiving the sample sign the "Received by" entry. If shipping samples by a common carrier, print the carrier to be used in this space (i.e., Federal Express).

- If a carrier is used, enter the airbill number under "Remarks," in the bottom right corner;

- Place the original (top, signed copy) of the Chain-of-Custody Record Form in a plastic zipper-type bag or other appropriate sample-shipping package. Retain the copy with field records.

- Sign and date the custody seal, a 1-inch by 3-inch white paper label with black lettering and an adhesive backing. Attachment C is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals shall be provided by the analytical laboratory.

- Place the seal across the shipping container opening (front and back) so that it would be broken if the container were to be opened.

- Complete other carrier-required shipping papers.

The custody record is completed using waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the shipping container (enclosed with other documentation in a plastic zipper-type bag). As long as custody forms are sealed inside the shipping container and the custody seals are intact, commercial carriers are not required to sign the custody form.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

V Quality Assurance Records

Once samples have been packaged and shipped, the Chain-of-Custody copy and airbill receipt become part of the quality assurance record.

VI Attachments

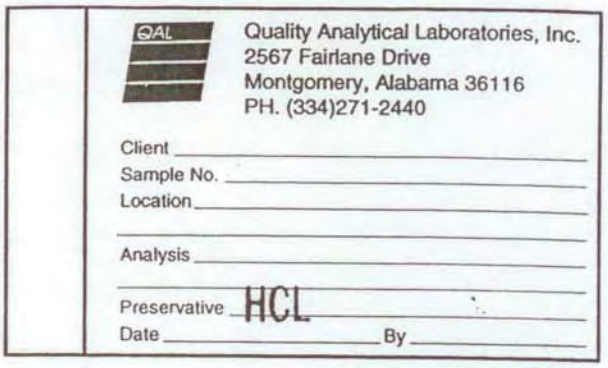
A. Sample Label
B. Chain of Custody Form
C. Custody Seal

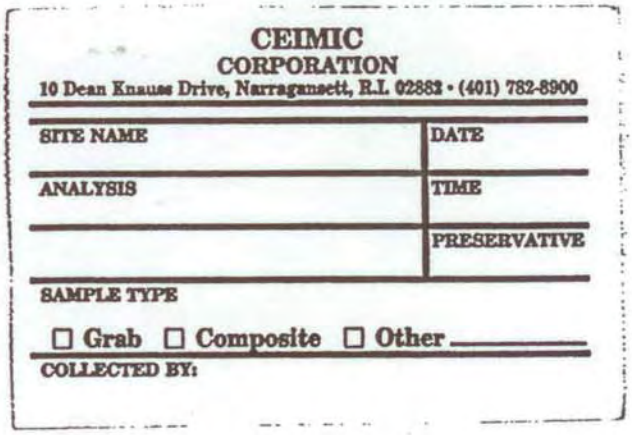
VII References

USEPA. *User's Guide to the Contract Laboratory Program*. Office of Emergency and Remedial Response, Washington, D.C. (EPA/540/P-91/002), January 1991.

Attachment A

Example Sample Label


QAL
Quality Analytical Laboratories, Inc.
2567 Fairlane Drive
Montgomery, Alabama 36116
PH. (334)271-2440
Client
Sample No.
Location
Analysis
Preservative HCL
Date
By


CEIMIC
CORPORATION
10 Dean Knauss Drive, Narragansett, R.I. 02882 • (401) 782-8900
SITE NAME
DATE
ANALYSIS
TIME
PRESERVATIVE
SAMPLE TYPE
☐ Grab ☐ Composite ☐ Other
COLLECTED BY:

Attachment B

Example Chain-of-Custody Record

CH2M HILL

APPLIED SCIENCES LABORATORY

CHAIN OF CUSTODY RECORD AND AGREEMENT TO PERFORM SERVICES

CH2M Hill Project # ☐☐☐☐☐☐☐☐.☐☐.☐☐

Purchase Order #

Project Name

Company Name CH2M HILL Office

Project Manager & Phone #
Mr. [ ]
Ms. [ ]
Dr. [ ]

Report Copy to:

Requested Completion Date:

Sampling Requirements: SDWA ☐ NPDES ☐ RCRA ☐ OTHER ____

Sample Disposal: Dispose ☐ Return ☐

Sampling Date	Sampling Time	Type COMP	Type GRAB	Matrix WATER	Matrix SOIL	Matrix AIR	CLIENT SAMPLE ID (9 CHARACTERS)	# OF CONTAINERS

LAB TEST CODES

ANALYSES REQUESTED

SHADED AREA– FOR LAB USE ONLY

Lab 1 #

Lab 2 #

Quote #

Kit Request #

Project #

No. of Samples

Page of

Login

LIMS Ver

REMARKS	LAB 1 ID	LAB 2 ID

Sampled By & Title (Please sign and print name) — Date/Time

Received By (Please sign and print name) — Date/Time

Received By (Please sign and print name) — Date/Time

Received By (Please sign and print name) — Date/Time

Work Authorized By (Please sign and print name)

Relinquished By (Please sign and print name) — Date/Time

Relinquished By (Please sign and print name) — Date/Time

Relinquished By (Please sign and print name) — Date/Time

Shipped Via UPS BUS Fed-Ex Hand Other ____

Shipping #

Remarks

QC Level: 1 2 3 Other: ____

COC Rec	ICE
Ana Req	TEMP
Cust Seal	Ph

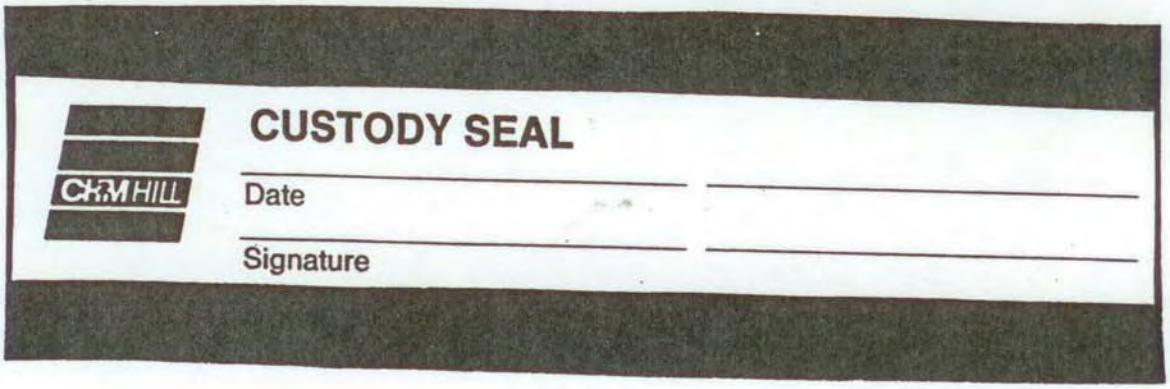
Instructions and Agreement Provisions on Reverse Side

DISTRIBUTION: Original - LAB, Yellow - LAB, Pink - Client

REV 3/94 FORM 340

Attachment C

Example Custody Seal


CH2M HILL
CUSTODY SEAL
Date
Signature

STANDARD OPERATING PROCEDURE 003

Preparing Field Log Books

I. Purpose

This SOP provides general guidelines for entering field data into log books during site investigation and remediation activities.

II. Scope

This is a general description of data requirements and format for field log books. Log books are needed to properly document all field activities in support of data evaluation and possible legal activities.

III. Equipment and Materials

- Log book
- Indelible pen

IV. Procedures and Guidelines

Properly completed field log books are a requirement for much of the work we perform under the Navy CLEAN contract. Log books are legal documents and, as such, must be prepared following specific procedures and must contain required information to ensure their integrity and legitimacy. This SOP describes the basic requirements for field log book entries.

A. PROCEDURES FOR COMPLETING FIELD LOG BOOKS

1. Field notes commonly are kept in bound, hard-cover logbooks used by surveyors and produced, for example, by Peninsular Publishing Company and Sesco, Inc. Pages should be water-resistant and notes should be taken only with water-proof, non-erasable permanent ink, such as that provided in Sanford Sharpie® permanent markers.
2. On the inside cover of the log book the following information should be included:
    - Company name and address
    - Log-holders name if log book was assigned specifically to that person
    - Activity or location

- Project name
- Project manager's name
- Phone numbers of the company, supervisors, emergency response, etc.

3. All lines of all pages should be used to prevent later additions of text, which could later be questioned. Any line not used should be marked through with a line and initialed and dated. Any pages not used should be marked through with a line, the author's initials, the date, and the note "Intentionally Left Blank."

4. If errors are made in the log book, cross a single line through the error and enter the correct information. All corrections shall be initialed and dated by the personnel performing the correction. If possible, all corrections should be made by the individual who made the error.

5. Daily entries will be made chronologically.

6. Information will be recorded directly in the field log book during the work activity. Information will not be written on a separate sheet and then later transcribed into the log book.

7. Each page of the log book will have the date of the work and the note takers initials.

8. The final page of each day's notes will include the note-takers signature as well as the date.

9. Only information relevant to the subject project will be added to the log book.

10. The field notes will be copied and the copies sent to the Project Manager or designee in a timely manner (at least by the end of each week of work being performed).

B. INFORMATION TO BE INCLUDED IN FIELD LOG BOOKS

1. Entries into the log book should be as detailed and descriptive as possible so that a particular situation can be recalled without reliance on the collector's memory. Entries must be legible and complete.

2. General project information will be recorded at the beginning of each field project. This will include the project title, the project number, and project staff.

3. Scope: Describe the general scope of work to be performed each day.

4. Weather: Record the weather conditions and any significant changes in the weather during the day.

5. Tail Gate Safety Meetings: Record time and location of meeting, who was present, topics discussed, issues/problems/concerns identified,

and corrective actions or adjustments made to address concerns/ problems, and other pertinent information.

6. Standard Health and Safety Procedures: Record level of personal protection being used (e.g., level D PPE), record air monitoring data on a regular basis and note where data were recording (e.g., reading in borehole, reading in breathing zone, etc). Also record other required health and safety procedures as specified in the project specific health and safety plan.

7. Instrument Calibration; Record calibration information for each piece of health and safety and field equipment.

8. Personnel: Record names of all personnel present during field activities and list their roles and their affiliation. Record when personnel and visitors enter and leave a project site and their level of personal protection.

9. Communications: Record communications with project manager, subcontractors, regulators, facility personnel, and others that impact performance of the project.

10. Time: Keep a running time log explaining field activities as they occur chronologically throughout the day.

11. Deviations from the Work Plan: Record any deviations from the work plan and document why these were required and any communications authorizing these deviations.

12. Heath and Safety Incidents: Record any health and safety incidents and immediately report any incidents to the Project Manager.

13. Subcontractor Information: Record name of company, record names and roles of subcontractor personnel, list type of equipment being used and general scope of work. List times of starting and stopping work and quantities of consumable equipment used if it is to be billed to the project.

14. Problems and Corrective Actions: Clearly describe any problems encountered during the field work and the corrective actions taken to address these problems.

15. Technical and Project Information: Describe the details of the work being performed. The technical information recorded will vary significantly between projects. The project work plan will describe the specific activities to be performed and may also list requirements for note taking. Discuss note-taking expectations with the Project Manager prior to beginning the field work.

16. Any conditions that might adversely affect the work or any data obtained (e.g., nearby construction that might have introduced excessive amounts of dust into the air).

17. Sampling Information; Specific information that will be relevant to most sampling jobs includes the following:

- Description of the general sampling area – site name, buildings and streets in the area, etc.
- Station/Location identifier
- Description of the sample location – estimate location in comparison to two fixed points – draw a diagram in the field log book indicating sample location relative to these fixed points – include distances in feet.
- Sample matrix and type
- Sample date and time
- Sample identifier
- Draw a box around the sample ID so that it stands out in the field notes
- Information on how the sample was collected – distinguish between "grab," "composite," and "discrete" samples
- Number and type of sample containers collected
- Record of any field measurements taken (i.e. pH, turbidity, dissolved oxygen, and temperature, and conductivity)
- Parameters to be analyzed for, if appropriate
- Descriptions of soil samples and drilling cuttings can be entered in depth sequence, along with PID readings and other observations. Include any unusual appearances of the samples.

C. SUGGESTED FORMAT FOR RECORDING FIELD DATA

1. Use the left side border to record times and the remainder of the page to record information (see attached example).

2. Use tables to record sampling information and field data from multiple samples.

3. Sketch sampling locations and other pertinent information.

4. Sketch well construction diagrams.

V. Attachments

Example field notes.

(47) MAY 12, 2003 EXAMPLE

0715 ARRIVE ON SITE AT XYZ SITE.
CH2M HILL STAFF:
John Smith: FIELD TEAM LEADER
Bob Builder: SITE SAFETY COORD.
WEATHER: OVERCAST + COOL, 45°F
CHANCE OF LATE SHOWERS
SCOPE: • COLLECT GROUNDWATER SAMPLES FOR LTM WORK AT SITE 14
• SUPERVISE SURVEY CREW AT SITE 17
0725 BB ~~Cal~~ ~~JS~~ (JS) Calibrates PID: 101 ppm/100 ppm ok
PID Model #, SERIAL #
0730 BB Calibrates HORIBA METER
Model #, SERIAL #
→ List calibration RESULTS
0738 Survey CREW ARRIVES ON SITE
→ List NAMES
0745 BB Holds H+S TALK ON Slips, Trips, Falls, Ticks + AIR Monitoring
JS + Survey CREW ATTEND
No H+S ISSUES IDENTIFIED as CONCERNS. All work is in "Level D."
0755 JS conducts SITE-WIDE AIR Monitoring
All readings = 0.0 ppm in

JS 5-12-03

MAY 12, 2003 EXAMPLE (48)

SITE 14 LTM
BREATHING ZONE (BZ)
0805 Mobilize to well MW-22 to SAMPLE, surveyors SETTING UP AT SITE 17
0815 PM (PAUL PAPER PUSHER) CALLS AND INFORMS JS to collect GW SAMPLE AT well MW-44 today for 24 hour TAT ANALYSIS OF VOCs
0820 Purging MW-22
→ RECORD WATER QUALITY DATA

JS 5-12-03

0843 Collect SAMPLE AT MW-22 for total TAL Metals AND VOC's. NO Dissolved Metals Needed PER PM
0905 JS + BB Mobilize to SITE 17 to show surveyors wells to Survey.
0942 Mobilize to well MW-22 to Collect SAMPLE
0950 CAN not ACCESS well MW-22 due to BASE OPERATIONS; CONTACT PAUL PAPERPUSHER AND HE STATED HE will check on GAINING ACCESS with BASE contact.
0955 Mobilize to well MW-19

JS 5-12-03

STANDARD OPERATING PROCEDURE 004

Field Measurement of pH, Specific Conductance, Turbidity, Dissolved Oxygen, ORP, and Temperature Using a Horiba or YSI Water Quality Parameter Meter with Flow-through Cell

I. Purpose and Scope

The purpose of this procedure is to provide a general guideline for using a water quality parameter meter (e.g., Horiba® or YSI) for field measurements of pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature of aqueous samples. The YSI instrument does not measure turbidity. A separate turbidity meter (i.e., Hanna Turbidity Meter) will need to be used in conjunction with the YSI meter. The operator's manual should be consulted for detailed operating procedures.

II. Equipment and Materials

- Water Quality Parameter Meter such as a Horiba® Water Quality Monitoring System or YSI with flow-though cell
- Auto-Calibration Standard Solution (provided by rental company)
- Distilled water in squirt bottle

III. Procedures and Guidelines

A. Parameters and Specifications:

Parameter	Range of measurement	Accuracy
pH	0 to 14 pH units	+/- 0.1 pH units
Specific conductance	0 to 9.99 S/m	+/- 3 % full scale
Turbidity	0 to 800 NTU	+/- 5 % full scale
Dissolved oxygen	0 to 19.99 mg/l	+/- 0.2 mg/l
Temperature	0 to 55 ^{o}C	+/- 1.0 ^{o}C
ORP	-999 to +999 mV	+/- 15 mV
Salinity	0 to 4 %	+/- 0.3 %

B. Calibration:

Prior to each day's use, clean the probe and flow-through cell using deionized water and calibrate using the Standard Solution.

Horiba Calibration procedure:

1. Fill a calibration beaker with standard solution to the recommended fill line.
2. Insert the probe into the beaker. All the parameter sensors will now be immersed in the standard solution except the D.O. sensor; the D.O. calibration is done using atmospheric air.
3. Turn power on and allow some time for the machine to warm-up prior to starting the calibration. When the initial readings appear to stabilize the instrument is ready to calibrate.
4. Press CAL key to put the unit in the calibration mode.
5. Press the ENT key to start automatic calibration. Wait a moment, and the upper cursor will gradually move across the four auto-calibration parameters one by one: pH, COND, TURB, and DO. When the calibration is complete, the readout will briefly show END. The instrument is now calibrated.
6. If the unit is calibrated properly the instrument readings, while immersed in the standard solution, will match the standard solution values provided on the solution container. The typical standard solution values are: pH = 4.0 +/- 3%, conductivity 4.49 mS/cm +/- 3%, and turbidity = 0 NTU +/- 3%.
7. Record the calibration data (e.g. time, instrument ID, solution lot number and expiration date, final calibrated readings, and solution temperature in the field logbook.

YSI Calibration procedure:

1. Press the **On/off** key to display the run screen
2. Press the **Escape** key to display the main menu screen
3. Use the arrow keys to highlight the **Calibrate**
4. Press the **Enter** key. The Calibrate screen is displayed
5. Choose the parameter to calibrate

A. Conductivity Calibration:

This procedure calibrates specific conductance (recommended), conductivity and salinity. Calibrating any one option automatically calibrates the other two.

1) Use the arrow keys to highlight the **Conductivity** selection
2) Press **Enter.** The Conductivity Calibration Selection Screen is displayed.
3) Use the arrow keys to highlight the Specific Conductance selection.
4) Press **Enter.** The Conductivity Calibration Entry Screen is displayed.
5) Place the correct amount of conductivity standard (see Instrument Manual) into a clean, dry or pre-rinsed transport/calibration cup.
6) Carefully immerse the sensor end of the probe module into the solution.

7) Gently rotate and/or move the probe module up and down to remove any bubbles from the conductivity cell.

   NOTE: The sensor must be completely immersed past its vent hole. Using the recommended volumes from the Instrument Manual Calibration Volumes should ensure that the vent hole is covered.

8) Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

   NOTE: Do not over tighten as this could cause damage to the threaded portions.

9) Use the keypad to enter the calibration value of the standard you are using.

   NOTE: Be sure to enter the value in **mS/cm at 25°C**.

10) Press **Enter**. The Conductivity Calibration Screen is displayed.
11) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
12) Observe the reading under Specific Conductance. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
13) Press **Enter**. This returns you to the Conductivity Calibrate Selection Screen
14) Press **Escape** to return to the calibrate menu.
15) Rinse the probe module and sensors in tap or purified water and dry.

B. Dissolved Oxygen Calibration:

This procedure calibrates dissolved oxygen. Calibrating any one option (% or mg/L) automatically calibrates the other.

1) Go to the calibrate screen as described in Section

   NOTE: The instrument must be on for at least 20 minutes to polarize the DO sensor before calibrating.

2) Use the arrow keys to highlight the **Dissolved Oxygen** selection.
3) Press **Enter**. The dissolved oxygen calibration screen is displayed.
4) DO calibration in mg/L is carried out in a water sample which has a known concentration of dissolved oxygen (usually determined by a Winkler titration).
5) Use the arrow keys to highlight the **DO mg/L** selection.
6) Press **Enter**. The DO mg/L Entry Screen is displayed.
7) Place the probe module in water with a known DO concentration.

   NOTE: Be sure to completely immerse all the sensors.

8) Use the keypad to enter the known DO concentration of the water.
9) Press **Enter**. The Dissolved Oxygen mg/L Calibration Screen is displayed.
10) Stir the water with a stir bar, or by rapidly moving the probe module, to provide fresh sample to the DO sensor.
11) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
12) Observe the DO mg/L reading, when the reading is stable (shows no significant change for approximately 30 seconds), press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
13) Press **Enter**. This returns you to the DO calibration screen.
14) Press **Escape** to return to the calibrate menu.

15) Rinse the probe module and sensors in tap or purified water and dry.

C. pH Calibration:

1) Go to the calibrate screen.
2) Use the arrow keys to highlight the **pH** selection.
3) Press **Enter**. The pH calibration screen is displayed.
   - 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 one point calibration. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select only one pH buffer.
   - Select the **2-point** option to calibrate the pH sensor using only two calibration standards. Use this option if the media being monitored is known to be either basic or acidic. For example, if the pH of a pond is known to vary between 5.5 and 7, a two-point calibration with pH 7 and pH 4 buffers is sufficient. A three point calibration with an additional pH 10 buffer will not increase the accuracy of this measurement since the pH is not within this higher range.
   - Select the **3-point** option to calibrate the pH sensor using three calibration solutions. In this procedure, the pH sensor is calibrated with a pH 7 buffer and two additional buffers. The 3-point calibration method assures maximum accuracy when the pH of the media to be monitored cannot be anticipated. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select a third pH buffer.
4) Use the arrow keys to highlight the **2-point** selection.
5) Press **Enter**. The pH Entry Screen is displayed.
6) Place the correct amount of pH buffer into a clean, dry or pre-rinsed transport/calibration cup.

   NOTE: For maximum accuracy, the pH buffers you choose should be within the same pH range as the water you are preparing to sample.

   NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the pH sensor with a small amount of buffer that can be discarded. Be certain that you avoid cross-contamination of buffers with other solutions.
7) Carefully immerse the sensor end of the probe module into the solution.
8) Gently rotate and/or move the probe module up and down to remove any bubbles from the pH sensor.

   NOTE: The sensor must be completely immersed. Using the recommended volumes from Table 6.1 Calibration Volumes, should ensure that the sensor is covered.
9) Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

   NOTE: Do not over tighten as this could cause damage to the threaded portions.
10) Use the keypad to enter the calibration value of the buffer you are using **at the current temperature**.

    NOTE: pH vs. temperature values are printed on the labels of all YSI pH buffers.
11) Press **Enter**. The pH calibration screen is displayed.

12) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
13) Observe the reading under pH, when the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
14) Press **Enter**. This returns you to the Specified pH Calibration Screen.
15) Rinse the probe module, transport/calibration cup and sensors in tap or purified water and dry.
16) Repeat steps 6 through 13 above using a second pH buffer.
17) Press **Enter**. This returns you to the pH Calibration Screen.
18) Press **Escape** to return to the calibrate menu.
19) Rinse the probe module and sensors in tap or purified water and dry.

D. ORP Calibration:

1) Go to the calibrate screen.
2) Use the arrow keys to highlight the **ORP** selection.
3) Press **Enter**. The ORP calibration screen is displayed.
4) Place the correct amount of a known ORP solution into a clean, dry or pre-rinsed transport/calibration cup.

   NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the ORP sensor with a small amount of solution that can be discarded. Be certain that you avoid cross-contamination with other solutions.
5) Carefully immerse the sensor end of the probe module into the solution.
6) Gently rotate and/or move the probe module up and down to remove any bubbles from the ORP sensor.

   NOTE: The sensor must be completely immersed.
7) Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.
8) Use the keypad to enter the correct value of the calibration solution you are using at the current temperature.
9) Press **Enter**. The ORP calibration screen is displayed.
10) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
11) Observe the reading under ORP, when the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
12) Press **Enter**. This returns you to the Calibrate Screen.
13) Rinse the probe module and sensors in tap or purified water and dry.

Record the calibration data (e.g. time, instrument ID, solution lot number and expiration date, final calibrated readings, and solution temperature in the field logbook.

C. Sample Measurement:

Horiba measurement procedure:

As water passes through the flow-through the flow cell, press MEAS to obtain reading;

record data in a field notebook.

YSI measurement procedure:

As water passes through the flow-through the flow cell, the readings are displayed for each parameter. Record the water quality parameter data in a field notebook. In addition, the data is recorded in the YSI and can be downloaded to a computer following completion of the sampling event.

IV. Key Checks and Preventive Maintenance

- Calibrate meter
- Clean probe with deionized water when done
- Refer to operations manual for recommended maintenance and troubleshooting
- Check batteries, and have a replacement set on hand
- Due to the importance of obtaining these parameters, the field team should have a spare unit readily available in case of an equipment malfunction.

V. References

YSI 556 Multi Probe System Operator Manual

YSI **Environmental**

Pure Data for a Healthy Planet.™



YSI 556 MPS
Multi Probe System

Operations Manual

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1. Safety

1.1 General Safety Information

Read all safety information in this manual carefully before using the YSI 556 Multi-Probe System (MPS). Reagents that are used to calibrate and check this instrument may be hazardous to your health. Take a moment to review *Appendix D Health and Safety*.

⚠ WARNING

Warnings are used in this manual when misuse of the instrument could result in death or serious injury to a person.

⚠ CAUTION

Cautions are used in this manual when misuse of the instrument could result in mild or serious injury to a person and/or damage to equipment.

⚠ IMPORTANT SAFETY INSTRUCTIONS!

⚠ SAVE THESE INSTRUCTIONS!

⚠ In essence, the most important safety rule for use of the YSI 556 MPS is to utilize the instrument ONLY for purposes documented in this manual. This is particularly true of the YSI 6117 rechargeable battery pack that contains nickel metal hydride (NiMH) batteries. The user should be certain to read all of the safety precautions outlined below before using the instrument.

⚠ YSI 6117 Rechargeable Battery Pack Safety Information

⚠ Restrictions on Usage

1. Never dispose of the battery pack in a fire.
2. Do not attempt to disassemble the YSI 6117 battery pack.
3. Do not tamper with any of the electronic components or the batteries within the battery pack. Tampering with either the electronic circuitry or the batteries will result in the voiding of the warranty and the compromising of the system performance, but, more importantly, can cause safety

hazards which result from overcharging such as overheating, venting of gas, and loss of corrosive electrolyte.

4. Do not charge the battery pack outside the 0–40°C temperature range.
5. Do not use or store the battery at high temperature, such as in strong direct sunlight, in cars during hot weather, or directly in front of heaters.
6. Do not expose the battery pack to water or allow the terminals to become damp.
7. Avoid striking or dropping the battery pack. If the pack appears to have sustained damage from these actions or malfunctions after an impact or drop, the user should not attempt to repair the unit. Instead, contact YSI Customer Service. Refer to *Appendix E Customer Service*.
8. If the battery pack is removed from the YSI 556 MPS, do not store it in pockets or packaging where metallic objects such as keys can short between the positive and negative terminals.

⚠ Precautions for Users with Small Children

Keep the battery pack out of reach of babies and small children.

⚠ Danger Notifications – Misuse creates a STRONG possibility of death or serious injury.

FAILURE TO CAREFULLY OBSERVE THE FOLLOWING PROCEDURES AND PRECAUTIONS CAN RESULT IN LEAKAGE OF BATTERY FLUID, HEAT GENERATION, BURSTING, AND SERIOUS PERSONAL INJURY.

1. Never dispose of the battery pack in a fire or heat it.
2. Never allow the positive and negative terminals of the battery pack to become shorted or connected with electrically conductive materials. When the battery pack has been removed from the YSI 556 MPS, store it in a heavy plastic bag to prevent accidental shorting of the terminals.

3. Never disassemble the battery pack and do not tamper with any of the electronic components or the batteries within the battery pack. The battery pack is equipped with a variety of safety features. Accidental deactivation of any of these safety features can cause a serious hazard to the user.
4. The NiMH batteries in the battery pack contain a strong alkaline solution (electrolyte). The alkaline solution is extremely corrosive and will cause damage to skin or other tissues. If any fluid from the battery pack comes in contact with a user's eyes, immediately flush with clean water and consult a physician immediately. The alkaline solution can damage eyes and lead to permanent loss of eyesight.

⚠ Warning Notifications – Misuse creates a possibility of death or serious injury

1. Do not allow the battery pack to contact freshwater, seawater, or other oxidizing reagents that might cause rust and result in heat generation. If a battery becomes rusted, the gas release vent may no longer operate and this failure can result in bursting.
2. If electrolyte from the battery pack contacts the skin or clothing, thoroughly wash the area immediately with clean water. The battery fluid can irritate the skin.

⚠ Caution Notifications – Misuse creates a possibility of mild or serious injury or damage to the equipment.

1. Do not strike or drop the battery pack. If any impact damage to the battery pack is suspected, contact YSI Customer Service. Refer to *Appendix E Customer Service*.
2. Store the battery pack out of reach of babies and small children.
3. Store the battery pack between the temperatures of -20 and 30°C.
4. Before using the battery pack, be sure to read the operation manual and all precautions carefully. Then store this information carefully to use as a reference when the need arises.

⚠ YSI 616 Cigarette Lighter Charger Safety Information

1. This section contains important safety and operating instructions for the YSI 556 MPS cigarette lighter battery charger (YSI 616; RadioShack Number 270-1533E). BE SURE TO SAVE THESE INSTRUCTIONS.
2. Before using the YSI 616 cigarette lighter charger, read all instructions and cautionary markings on battery charger, battery pack, and YSI 556 MPS.
3. Charge the YSI 6117 battery pack with the YSI 616 cigarette lighter charger ONLY when the YSI 6117 is installed in the YSI 556 MPS.
4. Do not expose charger to rain, moisture, or snow.
5. Use of an attachment not recommended or sold by the battery charger manufacturer may result in a risk of fire, electric shock, or injury to persons.
6. To reduce risk of damage to cigarette lighter and cord, pull by cigarette lighter rather than cord when disconnecting charger.
7. Make sure that the cord is located so that it will not be stepped on, tripped over, or otherwise subjected to damage or stress.
8. Do not operate charger with damaged cord or cigarette lighter connector – replace it immediately.
9. Do not operate charger if it has received a sharp blow, been dropped, or otherwise damaged in any way; contact YSI Customer Service. Refer to *Appendix E Customer Service*.
10. Do not disassemble charger other than to change the fuse as instructed. Replace the part or send it to YSI Product Service if repair is required (refer to *Appendix E Customer Service*). Incorrect reassembly may result in a risk of electric shock or fire.
11. To reduce risk of electric shock, unplug charger before attempting any maintenance or cleaning. Turning off controls will not reduce this risk.

⚠ YSI 556 MPS Water Leakage Safety Information

The YSI 556 MPS has been tested and shown to comply with IP67 criterion, i.e. submersion in 1 meter of water for 30 minutes with no leakage into either the battery compartment or the main case. However, if the instrument is submersed for periods of time in excess of 30 minutes, leakage may occur with subsequent damage to the batteries, the rechargeable battery pack circuitry, and/or the electronics in the main case.

If leakage into the battery compartment is observed when using alkaline C cells, remove batteries, dispose of batteries properly, and dry the battery compartment completely, ideally using compressed air. If corrosion is present on the battery terminals, contact YSI Customer Service for instructions. Refer to *Appendix E Customer Service*.

If leakage into the battery compartment is observed when using the YSI 6117 rechargeable battery pack, remove the battery assembly and set aside to dry. Return the battery pack to YSI Product Service for evaluation of possible damage. Finally dry the battery compartment completely, ideally using compressed air. If corrosion is present on the battery terminals, contact YSI Customer Service for instructions. Refer to *Appendix E Customer Service*.

⚠ **CAUTION:** If water has contacted the rechargeable battery pack, do not attempt to reuse it until it has been evaluated by YSI Product Service (refer to *Appendix E Customer Service*). Failure to follow this precaution can result in serious injury to the user.

If it is suspected that leakage into the main cavity of the case has occurred, remove the batteries immediately and return the instrument to YSI Product Service for damage assessment. Refer to *Appendix E Customer Service*.

⚠ **CAUTION:** Under no circumstances should the user attempt to open the main case.

2. General Information

2.1 Description

The rugged and reliable YSI 556 MPS (Multi-Probe System) combines the versatility of an easy-to-use, easy-to-read handheld unit with all the functionality of a multi-parameter system. Featuring a waterproof, impact-resistant case, the YSI 556 MPS simultaneously measures dissolved oxygen, conductivity, temperature, and optional pH and ORP. A simple cellular phone style keypad and large display make the instrument easy to use. The YSI 556 MPS is compatible with YSI EcoWatch™ for Windows™ software.

The YSI 556 MPS assists the user in conforming to Good Laboratory Practice (GLP) standards which help ensure that quality control/quality assurance methods are followed. Battery life is displayed with a fuel gauge, and the user can choose standard alkaline batteries or an optional rechargeable battery pack.

The 1.5 MB memory can store more than 49,000 data sets. Other options include a flow cell and barometer. The internal barometer can be user-calibrated and displayed along with other data, used in dissolved oxygen calibrations, and logged to memory for tracking changes in barometric pressure.

Features

- Waterproof - meets IP67 specifications
- Field-replaceable DO electrode module; pH and pH/ORP sensors
- Compatible with Ecowatch™ for Windows™ data analysis software
- Assists with Good Laboratory Practice Standards (GLP)
- Choice of DO membrane material for different applications
- Easy-to-use, screw-on cap DO membranes
- User-upgradable software from YSI website
- Three-year warranty on the instrument; one-year on the probe modules
- Available with 4,10, and 20 m cable lengths
- Stores over 49,000 data sets, time and date stamped

- Auto temperature compensating display contrast
- Optional barometer
- Optional rechargeable battery pack or standard alkaline batteries

2.2 Unpacking the Instrument

1. Remove the instrument from the shipping box. Note that the probe module and sensors are shipped in a separate box and will be unpacked later in Section *3.2 Unpacking the Probe Module*.

   NOTE: Do not discard any parts or supplies.

2. Use the packing list to ensure all items are present.

3. Visually inspect all components for damage.

   NOTE: If any parts are missing or damaged, contact your YSI Service Center immediately. Refer to *Appendix E Customer Service* or www.ysi.com.

2.3 Features of the YSI 556 Multi-Probe System

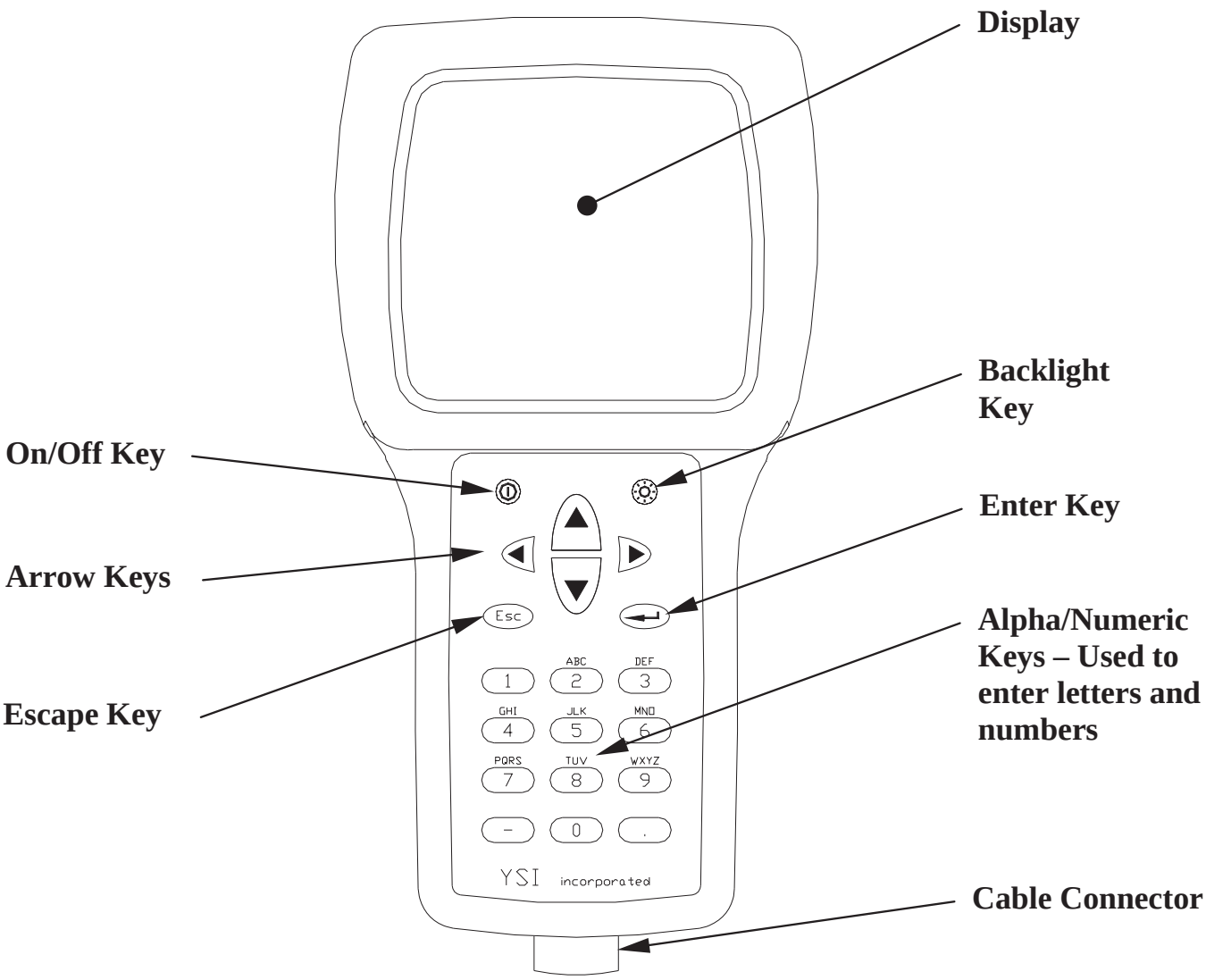


Figure 2.1 Front View of YSI 556 MPS

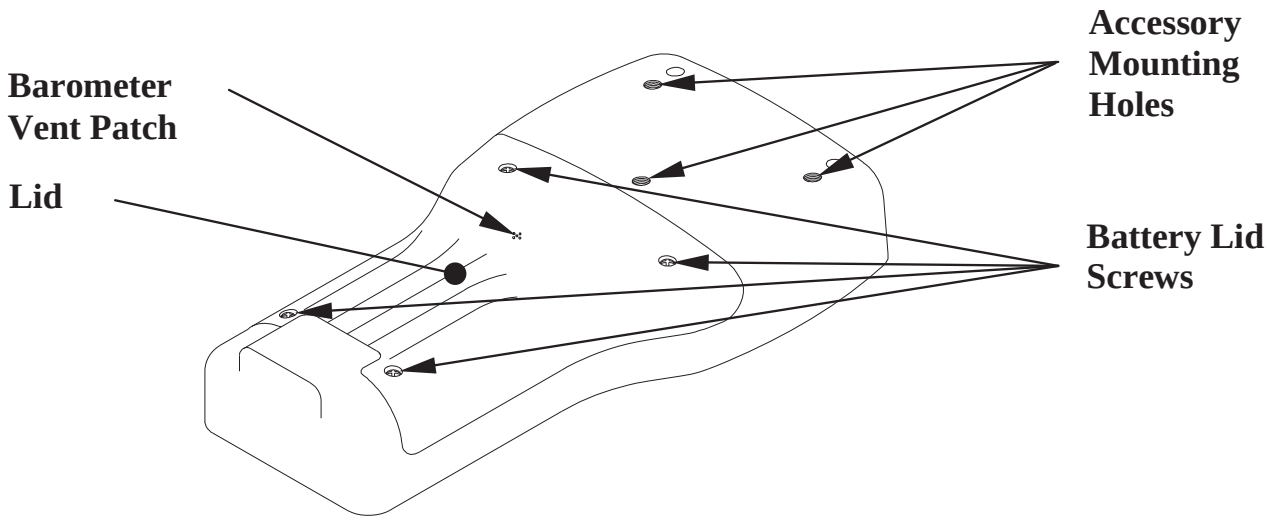


Figure 2.2 Back View of YSI 556 MPS

2.4 Batteries

2.4.1 Battery Life

Standard Alkaline Batteries

With the standard battery configuration of 4 alkaline C cells, the YSI 556 MPS will operate continuously for approximately 180 hours. Assuming a standard usage pattern when sampling of 3 hours of “on time” in a typical day, the alkaline cells will last approximately 60 days.

Optional Rechargeable Battery Pack

When fully charged, the optional rechargeable battery pack will provide approximately 50 hours of battery life.

2.4.2 Inserting 4 C Batteries

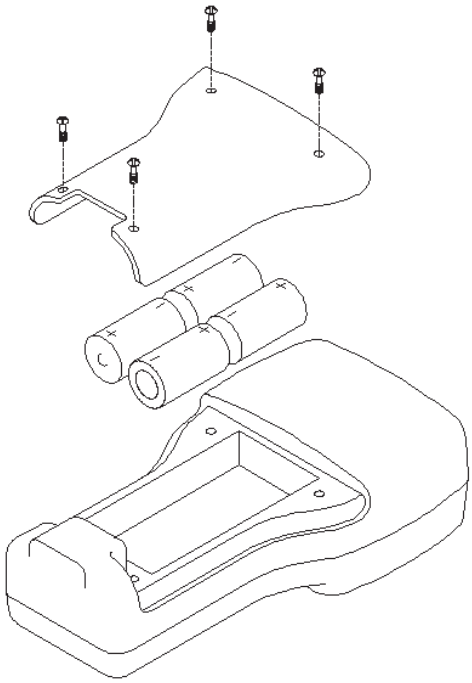


Figure 2.3 Inserting C Cells

⚠ **CAUTION: Install batteries properly to avoid damage to the instrument.**

1. Loosen the four screws in the battery lid on the back of the instrument using any screwdriver.

2. Remove the battery lid.

3. Insert four C batteries between the clips following the polarity (+ and -) labels on the bottom of the battery compartment.

4. Check gasket for proper placement on the battery lid.

5. Replace the battery lid and tighten the 4 screws securely and evenly.

   NOTE: Do not over-tighten the screws.

2.4.3 Inserting Optional Rechargeable Battery Pack

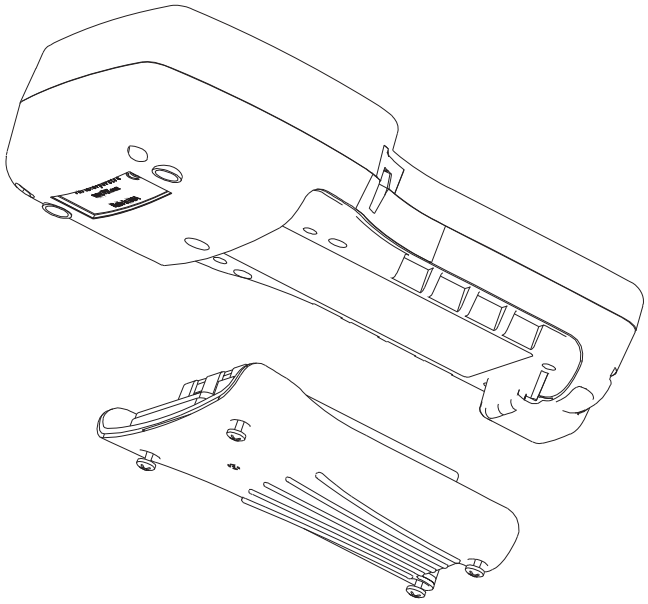


Figure 2.4 Inserting Battery Pack

⚠ **CAUTION: Read all cautions and warnings that come with the battery pack *before* using the battery pack.**

1. Loosen the four screws in the battery lid on the back of the instrument using any screwdriver.

2. Remove the C battery lid and store for future use. Remove C batteries, if installed.

3. Check for proper placement of gasket on the rechargeable battery pack and lid.

4. Install the rechargeable battery pack and lid and tighten the 4 screws securely and evenly.

   NOTE: Do not over tighten the screws.

2.4.4 Charging the Optional Rechargeable Battery Pack

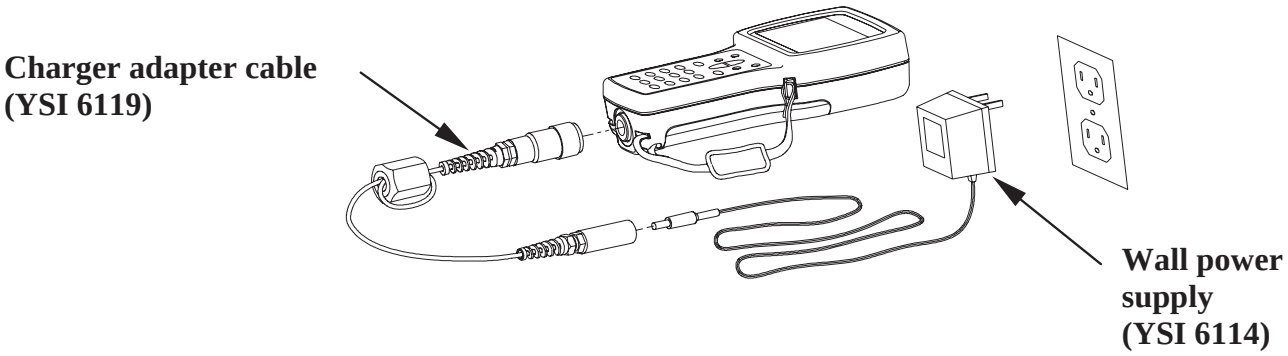


Figure 2.5 Charging the Battery Pack

⚠ **CAUTION: Do not use or store the battery pack at extreme temperatures such as in strong direct sunlight, in cars during hot weather or close to heaters.**

1. Install the rechargeable battery pack into the instrument as described in Section *2.4.3 Inserting Optional Rechargeable Battery Pack.*

2. Attach the charger adapter cable (YSI 6119) to the instrument.

   NOTE: Wall power supplies for use in countries outside the US and Canada can be found in *Appendix B Instrument Accessories*.

3. Insert the barrel connector of the wall power supply into the barrel of the adapter cable.

⚠ **CAUTION: Do not charge the battery pack continuously for more than 48 hours.**

⚠ **CAUTION: Do not drop or expose to water.**

⚠ **CAUTION: Do not charge the battery pack at temperatures below 0°C or above 40°C.**

4. Plug the wall power supply into an AC power outlet for approximately 2 hours to obtain an 80% to 90% charge and for 6 hours to get a full charge.

   NOTE: The battery pack can be recharged whether the instrument is on or off.

2.4.5 Storing the Battery Pack

Remove the battery pack from the instrument when the instrument will not be used for extended periods of time to prevent over discharge of the battery pack.

Store the battery pack in a heavy plastic bag to prevent accidental shorting of the terminals. Store between –20 and 30°C.

2.4.6 Optional Cigarette Lighter Charger

⚠ **CAUTION: Read all warnings and cautions that come with the charger before using the charger.**

⚠ **CAUTION: Only use cigarette lighter charger when *rechargeable* battery pack is inserted into instrument.**

⚠ **CAUTION: Do not mishandle cigarette lighter charger. Do not expose to moisture.**

1. Plug the barrel connector of the cigarette lighter charger into the mating end of the YSI 6119 Charger Adapter Cable.

2. Attach the MS-19 end of the YSI 6119 Charger Adapter Cable to the instrument.

3. Make one of the following modifications to the other end of the charger:

   Slide the adapter ring off the plug to use the device with an American or Japanese vehicle.

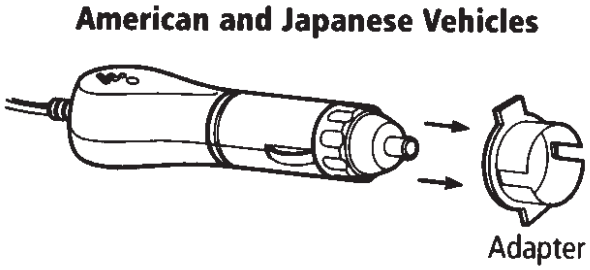


Figure 2.6 Charger Plug Adapter Use

Leave the adapter ring on the plug and position it so that the slots on the adapter ring line up with the plug's spring clips to use the device on a European vehicle.

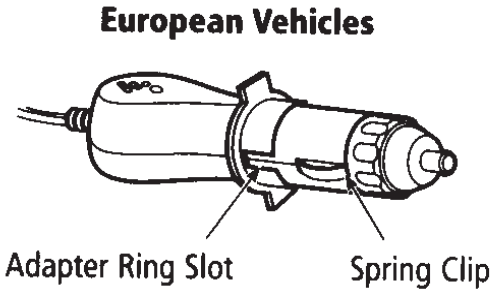


Figure 2.7 European Charger Plug Adapter Use

NOTE: If the charger stops working properly, refer to Section *13 Troubleshooting*.

2.5 Power On

Press and release the on/off button in the upper left corner of the instrument keypad to turn the instrument on or off. See Figure 2.1 Front View of YSI 556 MPS.

2.6 Setting Display Contrast

The display contrast automatically compensates for temperature changes. However, under extreme temperature conditions you may wish to optimize the display by manual adjustment as follows:

1. Press and *hold down* the backlight key in the upper right corner of the keypad and press the “up” arrow to increase (darken) the contrast.

2. Press and *hold down* the backlight key in the upper right corner of the keypad and press the “down” arrow to decrease (lighten) the contrast.

2.7 Backlight

Press and *release* the backlight key in the upper right corner of the keypad to turn the backlight on or off. See Figure 2.1 Front View of YSI 556 MPS.

NOTE: The backlight turns off automatically after two minutes of non-use.

2.8 General Screen Features

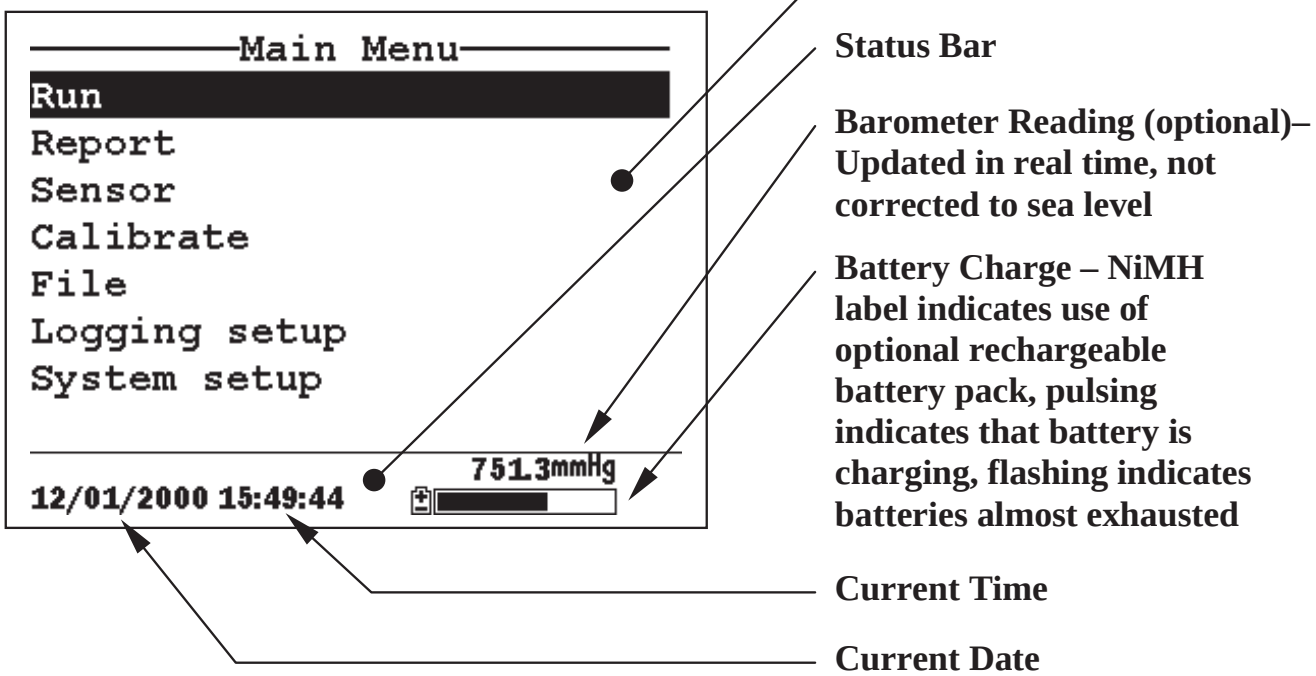


Figure 2.8 Main Menu Screen

2.9 Keypad Use

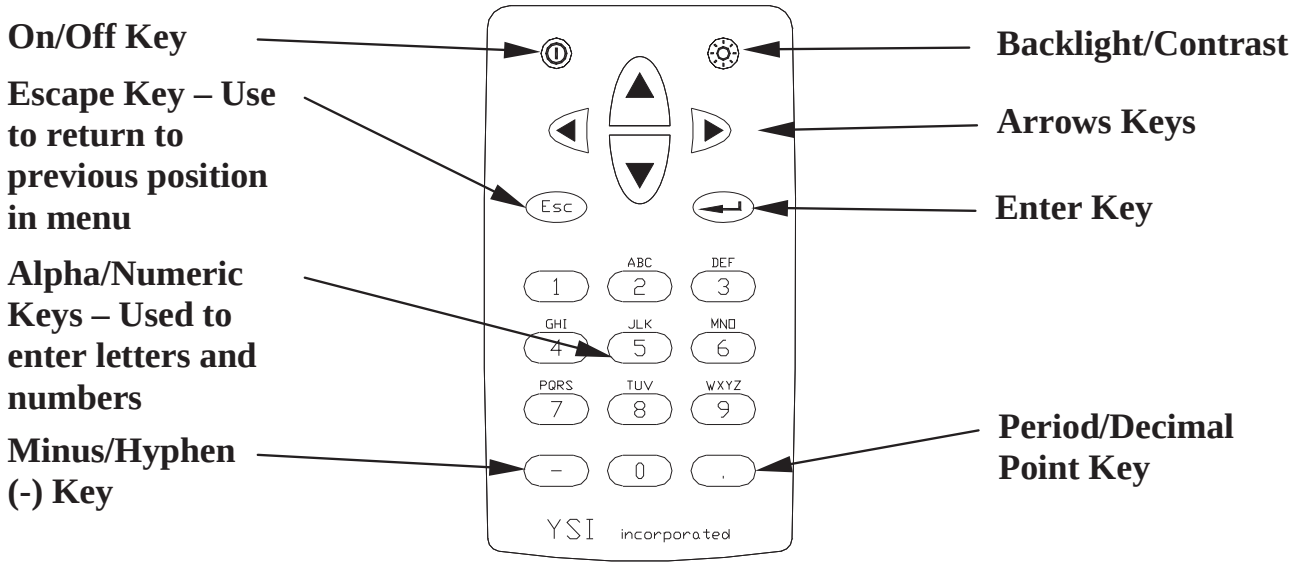


Figure 2.9 Keypad Features

KEY	LETTER/ NUMBER
1	1
2	ABC2abc3
3	DEF3def3
4	GHI4ghi4
5	JKL5jkl5
6	MNO6mno6
7	PQRS7pqrs7
8	TUV8tuv8
9	WXYZ9wxyz9
0	0

Figure 2.10 Keypad Letters & Numbers

1. See Figure 2.10 Keypad Letters & Numbers and press the appropriate key repeatedly until letter or number desired appears in display.

NOTE: Press the key repeatedly in rapid succession to get to the desired letter or number. If you pause for more than a

second, the cursor automatically scrolls to the right to prepare for the next input.

EXAMPLE 1: Press the **6** key *once* and *release* to display an uppercase “M.”

EXAMPLE 2: Press the **6** key *four times* and *release* to display the number “6.”

EXAMPLE 3: Press the **6** key *five times* and *stop* to display a lowercase “m.”

2. Press the left arrow key to go back and reenter a number or letter that needs to be changed.

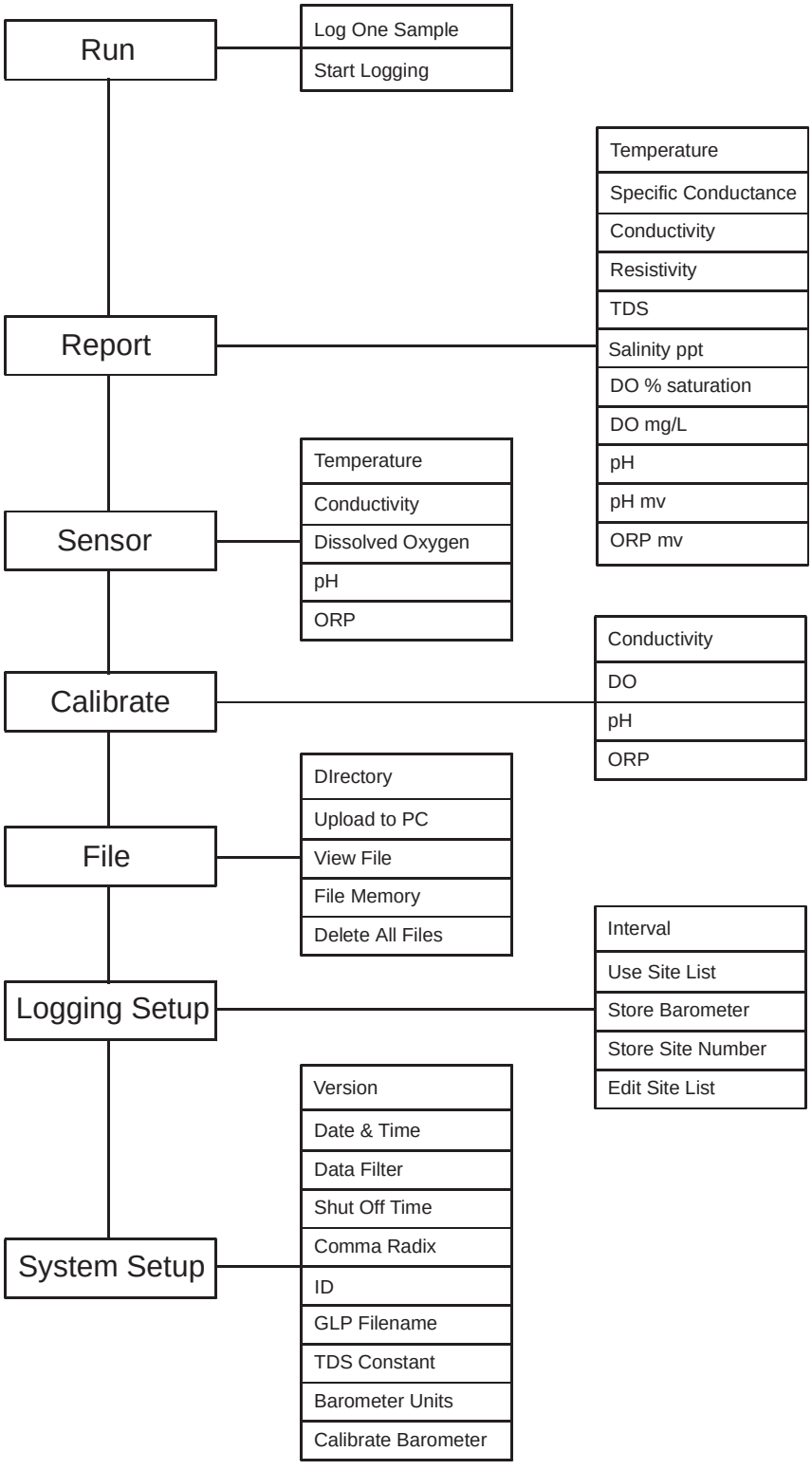
3. Press the **Enter** key when your entry is complete.

NOTE: The instrument software permits only numeric entries in many instances, such as when setting the clock or entering calibration parameters.

2.10 Instrument Reset

The YSI 556 MPS is characterized by sophisticated software that should provided trouble-free operation. However as with all high-capability software packages, it is always possible that the user will encounter circumstances in which the instrument does not respond to keypad entry. If this occurs, the instrument function can easily be restored by removing and then reapplying battery power. Simply remove either your C-cells or rechargeable battery pack from the battery compartment, wait 30 seconds and then replace the batteries. See Section *2.4 Batteries* for battery removal/reinstallation instructions.

2.11 Menu Flowchart



3. Probe Module

3.1 Introduction

The YSI 5563 Probe module is used for measuring dissolved oxygen, temperature, conductivity, and optional pH and ORP. The probe module is rugged, with the sensors enclosed in a heavy duty probe sensor guard with attached sinking weight. A 4, 10 or 20 meter cable is directly connected to the probe module body making it waterproof. An MS-19 connector at the end of the cable makes the YSI 5563 fully compatible with the YSI 556 Multi-Probe System.

3.2 Unpacking the Probe Module

1. Remove the YSI 5563 Probe module from the shipping boxes.

   NOTE: Do not discard any parts or supplies.

2. Use the packing list to ensure all items are present.

3. Visually inspect all components for damage.

   NOTE: If any parts are missing or damaged, contact your YSI Service Center immediately. Refer to *Appendix E Customer Service* or www.ysi.com.

3.3 Features of the YSI 5563 Probe Module

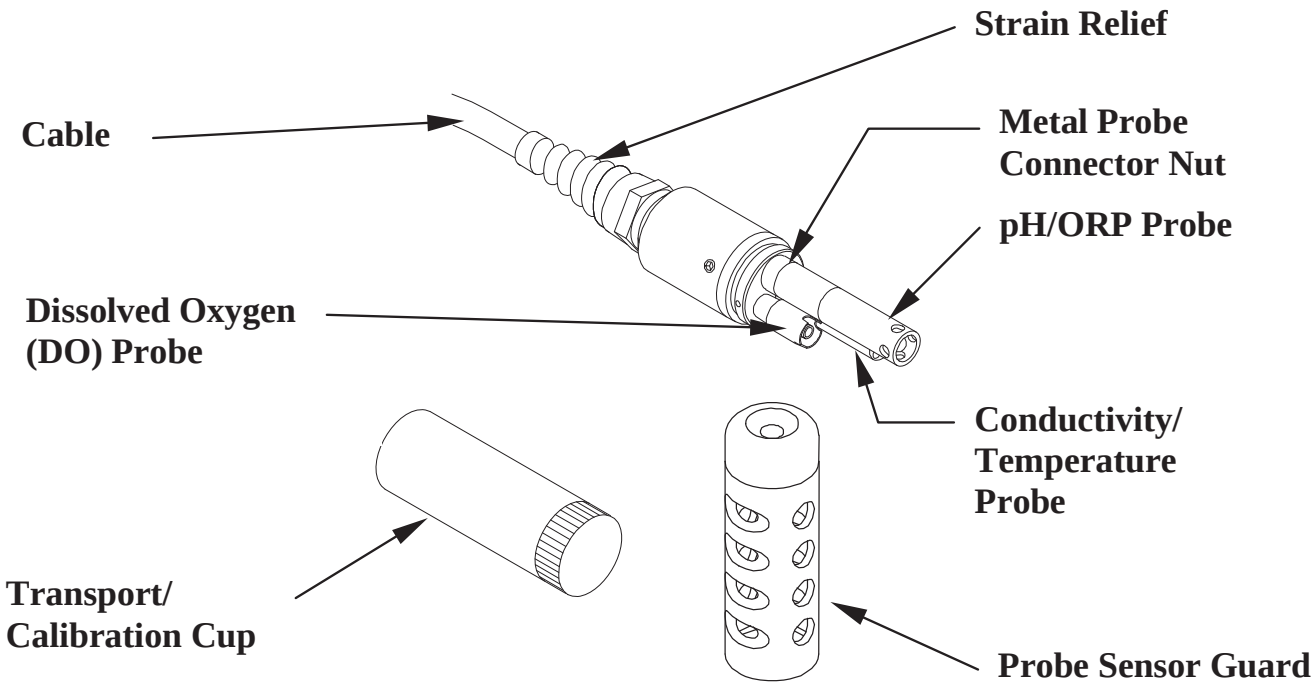


Figure 3.1 Probe Module

3.4 Preparing the Probe Module

To prepare the probe module for calibration and operation, you need to install the sensors into the connectors on the probe module bulkhead. In addition to sensor installation, you need to install a new DO membrane cap.

3.4.1 Sensor Installation

Whenever you install, remove or replace a sensor, it is extremely important that the entire probe module and all sensors be thoroughly dried prior to the removal of a sensor or a sensor port plug. This will prevent water from entering the port. Once you remove a sensor or plug, examine the connector inside the probe module sensor port. If any moisture is present, use compressed air to completely dry the connector. If the connector is corroded, return the probe module to your dealer or directly to YSI Customer Service. Refer to *Appendix E Customer Service*.

Conductivity/Temperature and pH, pH/ORP Sensor Installation

1. Unscrew and remove the probe sensor guard.

2. Using the sensor installation tool supplied in the YSI 5511 maintenance kit, unscrew and remove the sensor port plugs.

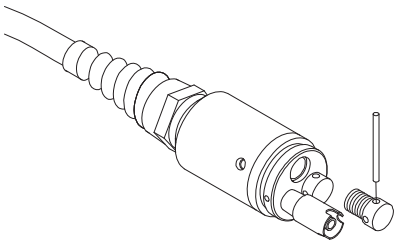


Figure 3.2 Port Plug Removal

3. Locate the port with the connector that corresponds to the sensor that is to be installed.

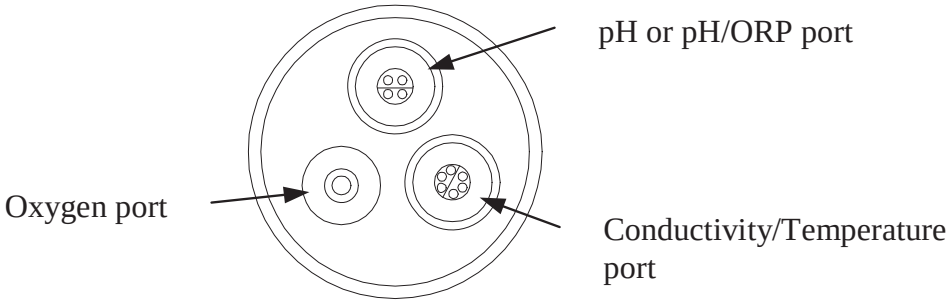


Figure 3.3 Sensor Port Identification

4. Apply a thin coat of o-ring lubricant (supplied in the YSI 5511 maintenance kit) to the o-rings on the connector side of the sensor (see Figure 3.4 O-Ring Lubrication).

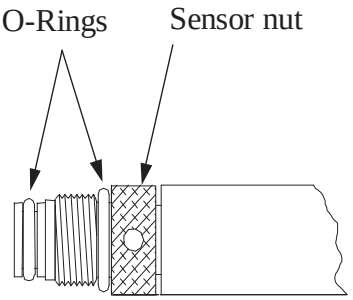


Figure 3.4 O-Ring Lubrication

⚠ **CAUTION:** Make sure that there are NO contaminants between the O-ring and the sensor. Contaminants that are present under the O-ring may cause the O-ring to leak.

5. Be sure the probe module sensor port is free of moisture and then insert the sensor into the correct port. Gently rotate the sensor until the two connectors align.

6. With connectors aligned, screw down the sensor nut using the sensor installation tool.

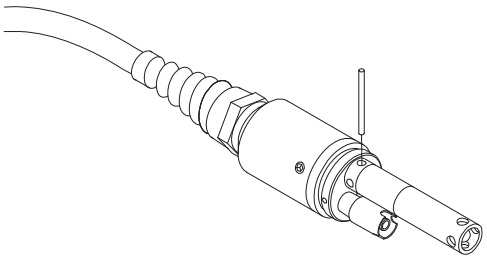


Figure 3.5 Sensor Installation

⚠ **CAUTION:** Do not cross thread the sensor nut. Tighten the nut until it is flush with the face of the probe module bulkhead. Do not over tighten.

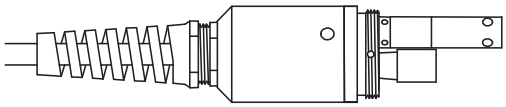


Figure 3.6 Bulkhead Seating

7. Repeat steps 3-6 for any other sensors.

8. Replace the probe sensor guard.

Dissolved Oxygen Sensor Installation

The YSI 5563 comes with the DO sensor already installed. Refer to Section *11.1.2 DO Sensor Replacement* for instructions on installing the YSI 558 Replaceable DO Module Kit.

3.4.2 Membrane Cap Selection

The YSI 5563 is shipped with a YSI 5909 kit that contains membrane caps made with 2 mil polyethylene (PE), a material which should be ideal for most field applications of the 556. However, YSI also offers membrane caps made with two other materials (1 mil polyethylene and 1 mil Teflon) which some users may also prefer. All membranes available for the 556/5563 system provide comparable accuracy if used properly. The difference between the two thicknesses of PE is found in the trade-off of flow dependence and response time as described below. Teflon is offered because some users may prefer to continue using the traditional membrane material used by YSI. To avoid confusion, the membrane caps are color coded as described below and can be ordered in kits as noted:

1 mil Teflon – Black Caps (Kit = YSI 5906)
1 mil Polyethylene (PE) – Yellow Caps (Kit = YSI 5908)
2 mil Polyethylene (PE) – Blue Caps (Kit = YSI 5909)

The 1 mil Teflon caps will offer traditional, reliable performance for most dissolved oxygen applications. The 1 mil PE caps will provide a significantly faster dissolved oxygen response (as long as your 556 Data Filter is set correctly as described below in Sections 10.2 and 10.3.1)) while also giving readings which are significantly less flow dependent than the 1 mil Teflon caps. Finally, 2 mil PE caps will show a large reduction in flow dependence over 1 mil Teflon while not significantly increasing the response time. Generally, one of the PE caps is likely to provide better performance for your application.

IMPORTANT: No matter which type of membrane cap you select, you will also have to confirm your selection in the 556

software from the Sensor menu as described in Section *4 Sensors*.

3.4.3 Membrane Cap Installation

NOTE: The YSI 5563 DO sensor (already installed in the probe module) was shipped dry. A shipping membrane was installed to protect the electrode. **A new membrane cap must be installed before the first use**.

1. Unscrew and remove the probe sensor guard.
2. Unscrew, remove, and discard the old membrane cap.
3. Thoroughly rinse the sensor tip with distilled water.
4. Prepare the electrolyte according to the directions on the electrolyte solution bottle.
5. Hold the new membrane cap and fill it at least 1/2 full with the electrolyte solution.
6. Screw the membrane cap onto the sensor moderately tight. A small amount of electrolyte should overflow.

⚠ **CAUTION:** Do not touch the membrane surface.

7. Screw the probe sensor guard on moderately tight.

3.5 Transport/Calibration Cup

The YSI 5563 Probe module has been supplied with a convenient transport/calibration cup. This cup is an ideal container for calibration of the different sensors, minimizing the amount of solution needed. Refer to Section *6 Calibrate*.

3.5.1 Transport/Calibration Cup Installation

1. Remove probe sensor guard, if already installed.

2. Ensure that an o-ring is installed in the o-ring groove on the threaded end of the probe module body.

3. Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

   NOTE: Do not overtighten as this could cause damage to the threaded portions.

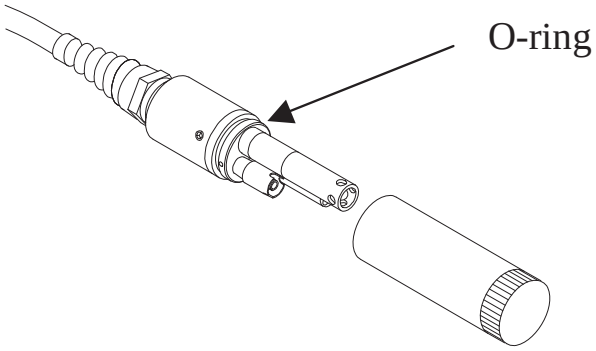


Figure 3.7 Transport/Calibration Cup Installation

3.6 Instrument/Cable Connection

Attach the cable to the instrument as follows:

1. Line up the pins and guides on the cable with the holes and indentations on the cable connector at the bottom of the YSI 556 instrument. See Figure 2.1 Front View of YSI 556 MPS.

2. Holding the cable firmly against the cable connector, turn the locking mechanism clockwise until it snaps into place.

Remove the cable from the instrument by turning the cable connector counterclockwise until the cable disengages from the instrument.

4. Sensors

The Sensors Enabled screen allows the user to enable or disable each of the sensors and select which membrane material will be used for the dissolved oxygen sensor. Disabled sensors will not be displayed on the screen in real time or logged to files.

1. Press the **On/off** key to display the run screen.

2. Press the **Escape** key to display the main menu screen.

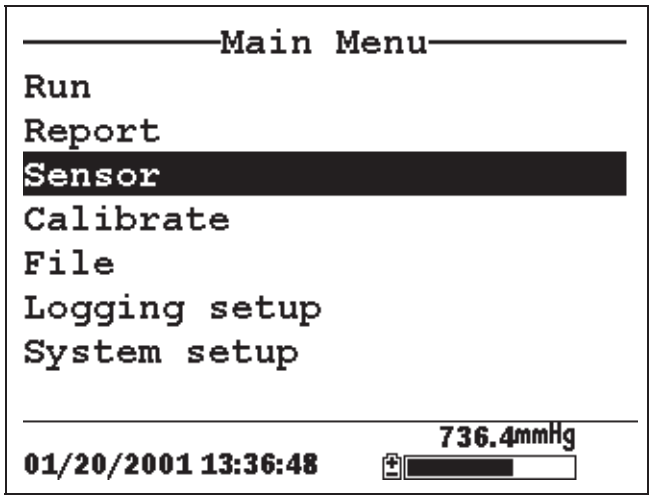


Figure 4.1 Main Menu Screen

3. Use the arrow keys to highlight the **Sensor** selection.

4. Press the **Enter** key to display the sensors enabled screen.

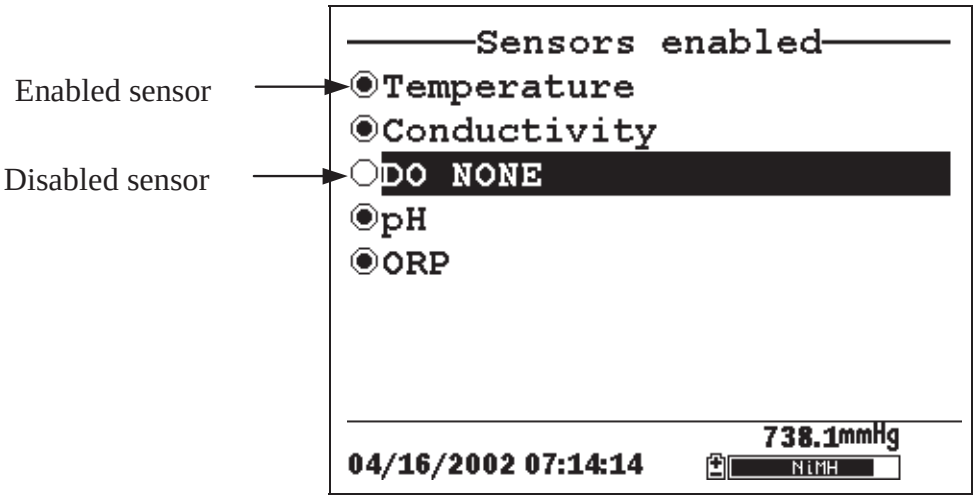


Figure 4.2 Sensors Enabled Screen Before DO Membrane Selection

A black dot to the left of a sensor indicates that sensor is enabled. Sensors with an empty circle are disabled.

Highlight the “DO None” entry as shown above and press **Enter** to display the membrane choice screen. Consult Section *3.4.2 Membrane Cap Selection* for information on the advantages of each type of membrane material. Blue membrane caps using 2 mil polyethylene (PE) were shipped with your YSI 5563 and are likely to be the best choice for most 556 field applications.

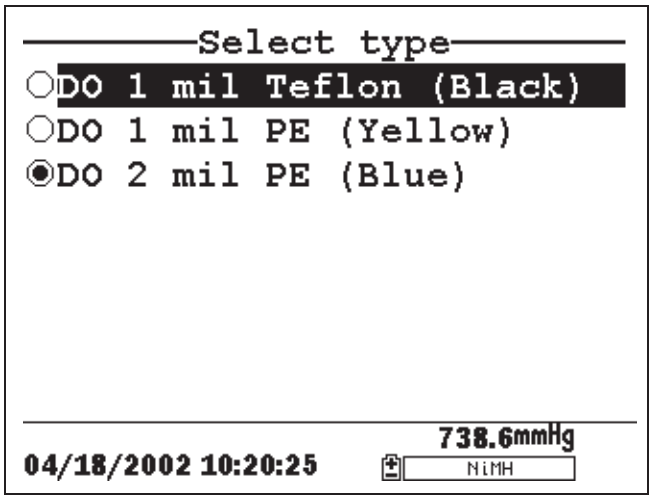


Figure 4.3 Membrane Selection Screen

Highlight the desired membrane choice – in this case, 2 mil PE -- and press Enter to activate your selection with a dot to the left of the screen. Then press **Escape** to return to the Sensor menu that now shows your DO membrane selection.

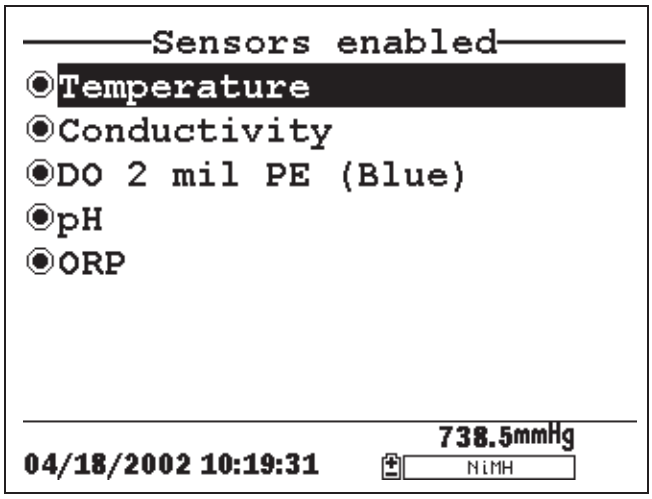


Figure 4.4 Sensors Enabled Screen After DO Membrane Selection

NOTE: The Temperature sensor cannot be disabled. Most other sensors require temperature compensation for accurate readings. In addition, the conductivity sensor must be activated in order to obtain accurate dissolved oxygen mg/L readings.

5. Use the arrow keys to highlight the sensor you want to change, then press the **Enter** key to enable or disable it.

6. Repeat step 5 for each sensor you want to change.

7. Press the **Escape** key to return to the main menu screen.

5. Report

The Report Setup screen allows the user to select which sample parameters and units the YSI 556 MPS will display on the screen. It does NOT determine which parameters are logged to memory. Refer to Section *4 Sensors*.

1. Press the **On/off** key to display the run screen.

2. Press the **Escape** key to display the main menu screen.

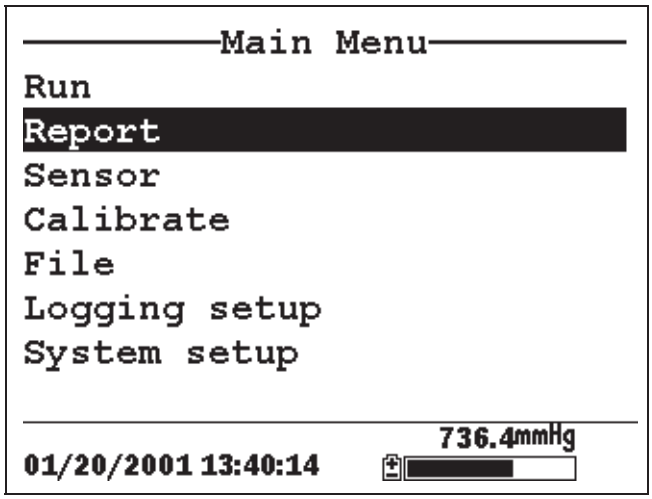


Figure 5.1 Main Menu

3. Use the arrow keys to highlight the **Report** selection.

4. Press the **Enter** key to display the report setup screen.

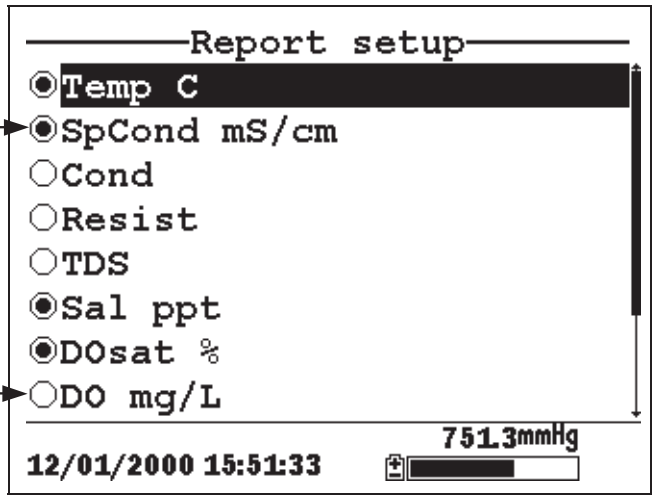


Figure 5.2 Report Setup Screen

NOTE: A black dot to the left of a parameter indicates that parameter is selected for display. Parameters with an empty circle will not be displayed.

NOTE: You may have to scroll down past the bottom of the screen to see all the parameters.

5. Use the arrow keys to highlight the parameter you want to change, then press the **Enter** key. If you can't find the parameter you want, even after scrolling down past the bottom of the screen, the sensor used for that parameter is disabled. Refer to Section *4 Sensors*.

6. If you selected Temperature, Specific Conductivity, Conductivity, Resistance or Total Dissolved Solids, the Units screen will appear.

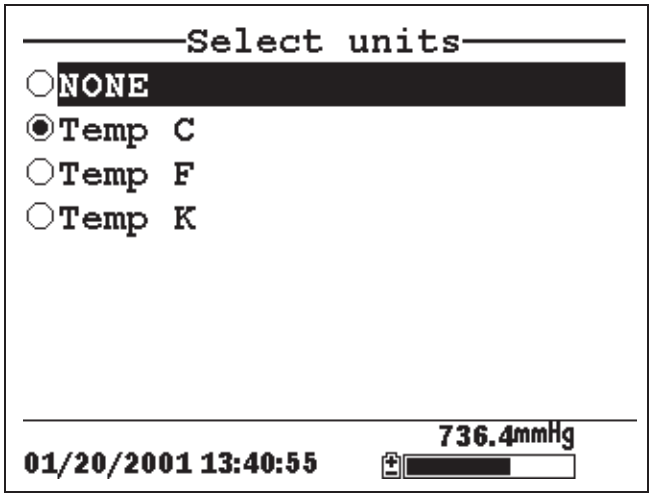


Figure 5.3 Units Screen

7. Use the arrow keys to select the units desired, then press the **Enter** key to return to the report setup screen.

   If you selected Salinity, Dissolved Oxygen %, Dissolved Oxygen mg/L, pH, pH mv or ORP mv, the selection dot will simply toggle on or off.

8. Repeat steps 5 and 6 for each parameter you want to change.

NOTE: All parameters may be enabled at the same time.

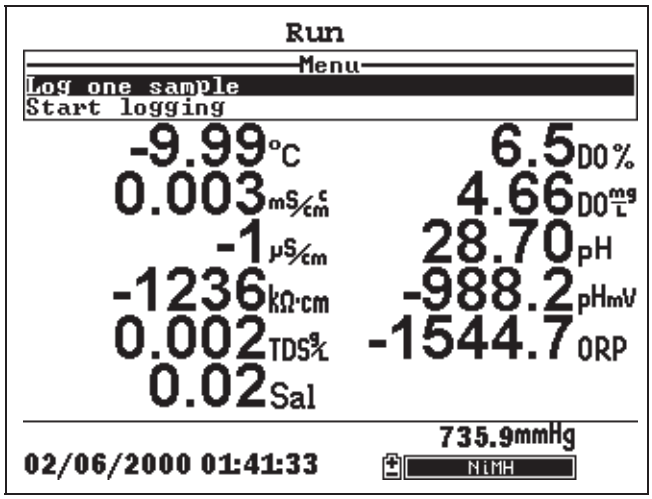


Figure 5.4 All Parameters Displayed

9. Press the **Escape** key to return to the Main menu screen.

6. Calibrate

All of the sensors, except temperature, require periodic calibration to assure high performance. You will find specific calibration procedures for all sensors that require calibration in the following sections. If a sensor listed is not installed in your probe module, skip that section and proceed to the next sensor until the calibration is complete.

⚠ **CAUTION:** Reagents that are used to calibrate and check this instrument may be hazardous to your health. Take a moment to review *Appendix D Health and Safety*. Some calibration standard solutions may require special handling.

6.1 Getting Ready to Calibrate

6.1.1 Containers Needed to Calibrate the Probe Module

The transport/calibration cup that comes with your probe module serves as a calibration chamber for all calibrations and minimizes the volume of calibration reagents required.

Instead of the transport/calibration cup, you may use laboratory glassware to perform calibrations. If you do not use the transport/calibration cup that is designed for the probe module, you are cautioned to do the following:

- ✓ Perform all calibrations with the Probe Sensor Guard installed. This protects the sensors from possible physical damage.
- ✓ Use a ring stand and clamp to secure the probe module body to prevent the module from falling over. Most laboratory glassware has convex bottoms.
- ✓ Ensure that all sensors are immersed in calibration solutions. Many of the calibrations factor in readings from other sensors (e.g., temperature sensor). The top vent hole of the conductivity sensor must also be immersed during some calibrations.

6.1.2 Calibration Tips

1. If you use the Transport/Calibration Cup for dissolved oxygen (DO) calibration, make certain to loosen the seal to allow pressure equilibration before calibration. The DO calibration is a water-saturated air calibration.

2. The key to successful calibration is to ensure that the sensors are completely submersed when calibration values are entered. Use recommended volumes when performing calibrations.

3. For maximum accuracy, use a small amount of previously used calibration solution to pre-rinse the probe module. You may wish to save old calibration standards for this purpose.

4. Fill a bucket with ambient temperature water to rinse the probe module between calibration solutions.

5. Have several clean, absorbent paper towels or cotton cloths available to dry the probe module between rinses and calibration solutions. Shake the excess rinse water off of the probe module, especially when the probe sensor guard is installed. Dry off the outside of the probe module and probe sensor guard. Making sure that the probe module is dry reduces carry-over contamination of calibrator solutions and increases the accuracy of the calibration.

6. If you are using laboratory glassware for calibration, you do not need to remove the probe sensor guard to rinse and dry the sensors between calibration solutions. The inaccuracy resulting from simply rinsing the sensor compartment and drying the outside of the guard is minimal.

7. If you are using laboratory glassware, remove the stainless steel weight from the bottom of the probe sensor guard by turning the weight counterclockwise. When the weight is removed, the calibration solutions have access to the sensors without displacing a lot of fluid. This also reduces the amount of liquid that is carried between calibrations.

8. Make certain that port plugs are installed in all ports where sensors are not installed. It is extremely important to keep these electrical connectors dry.

6.1.3 Recommended Volumes

Follow these instructions to use the transport/calibration cup for calibration procedures.

- ✓ Ensure that an o-ring is installed in the o-ring groove of the transport/calibration cup bottom cap, and that the bottom cap is securely tightened.

  NOTE: Do not over-tighten as this could cause damage to the threaded portions.

- ✓ Remove the probe sensor guard, if it is installed.
- ✓ Remove the o-ring, if installed, from the probe module and inspect the installed o-ring on the probe module for obvious defects and, if necessary, replace it with the extra o-ring supplied.
- ✓ Some calibrations can be accomplished with the probe module upright or upside down. A separate clamp and stand, such as a ring stand, is required to support the probe module in the inverted position.
- ✓ To calibrate, follow the procedures in the next section, Calibration Procedures. The approximate volumes of the reagents are specified below for both the upright and upside down orientations.
- ✓ When using the Transport/Calibration Cup for dissolved oxygen % saturation calibration, make certain that the vessel is vented to the atmosphere by loosening the bottom cap or cup assembly and that approximately 1/8” of water is present in the cup.

Sensor to Calibrate	Upright	Upside Down
Conductivity	55ml	55ml
pH/ORP	30ml	60ml

Table 6.1 Calibration Volumes

6.2 Calibration Procedures

6.2.1 Accessing the Calibrate Screen

1. Press the **On/off** key to display the run screen.
2. Press the **Escape** key to display the main menu screen.
3. Use the arrow keys to highlight the **Calibrate** selection.

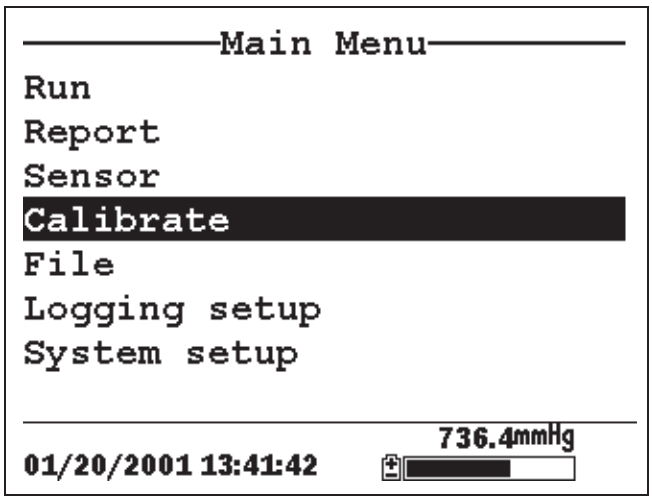


Figure 6.1 Main Menu

4. Press the **Enter** key. The Calibrate screen is displayed.

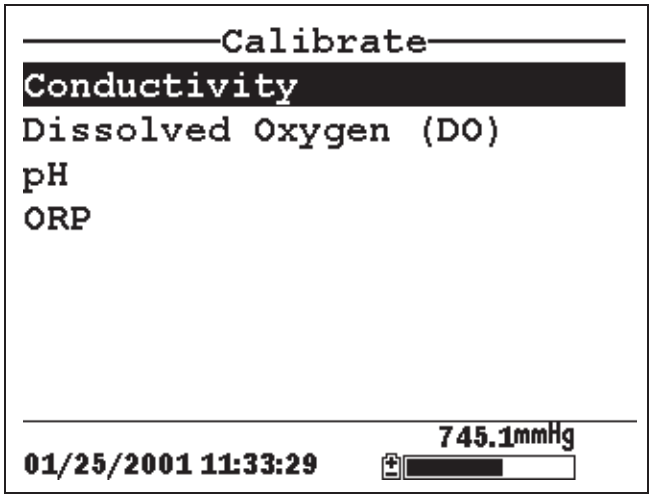


Figure 6.2 Calibrate Screen

6.2.2 Conductivity Calibration

This procedure calibrates specific conductance (recommended), conductivity and salinity. Calibrating any one option automatically calibrates the other two.

1. Go to the calibrate screen as described in Section 6.2.1 Accessing the Calibrate Screen.

2. Use the arrow keys to highlight the **Conductivity** selection. See Figure 6.2 Calibrate Screen.

3. Press **Enter.** The Conductivity Calibration Selection Screen is displayed.

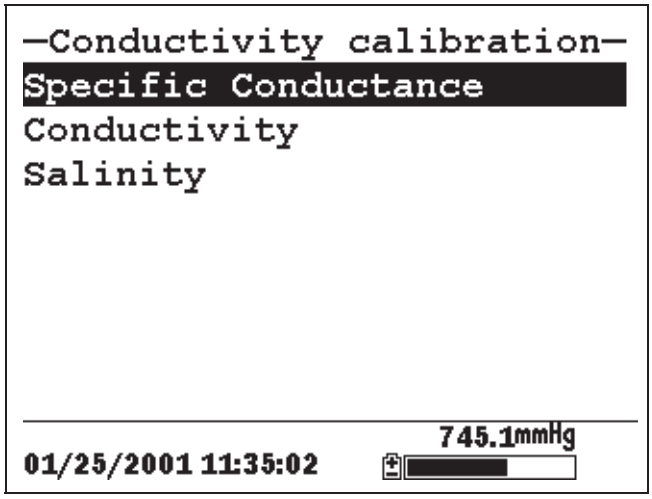


Figure 6.3 Conductivity Calibration Selection Screen

4. Use the arrow keys to highlight the Specific Conductance selection.

5. Press **Enter.** The Conductivity Calibration Entry Screen is displayed.

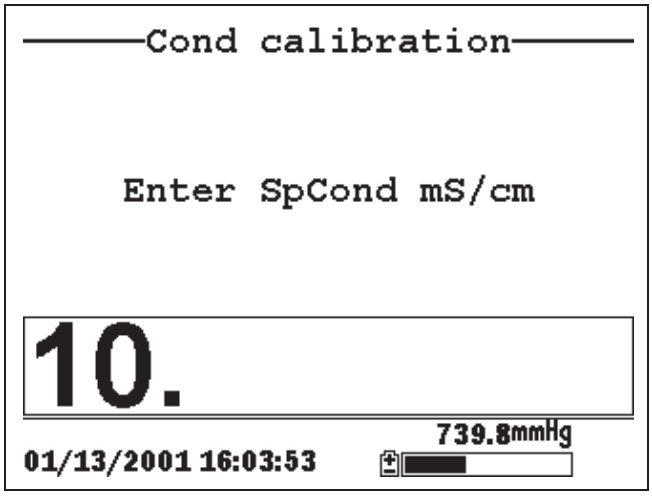


Figure 6.4 Conductivity Calibration Entry Screen

6. Place the correct amount of conductivity standard (see Table 6.1 Calibration Volumes) into a clean, dry or pre-rinsed transport/calibration cup.

⚠ **WARNING**: Calibration reagents may be hazardous to your health. See *Appendix D Health and Safety* for more information.

NOTE: For maximum accuracy, the conductivity standard you choose should be within the same conductivity range as the samples you are preparing to measure. However, we do not recommend using standards less than 1 mS/cm. For example:

- ✓ For fresh water use a 1 mS/cm conductivity standard.
- ✓ For brackish water use a 10 mS/cm conductivity standard.
- ✓ For seawater use a 50 mS/cm conductivity standard.

NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the conductivity sensor with a small amount of standard that can be discarded. Be certain that you avoid cross-contamination of solutions. Make certain that there are no salt deposits around the oxygen and pH/ORP sensors, particularly if you are employing standards of low conductivity.

7. Carefully immerse the sensor end of the probe module into the solution.

8. Gently rotate and/or move the probe module up and down to remove any bubbles from the conductivity cell.

   NOTE: The sensor must be completely immersed past its vent hole. Using the recommended volumes from Table 6.1 Calibration Volumes, should ensure that the vent hole is covered.

9. Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

   NOTE: Do not overtighten as this could cause damage to the threaded portions.

10. Use the keypad to enter the calibration value of the standard you are using.

    NOTE: Be sure to enter the value in **mS/cm at 25°C**.

11. Press **Enter**. The Conductivity Calibration Screen is displayed.

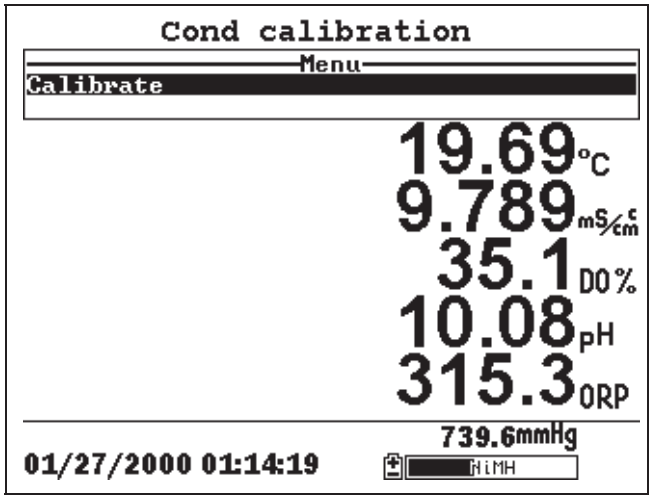


Figure 6.5 Conductivity Calibration Screen

12. Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors

will appear on the screen and will change with time as they stabilize.

13. Observe the reading under Specific Conductance. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.

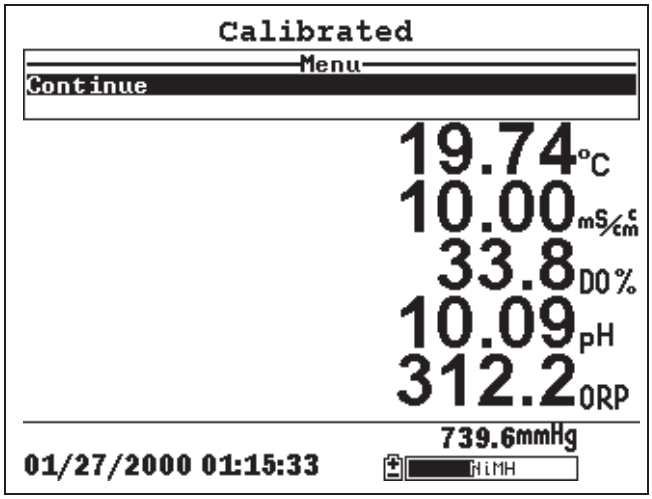


Figure 6.6 Calibrated

14. Press **Enter**. This returns you to the Conductivity Calibrate Selection Screen, See Figure 6.3 Conductivity Calibration Selection Screen.

15. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

16. Rinse the probe module and sensors in tap or purified water and dry.

6.2.3 Dissolved Oxygen Calibration

This procedure calibrates dissolved oxygen. Calibrating any one option (% or mg/L) automatically calibrates the other.

1. Go to the calibrate screen as described in Section *6.2.1 Accessing the Calibrate Screen.*

NOTE: The instrument must be on for at least 20 minutes to polarize the DO sensor before calibrating.

2. Use the arrow keys to highlight the **Dissolved Oxygen** selection. See Figure 6.2 Calibrate Screen.

3. Press **Enter**. The dissolved oxygen calibration screen is displayed.

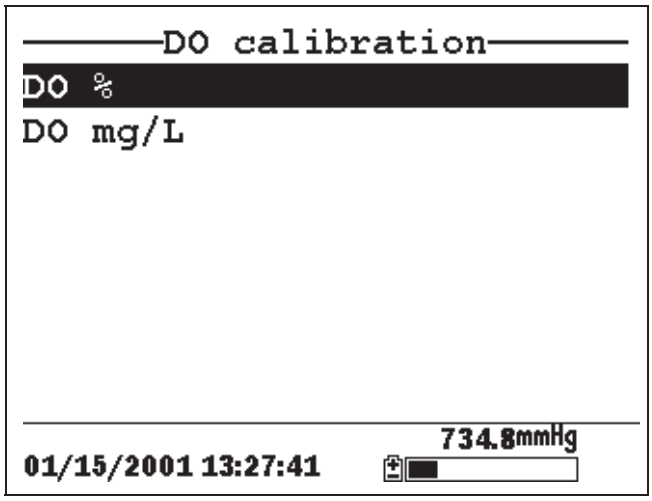


Figure 6.7 DO Calibration Screen

DO Calibration in % Saturation

1. Use the arrow keys to highlight the DO% selection.

2. Press **Enter**. The DO Barometric Pressure Entry Screen is displayed.

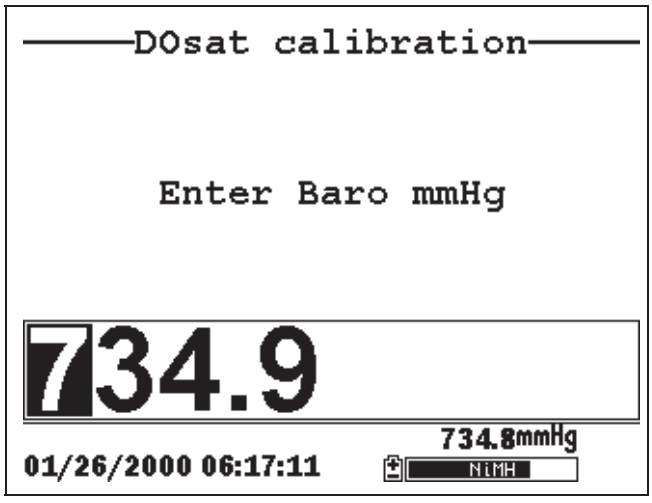


Figure 6.8 DO Barometric Pressure Entry Screen

3. Place approximately 3 mm (1/8 inch) of water in the bottom of the transport/calibration cup.

4. Place the probe module into the transport/calibration cup.

   NOTE: Make sure that the DO and temperature sensors are **not** immersed in the water.

5. Engage only 1 or 2 threads of the transport/calibration cup to ensure the DO sensor is vented to the atmosphere.

6. Use the keypad to enter the current local barometric pressure.

   NOTE: If the unit has the optional barometer, no entry is required.

   NOTE: Barometer readings that appear in meteorological reports are generally corrected to sea level and must be uncorrected before use (refer to Section *10.10 Calibrate Barometer, Step 2*).

7. Press **Enter**. The DO% saturation calibration screen is displayed.

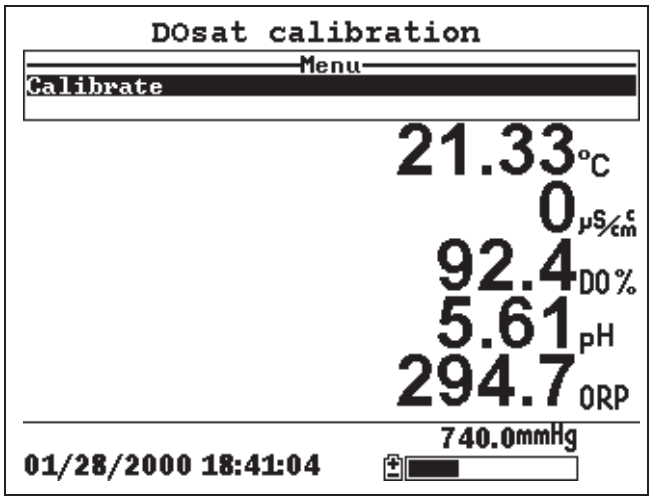


Figure 6.9 DO Sat Calibration Screen

8. Allow approximately ten minutes for the air in the transport/calibration cup to become water saturated and for

the temperature to equilibrate before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

9. Observe the reading under DO %. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue. See Figure 6.6 Calibrated.

10. Press **Enter**. This returns you to the DO calibration screen, See Figure 6.7 DO Calibration Screen.

11. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

12. Rinse the probe module and sensors in tap or purified water and dry.

DO Calibration in mg/L

DO calibration in mg/L is carried out in a water sample which has a known concentration of dissolved oxygen (usually determined by a Winkler titration).

1. Go to the DO calibrate screen as described in Section *6.2.3 Dissolved Oxygen Calibration*, steps 1 through 3.

2. Use the arrow keys to highlight the **DO mg/L** selection.

3. Press **Enter**. The DO mg/L Entry Screen is displayed.

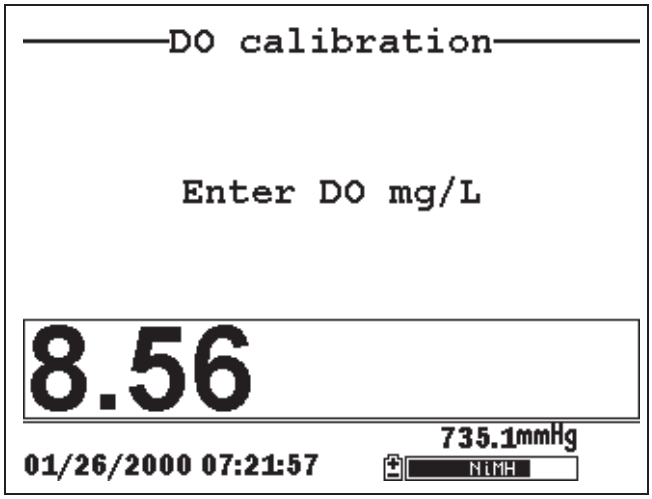


Figure 6.10 DO mg/L Entry Screen

4. Place the probe module in water with a known DO concentration.

NOTE: Be sure to completely immerse all the sensors.

5. Use the keypad to enter the known DO concentration of the water.

6. Press **Enter**. The Dissolved Oxygen mg/L Calibration Screen is displayed.

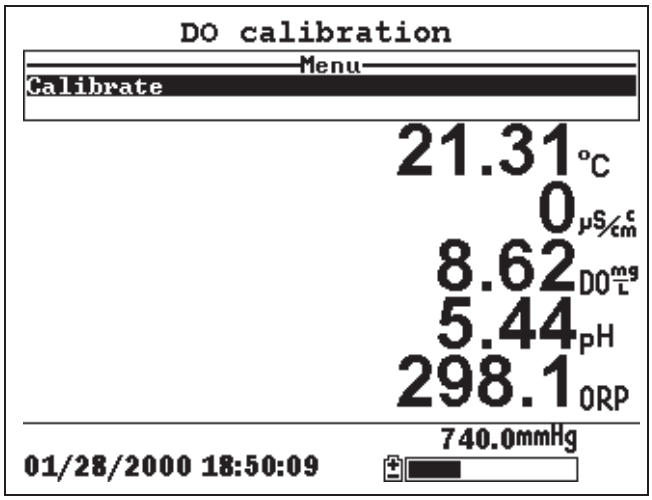


Figure 6.11 DO mg/L Calibration Screen

7. Stir the water with a stir bar, or by rapidly moving the probe module, to provide fresh sample to the DO sensor.

8. Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

9. Observe the DO mg/L reading, when the reading is stable (shows no significant change for approximately 30 seconds), press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.

10. Press **Enter**. This returns you to the DO calibration screen. See Figure 6.7 DO Calibration Screen.

11. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

12. Rinse the probe module and sensors in tap or purified water and dry.

6.2.4 pH Calibration

1. Go to the calibrate screen as described in *Section 6.2.1 Accessing the Calibrate Screen*.

2. Use the arrow keys to highlight the **pH** selection. See Figure 6.2 Calibrate Screen.

3. Press **Enter**. The pH calibration screen is displayed.

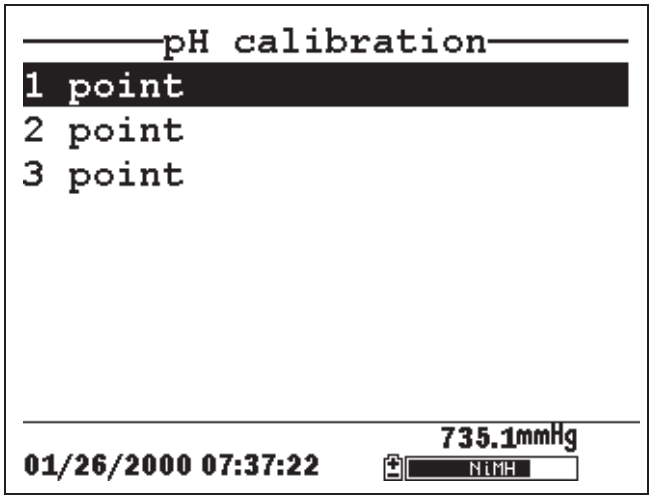


Figure 6.12 pH Calibration Screen

- 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 one point calibration. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select only one pH buffer.
- Select the **2-point** option to calibrate the pH sensor using only two calibration standards. Use this option if the media being monitored is known to be either basic or acidic. For example, if the pH of a pond is known to vary between 5.5 and 7, a two-point calibration with pH 7 and pH 4 buffers is sufficient. A three point calibration with an additional pH 10 buffer will not increase the accuracy of this measurement since the pH is not within this higher range.
- Select the **3-point** option to calibrate the pH sensor using three calibration solutions. In this procedure, the pH sensor is calibrated with a pH 7 buffer and two additional buffers. The 3-point calibration method assures maximum accuracy when the pH of the media to be monitored cannot be anticipated. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select a third pH buffer.

4. Use the arrow keys to highlight the **2-point** selection.

5. Press **Enter**. The pH Entry Screen is displayed.

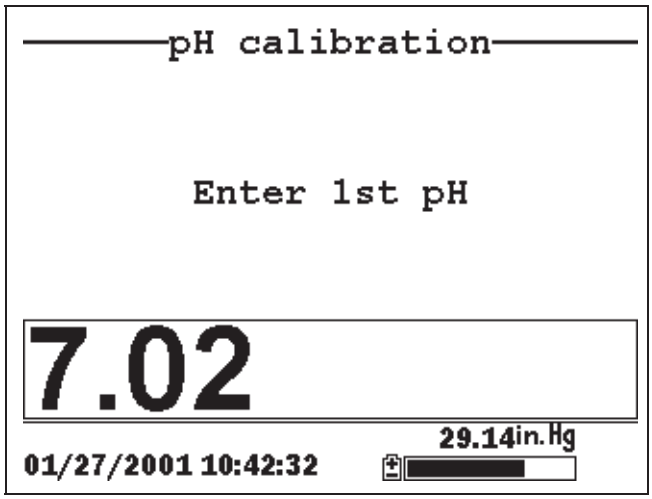


Figure 6.13 pH Entry Screen

6. Place the correct amount (see Table 6.1 Calibration Volumes) of pH buffer into a clean, dry or pre-rinsed transport/calibration cup.

⚠ **WARNING**: Calibration reagents may be hazardous to your health. See *Appendix D Health and Safety* for more information.

NOTE: For maximum accuracy, the pH buffers you choose should be within the same pH range as the water you are preparing to sample.

NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the pH sensor with a small amount of buffer that can be discarded. Be certain that you avoid cross-contamination of buffers with other solutions.

7. Carefully immerse the sensor end of the probe module into the solution.

8. Gently rotate and/or move the probe module up and down to remove any bubbles from the pH sensor.

NOTE: The sensor must be completely immersed. Using the recommended volumes from Table 6.1 Calibration Volumes, should ensure that the sensor is covered.

9. Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

NOTE: Do not overtighten as this could cause damage to the threaded portions.

10. Use the keypad to enter the calibration value of the buffer you are using **at the current temperature**.

NOTE: pH vs. temperature values are printed on the labels of all YSI pH buffers.

11. Press **Enter**. The pH calibration screen is displayed.

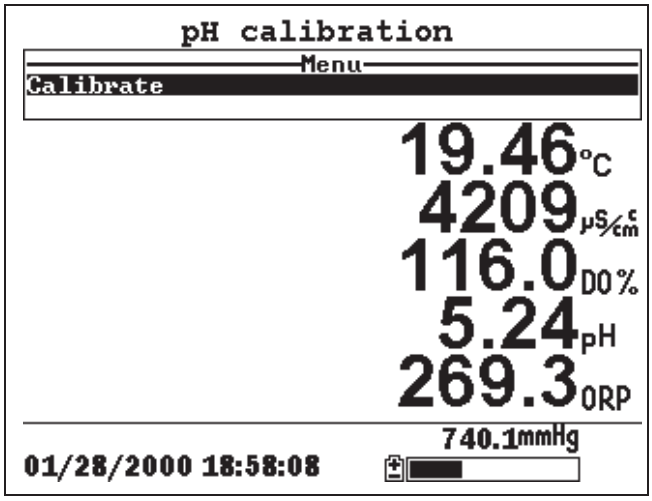


Figure 6.14 pH Calibration Screen

12. Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

13. Observe the reading under pH, when the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.

14. Press **Enter**. This returns you to the Specified pH Calibration Screen, See Figure 6.13 pH Entry Screen.

15. Rinse the probe module, transport/calibration cup and sensors in tap or purified water and dry.

16. Repeat steps 6 through 13 above using a second pH buffer.

17. Press **Enter**. This returns you to the pH Calibration Screen, See Figure 6.12 pH Calibration Screen.

18. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

19. Rinse the probe module and sensors in tap or purified water and dry.

6.2.5 ORP Calibration

1. Go to the calibrate screen as described in Section *6.2.1 Accessing the Calibrate Screen*.

2. Use the arrow keys to highlight the **ORP** selection. See Figure 6.2 Calibrate Screen.

3. Press **Enter**. The ORP calibration screen is displayed.

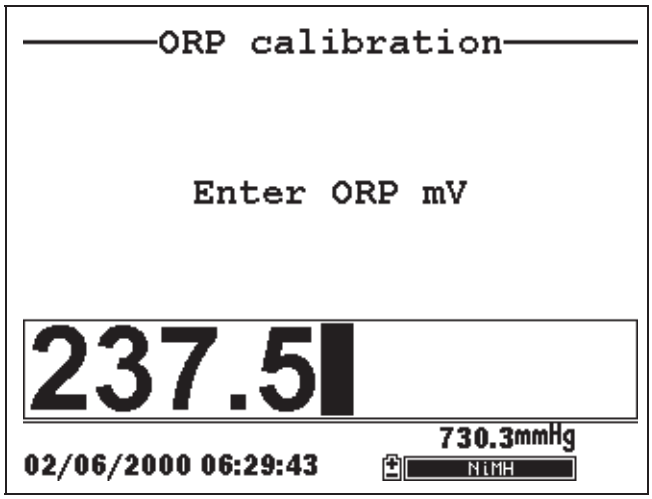


Figure 6.15 Specified ORP Calibration Screen

4. Place the correct amount (see Table 6.1 Calibration Volumes) of a known ORP solution (we recommend Zobell solution) into a clean, dry or pre-rinsed transport/calibration cup.

⚠ **WARNING**: Calibration reagents may be hazardous to your health. See *Appendix D Health and Safety* for more information.

NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the ORP sensor with a small amount of solution that can be discarded. Be certain that you avoid cross-contamination with other solutions.

5. Carefully immerse the sensor end of the probe module into the solution.

6. Gently rotate and/or move the probe module up and down to remove any bubbles from the ORP sensor.

NOTE: The sensor must be completely immersed. Using the recommended volumes from Table 6.1 Calibration Volumes should ensure that the sensor is covered.

7. Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

NOTE: Do not overtighten as this could cause damage to the threaded portions.

8. Use the keypad to enter the correct value of the calibration solution you are using at the current temperature. Refer to Table 6.2 Zobel Solution Values.

Temperature °C	Zobell Solution Value, mV
-5	270.0
0	263.5
5	257.0
10	250.5
15	244.0
20	237.5
25	231.0
30	224.5
35	218.0
40	211.5
45	205.0
50	198.5

Table 6.2 Zobel Solution Values

9. Press **Enter**. The ORP calibration screen is displayed.

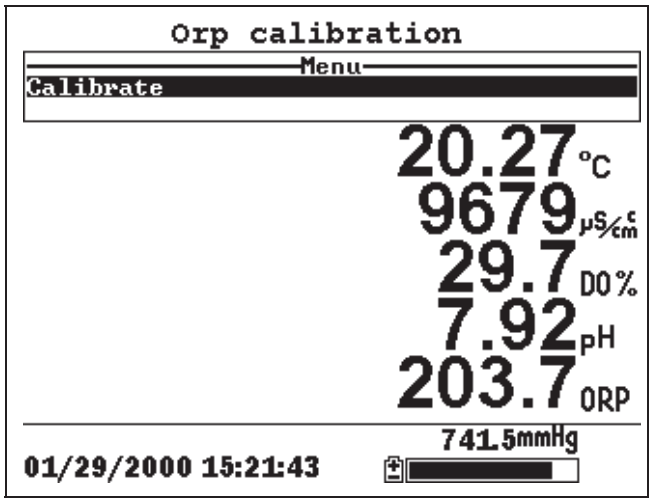


Figure 6.16 ORP Calibration Screen

10. Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

NOTE: Verify that the temperature reading matches the value you used in Table 6.2 Zobel Solution Values.

11. Observe the reading under ORP, when the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.

12. Press **Enter**. This returns you to the Calibrate Screen. See Figure 6.2 Calibrate Screen.

13. Rinse the probe module and sensors in tap or purified water and dry.

6.3 Return to Factory Settings

1. Go to the calibrate screen as described in Section *6.2.1 Accessing the Calibrate Screen*.

2. Use the arrow keys to highlight the **Conductivity** selection. See Figure 6.2 Calibrate Screen.

   NOTE: We will use the Conductivity sensor as an example; however, this process will work for any sensor.

3. Press **Enter.** The Conductivity Calibration Selection Screen is displayed. See Figure 6.3 Conductivity Calibration Selection Screen.

4. Use the arrow keys to highlight the **Specific Conductance** selection.

5. Press **Enter.** The Conductivity Calibration Entry Screen is displayed. See Figure 6.4 Conductivity Calibration Entry Screen.

6. Press and hold the **Enter** key down and press the **Escape** key.

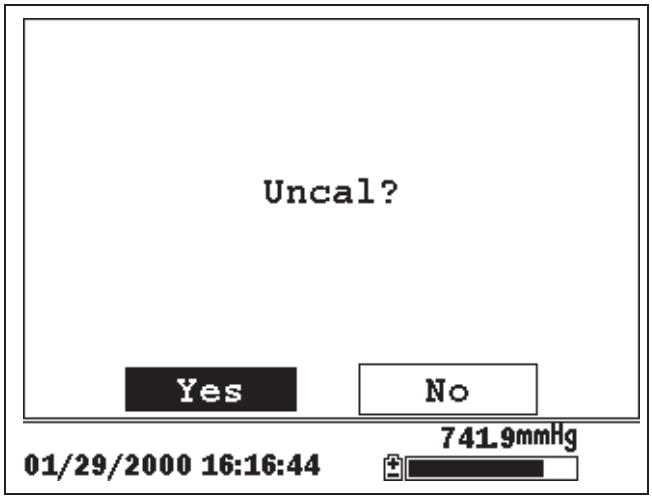


Figure 6.17 ORP Calibration Screen

7. Use the arrow keys to highlight the **YES** selection.

CAUTION: This returns a sensor to the factory settings. For example, in selecting to return specific conductance to the factory setting, salinity and conductivity will automatically return to their factory settings.

8. Press **Enter**. This returns you to the Conductivity Calibrate Selection Screen, See Figure 6.3 Conductivity Calibration Selection Screen.

9. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

7. Run

The Run screen displays data from the sensors in real-time and allows the user to log sample data to memory for later analysis. Refer to Section *9 Logging* for details on logging sample data.

7.1 Real-Time Data

NOTE: Before measuring samples you must prepare the probe module (refer to Section *3.4 Preparing the Probe Module*), attach the probe module to the instrument (refer to Section *3.6 Instrument/Cable Connection*) and calibrate the sensors (refer to Section *6 Calibrate*).

1. Press the **On/off** key.

OR select Run from the main menu to display the run screen.

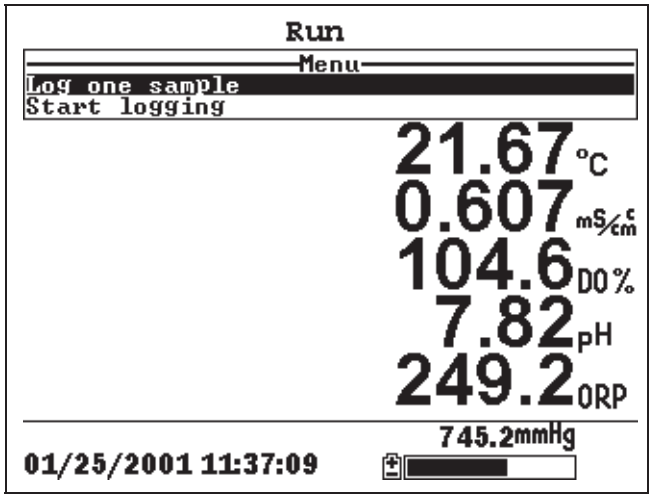


Figure 7.1 Run Screen

2. Make sure the probe sensor guard is installed.

3. Place the probe module in the sample. Be sure to completely immerse all the sensors.

4. Rapidly move the probe module through the sample to provide fresh sample to the DO sensor.

5. Watch the readings on the display until they are stable.

6. Refer to Section *9 Logging* for instructions on logging sample data.

8. File

The File menu allows the user to view, upload or delete sample data and calibration record files stored in the YSI 556 MPS.

8.1 Accessing the File Screen

1. Press the **On/off** key to display the run screen.

2. Press the **Escape** key to display the main menu screen.

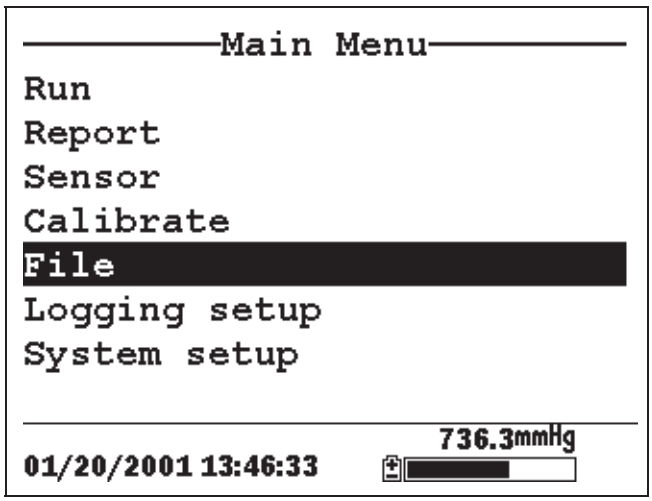


Figure 8.1 Main Menu Screen

3. Use the arrow keys to highlight the **File** selection.

4. Press the **Enter** key. The file screen is displayed.

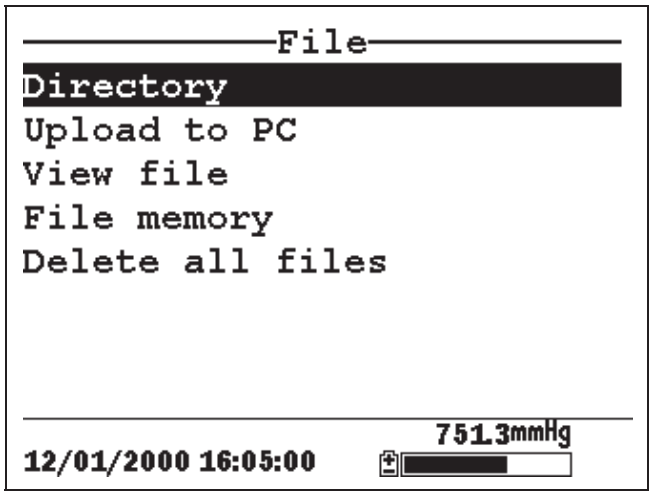


Figure 8.2 File Screen

8.2 Directory

1. Go to the file screen as described in Section *8.1 Accessing the File Screen*.

2. Use the arrow keys to highlight the **Directory** selection. See Figure 8.2 File Screen.

3. Press the **Enter** key. The file list screen is displayed.

   NOTE: Files are listed in the order in which they are logged to memory. Sample Data files have the file extension **.dat**, while Calibration Record files have the file extension **.glp**.

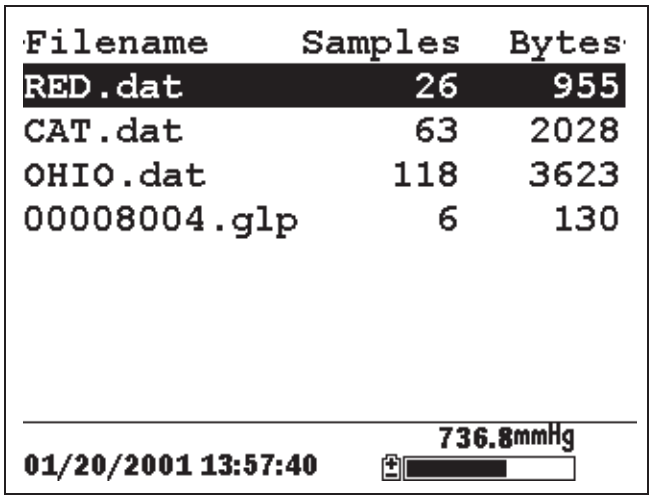


Figure 8.3 File List Screen

4. Use the arrow keys to highlight a file.

5. Press the **Enter** key. The file details screen is displayed.

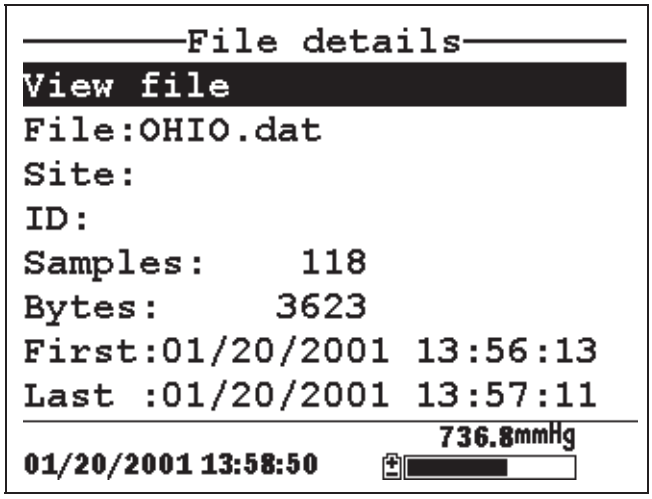


Figure 8.4 File Details Screen

6. Press the **Enter** key to view the file data. Refer to Section *8.3 View File* for details.

7. Press the **Escape** key repeatedly to return to the main menu screen.

8.3 View File

1. Go to the file screen as described in Section *8.1 Accessing the File Screen*. See Figure 8.2 File Screen.

2. Use the arrow keys to highlight the **View file** selection.

3. Press the **Enter** key. A list of files is displayed. See Figure 8.3 File List Screen.

4. Use the arrow keys to highlight an individual file.

   NOTE: You may have to scroll down to see all the files.

5. Press the **Enter** key. The file data is displayed with the file name at the top of the display.

   NOTE: If no file name was specified, the data is stored under the default name NONAME1.dat.

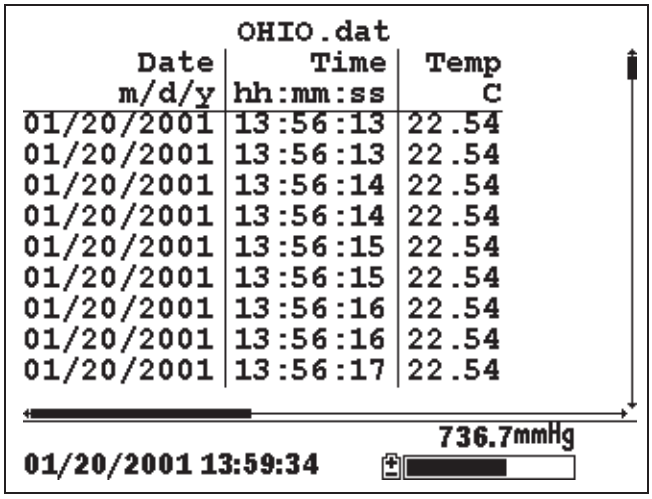


Figure 8.5 File Data Screen

6. Use the arrow keys to scroll horizontally and/or vertically to view all the data.

7. Press the **Escape** key repeatedly to return to the main menu screen.

8.4 Upload to PC

EcoWatch™ for Windows™ must be used as the PC software interface to the YSI 556 MPS. Refer to *Appendix G EcoWatch* for more information. EcoWatch for Windows is available at no cost via a download from the YSI Web Site (www.ysi.com) or by contacting YSI Customer Support. Refer to *Appendix E Customer Service.*

8.4.1 Upload Setup

1. Disconnect the YSI 5563 Probe Module from the YSI 556 MPS instrument.

2. Connect the YSI 556 MPS to a serial (Comm) port of your computer via the 655173 PC Interface cable as shown in the following diagram:

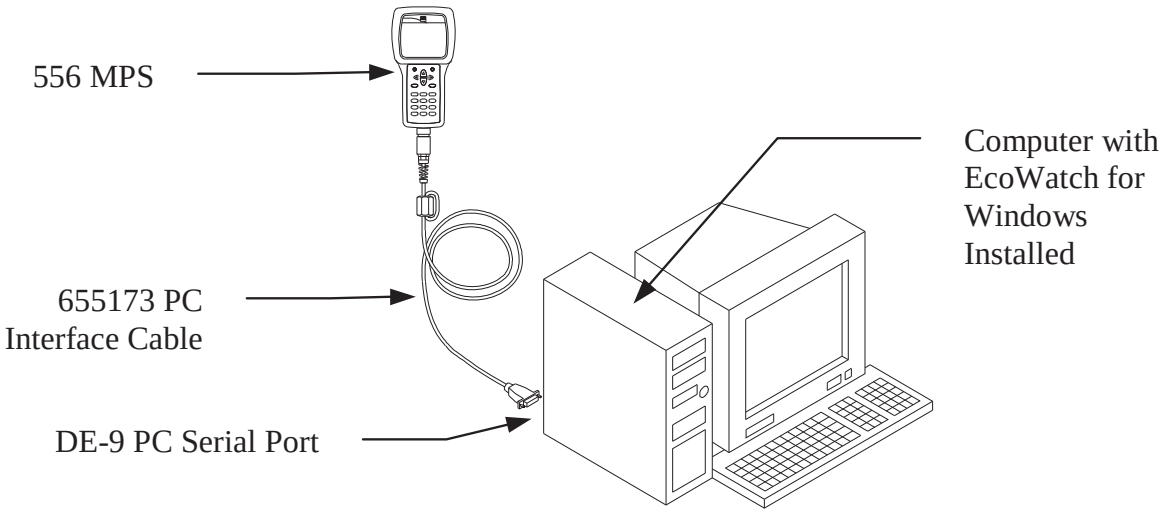


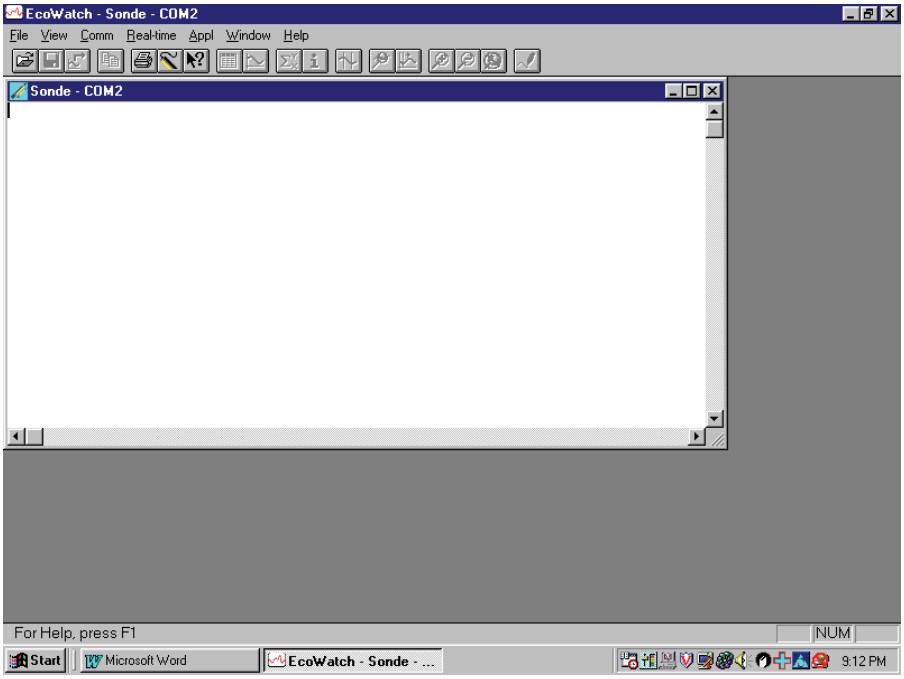
Figure 8.6 Computer/Instrument Interface

3. Open EcoWatch for Windows on your computer.

NOTE: See *Appendix G EcoWatch* for installation instructions.

4. Click on the sonde/probe icon  in the upper toolbar.

5. Set the Comm port number to match the port the YSI 556 MPS is connected to. After this setup procedure, the following screen will be present on your PC monitor:



8.4.2 Uploading a .DAT File

1. Setup the instrument as described in Section *8.4.1 Upload Setup*.

2. Go to the YSI 556 MPS file screen as described in Section *8.1 Accessing the File Screen.*

3. Use the arrow keys to highlight the **Upload to PC** selection. See Figure 8.2 File Screen.

4. Press the **Enter** key. The file list screen is displayed. See Figure 8.3 File List Screen.

5. Use the arrow keys to highlight the DAT file that you wish to transfer and press **Enter**, both the YSI 556 MPS and PC displays show the progress of the file transfer.

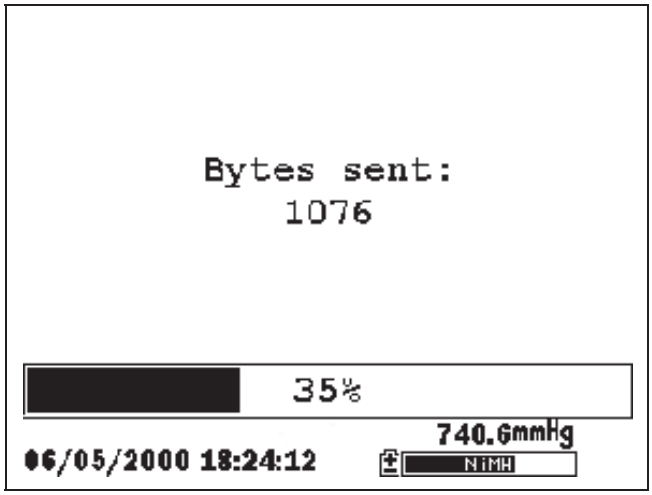
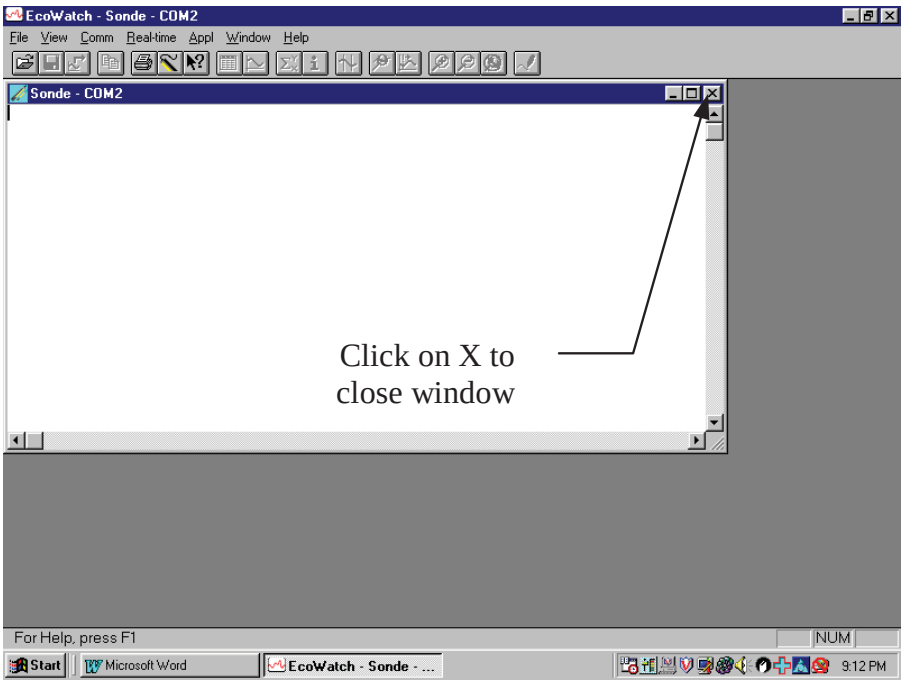


Figure 8.7 File Transfer Progress Screen

NOTE: After transfer, the file will be located in the C:\ECOWWIN\DATA folder of your PC, designated with a .DAT extension.

6. After the file transfer is complete, close the terminal window (small window on the PC) by clicking on the "X" at its upper right corner.



7. Press the **Escape** key on the YSI 556 MPS repeatedly to return to the main menu screen.

8.4.3 Uploading a Calibration Record (.glp) File

For more information on the calibration record, Refer to *Appendix H Calibration Record Information.*

1. Setup up the instrument as described in Section *8.4.1 Upload Setup*.

2. Go to the YSI 556 MPS file screen as described in Section *8.1 Accessing the File Screen.*

3. Use the arrow keys to highlight the **Upload to PC** selection. See Figure 8.2 File Screen.

4. Press the **Enter** key. The file list screen is displayed. See Figure 8.3 File List Screen.

5. Use the arrow keys to highlight the calibration record file that you wish to transfer and press **Enter.**

6. You will then be given a choice of uploading the file in three formats; **Binary, Comma & "" Delimited, and ASCII Text**.

   NOTE: The binary format is reserved for future YSI software packages.

7. Choose an option and press **Enter,** both the YSI 556 and PC displays show the progress of the file transfer.

   NOTE: After transfer, the file will be located in the C:\ECOWWIN\DATA folder of your PC, designated with the appropriate file extension.

   NOTE: To view the Calibration Record data after upload, simply open the .txt file in a general text editor such as Wordpad or Notepad.

8. After the file transfer is complete, close the terminal window (small window on the PC) by clicking on the "X" at its upper right corner.

9. Press the **Escape** key repeatedly to return to the main menu screen.

8.5 File Memory

1. Go to the file screen as described in Section *8.1 Accessing the File Screen*.

2. Use the arrow keys to highlight the **File memory** selection. See Figure 8.2 File Screen.

3. Press the **Enter** key. The file bytes used screen is displayed.

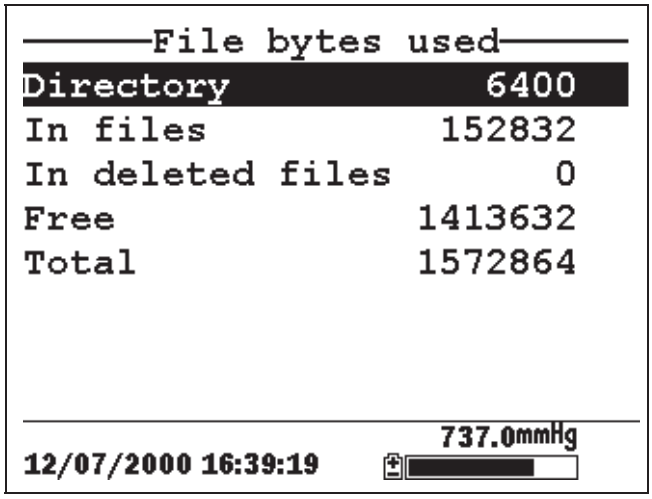


Figure 8.8 File Bytes Used Screen

4. The amount of free memory is listed in line 4 of the file bytes used screen.

   NOTE: If the amount of free memory is low, it may be time to delete all files (after first uploading all data to a PC). Refer to Section *8.6 Delete All Files*.

5. Press the **Escape** key repeatedly to return to the main menu screen.

8.6 Delete All Files

NOTE: It is not possible to delete individual files in order to free up memory. The only way to free up memory is to delete ALL files present. Take care to transfer all files to your computer (refer to Section *8.4 Upload to PC*) *before* deleting them.

1. Go to the file screen as described in Section *8.1 Accessing the File Screen*.

2. Use the arrow keys to highlight the **Delete all files** selection. See Figure 8.2 File Screen.

3. Press the **Enter** key. The Delete all Files screen is displayed.

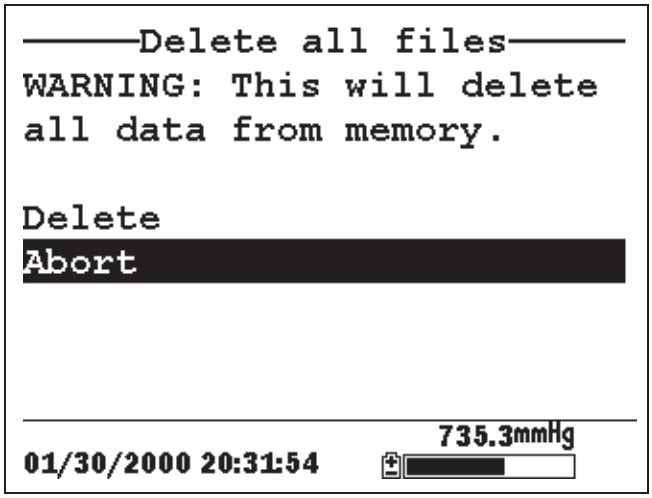


Figure 8.9 Delete All Files Screen

4. Use the arrow keys to highlight the **Delete** selection.

5. Press the **Enter** key.

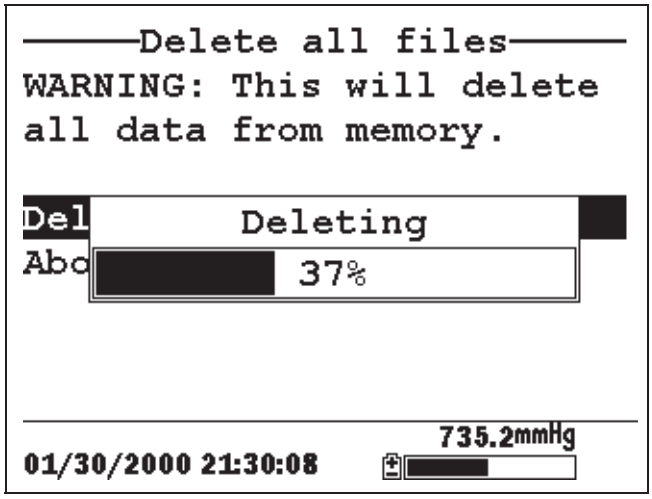


Figure 8.10 Deleting

The progress of file deletion is displayed in bar graph format.

NOTE: Deleting all files in the directory will not change any information in the site list.

6. Press the **Escape** key repeatedly to return to the main menu screen.

9. Logging

9.1 Accessing the Logging Setup Screen

1. Press the **On/off** key to display the run screen.

2. Press the **Escape** key to display the main menu screen.

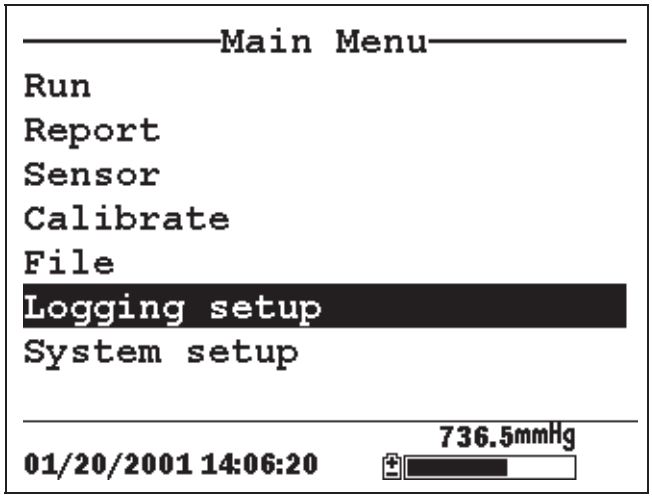


Figure 9.1 Main Menu

3. Use the arrow keys to highlight the **Logging setup** selection.

4. Press the **Enter** key. The logging setup screen is displayed.

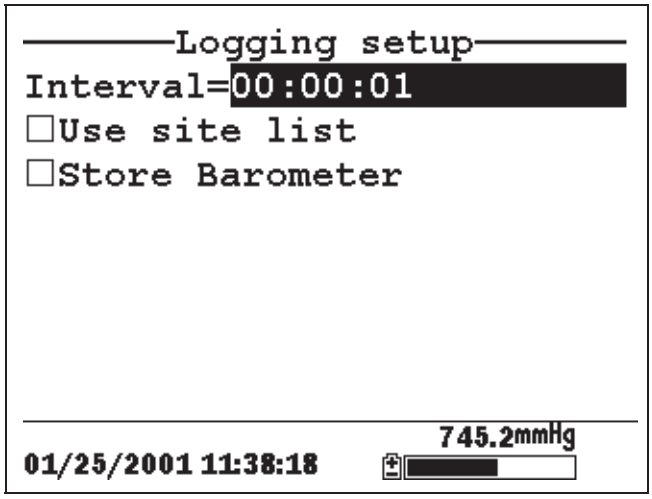


Figure 9.2 Logging Setup Screen

9.2 Setting Logging Interval

Follow steps below to set the interval for logging a data stream.

NOTE: If you do not specify an interval, the instrument will use a default interval setting of 1 second.

NOTE: It is not necessary to set a logging interval when logging a single sample.

1. Go to the logging setup screen as described in Section *9.1 Accessing the Logging Setup Screen*.

2. Use the keypad to enter an interval between 1 second and 15 minutes. Refer to Section *2.9 Keypad Use*.

   NOTE: The interval field has hour, minute and second entry fields. Any entry over 15 minutes will change automatically to a 15-minute setting.

3. Press the **Enter** key. The data stream interval is set.

4. Press the **Escape** key repeatedly to return to the main menu screen.

9.3 Storing Barometer Readings

NOTE: The **Store barometer** option is only available on instruments that are equipped with the optional barometer.

1. Go to the logging setup screen as described in Section *9.1 Accessing the Logging Setup Screen*.

2. Use the arrow keys to highlight the **Store barometer** selection. See Figure 9.2 Logging Setup Screen.

3. Press the **Enter** key until a check mark is entered in the box next to the store barometer selection if you want to log barometric readings.

   OR press the **Enter** key until the box next to the barometer selection is empty if you do not want to log barometric readings.

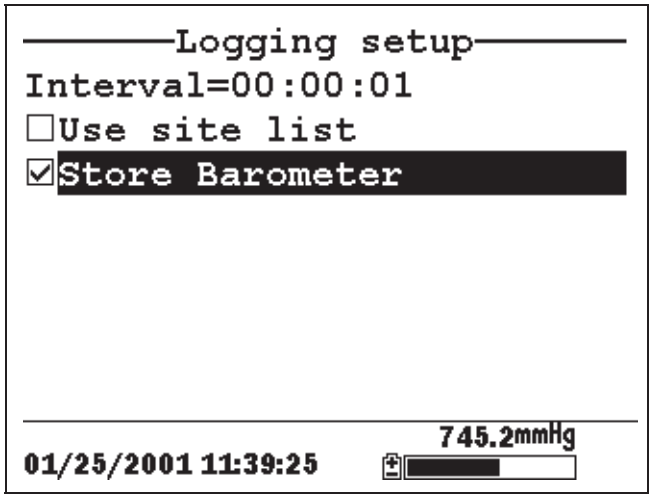


Figure 9.3 Store Barometer

4. Press the **Escape** key repeatedly to return to the main menu screen.

9.4 Creating a Site List

The site list option allows you to define file and site descriptions in the office or laboratory before moving to field logging studies. This is usually more convenient than entering the information at the site and is particularly valuable if you are visiting certain sites on a regular basis. The following section describes how to set up site lists which contain entries designated "Site Descriptions" that will be instantly available to the user in the field to facilitate the logging of data with pre-established naming of files and sites. There are two kinds of **Site Descriptions** available for use in Site lists:

- **Site Descriptions** associated with applications where data from a single site is always logged to a single file. This type is referred to as a "Single-Site Description" and is characterized by two parameters – a file name and a site name. Files logged to YSI 556 MPS memory under a **Single-Site Description** will be characterized primarily by the file name, but will also have the Site name attached, so that it is viewable in either the YSI 556 MPS **File directory** or in EcoWatch for Windows after upload to a PC

- **Site Descriptions** associated with applications where data from multiple sites are logged to a single file. This type is referred to as a "Multi-site Description" and is characterized by three parameters – a file name, a site name, and a site number. Files logged to YSI 556 MPS memory under a **Multi-site Description** are characterized by a file name, but not a site name, since multiple sites are involved. However, each data point has a Site Number attached to it so that the user can easily determine the sampling site when viewing the data from the YSI 556 MPS **File** menu or processing the data in EcoWatch for Windows after upload to a PC.

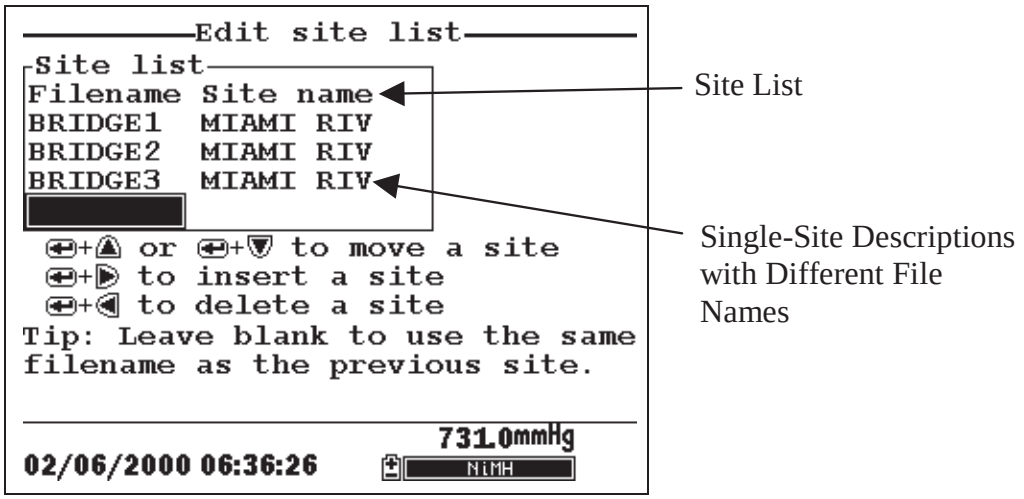


Figure 9.4 Single-Site Descriptions

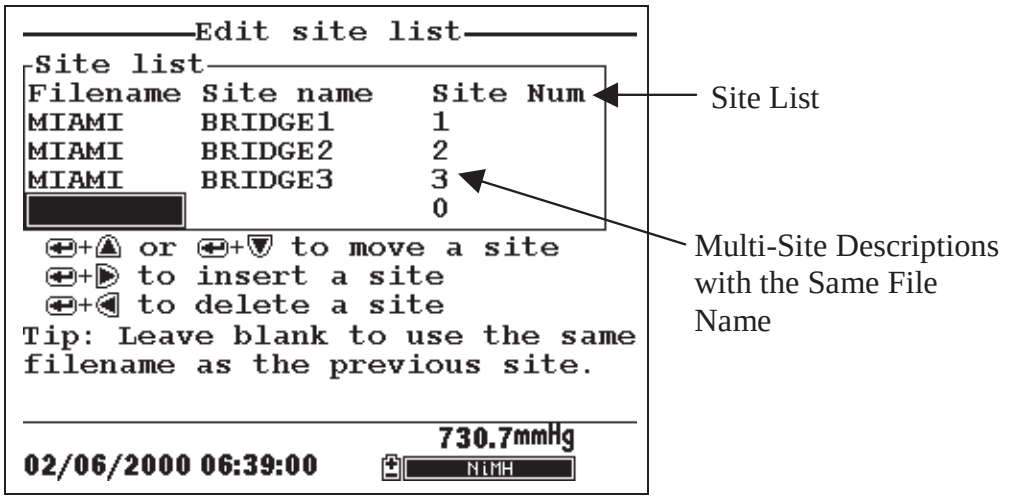


Figure 9.5 Multiple-Site Descriptions

NOTE: Site lists containing Single Site Descriptions are usually input with the designation **Store Site Number** INACTIVE in the YSI 556 MPS **Logging setup** menu. Thus, no site numbers appear in the first **Site list** example. Conversely, **Site lists** containing **Multi-Site Descriptions** MUST be input with the **Store Site Number** selection ACTIVE as shown in the second example.

To create a site list:

1. Go to the logging setup screen as described in Section *9.1 Accessing the Logging Setup Screen*.

2. Use the arrow keys to highlight the **Use site list** selection.

3. Press the **Enter** key. A check mark is entered in the box next to the use site list selection *and* two new entries appear on the logging setup screen. See Figure 9.6 Logging Setup Screen.

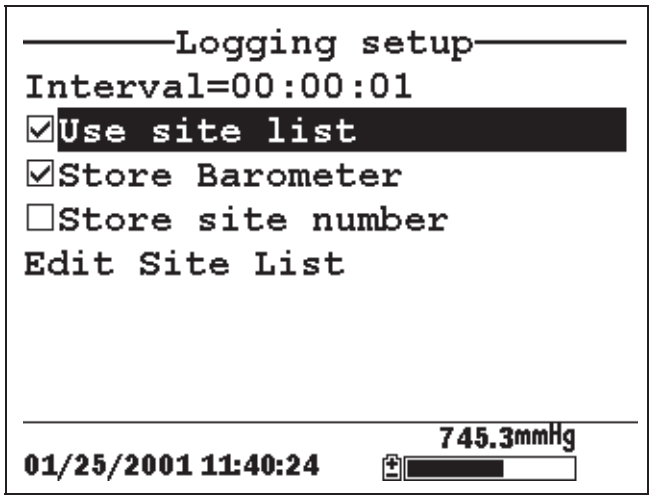


Figure 9.6 Logging Setup Screen

4. Use the arrow keys to highlight the **Store site number** selection.

5. If you are creating Multi-Site Descriptions (which require that the site **number** be stored in your data files), press the **Enter** key until a check mark appears in the box next to the store site number selection.

OR Press the **Enter** key until the box next to the store site number selection is empty, to create Single-Site Descriptions. The site **name** will be stored in the header of your data files.

6. Use the arrow keys to highlight the **Edit site list** selection.

7. Press the **Enter** key. The edit site list screen is displayed. See Figure 9.7 Edit Site List Screen. The **Filename** field is ready for input.

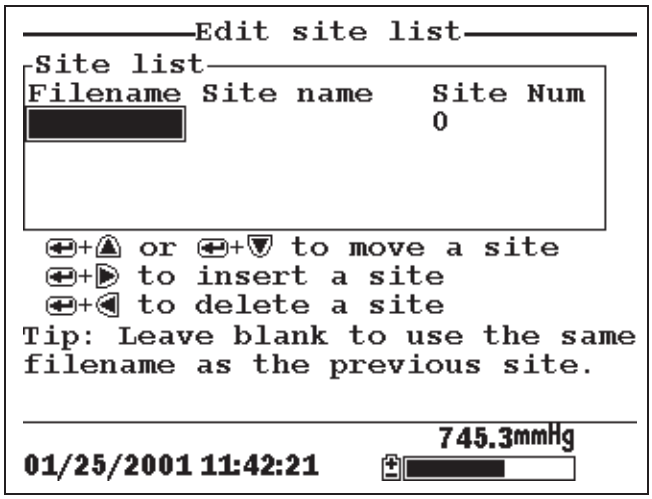


Figure 9.7 Edit Site List Screen

8. Use the keypad to enter a filename up to 8 characters in length. Refer to Section *2.9 Keypad Use*.

9. Press the **Enter** key. The cursor moves to the right for the entry of a **Site name**.

10. Use the keypad to enter a site name up to 11 characters in length. Refer to Section *2.9 Keypad Use*.

NOTE: If the store site number selection is *not* checked, skip to Step 13.

11. Press the **Enter** key. The cursor moves to the site number entry position.

12. Use the keypad to enter a site number up to 7 characters in length. Refer to Section *2.9 Keypad Use*.

13. Press **Enter**. The cursor moves to the next filename entry position.

14. Repeat Steps 8 to 13 until all filenames and sites have been entered.

15. Press **Escape** repeatedly to return to the main menu screen.

9.5 Editing a Site List

1. Go to the logging setup screen as described in Section *9.1 Accessing the Logging Setup Screen*.

2. Use the arrow keys to highlight the **Edit Site List** selection. See Figure 9.6 Logging Setup Screen.

3. Press the **Enter** key. The edit site list screen is displayed.

4. Edit the site list using the keystrokes described below.

   NOTE: Editing the site list will not have any effect on files stored in the instrument memory.

To MOVE a site: **Use the arrow keys to highlight a site. Press the Up or Down arrow key while holding down the Enter key.**

To INSERT a site above another site: **Use the arrow keys to highlight the site. Press the** Right **arrow key while holding down the** Enter **key. Use keypad to input letters. Refer to Section *2.9 Keypad Use*.**

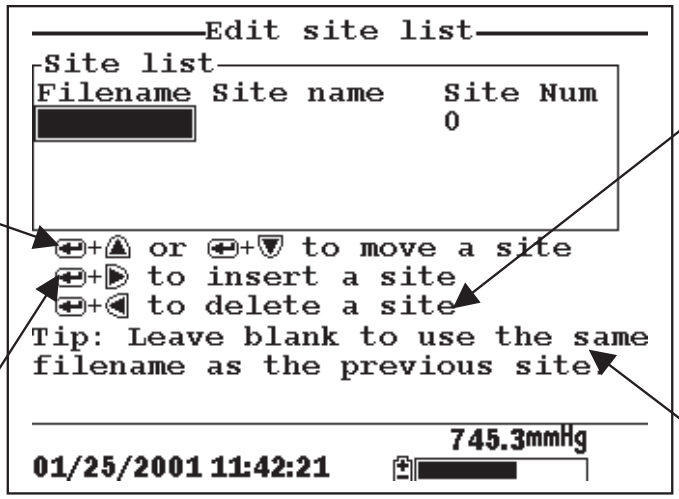


Figure 9.8 Keystrokes for Editing Site List

To DELETE a site: **Use the arrow keys to highlight a site. Press the Left arrow key while holding down the Enter key.**

To use the same file name as the previous site: **Leave the filename blank.**

9.6 Logging Data Without a Site List

1. Follow Steps 1 through 5 in Section 7.1 Real-Time Data.

2. Use the arrow keys to highlight the **Log one sample** selection on the run screen if only a single sample is being logged.

   OR Use the arrow keys to highlight the **Start logging** selection on the run screen if a data stream is being logged.

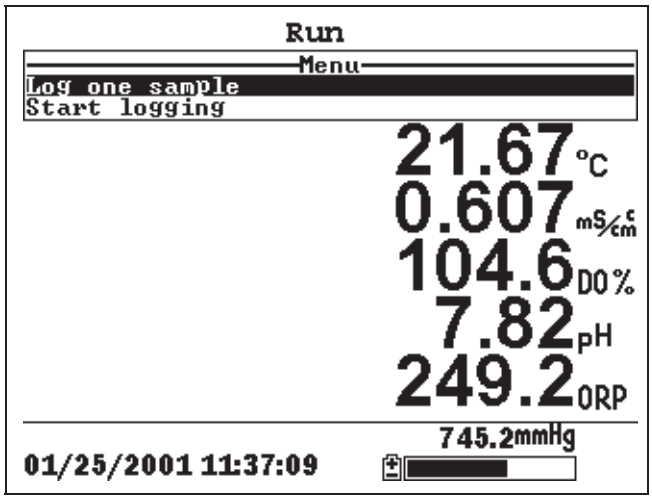


Figure 9.9 Run Screen

3. Press the **Enter** key. The Enter information screen is displayed.

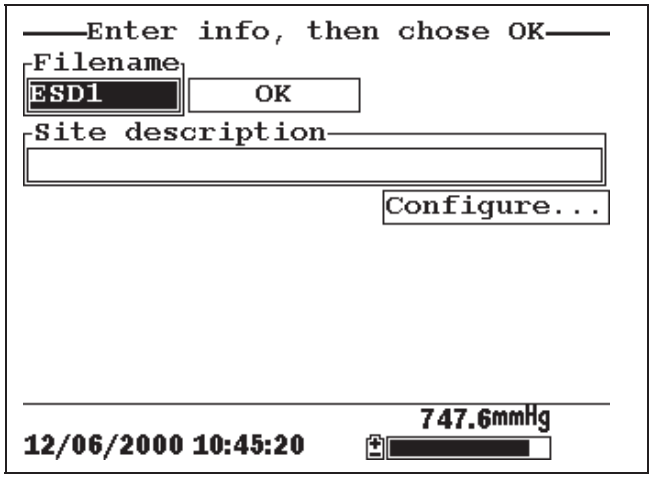


Figure 9.10 Enter Information Screen

NOTE: The last filename used will be displayed.

4. Use the keypad to enter a file name. Refer to Section *2.9 Keypad Use*.

   NOTE: The instrument will assign a default file name of NONAME if no file name is specified.

5. Press the **Enter** key to input the file name.

6. Use the arrow keys to highlight the **Site description** field in the enter information screen.

   NOTE: Entering a Site Description is optional. You may leave the Site Description blank and skip to Step 9.

7. Use the keypad to enter a site description name. Refer to Section *2.9 Keypad Use*.

8. Press the **Enter** key to input the site description.

   NOTE: If you want to change the logging setup, such as sampling interval or storing the barometer reading, use the arrow keys to highlight the **Configure** field, press the **Enter** key, then refer to Section *9.2 Setting Logging Interval* or *9.3 Storing Barometer Readings* for details.

9. Use the arrow keys to highlight the **OK** field in the center of the information screen.

10. Press the **Enter** key to start logging.

    NOTE: If the parameter mismatch screen is displayed, refer to Section *9.8 Adding Data to Existing Files*.

11. If a single point is being logged, the header on the run screen changes momentarily from **Menu** to **Sample logged** to confirm that the point was successfully logged. Skip to Step 13.

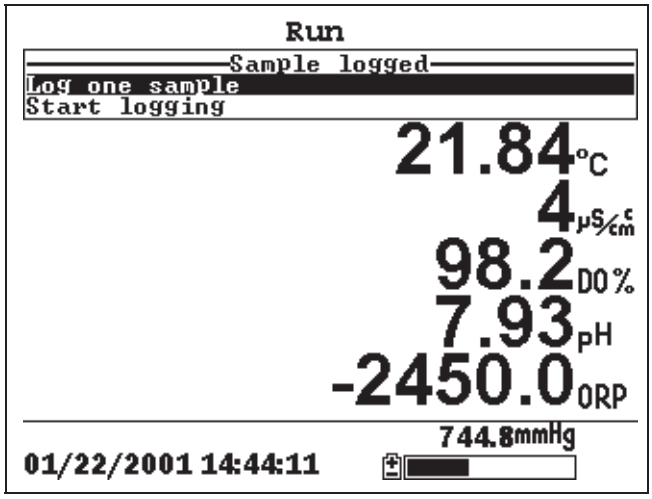


Figure 9.11 Sample Logged Screen

If a continuous stream of points is being logged, the start logging entry in the run screen changes from **Start logging** to **Stop logging**.

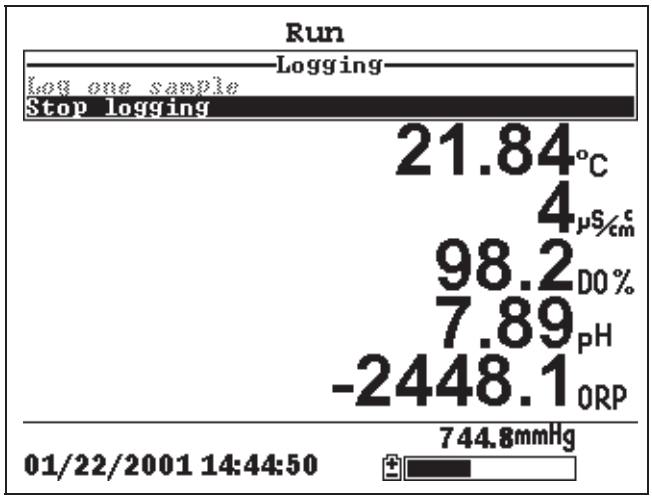


Figure 9.12 Logging Screen

12. At the end of the logging interval, press **Enter** to stop logging.

13. Refer to Section *8.3 View File* to view the data on the instrument display.

9.7 Logging Data With a Site List

1. If you have not already created a site list, refer to Section *9.4 Creating a Site List*.

2. Follow Steps 1 through 5 in Section 7.1 Real-Time Data.

3. Use the arrow keys to highlight the **Log one sample** selection on the run screen if only a single sample is being logged.

   OR Use the arrow keys to highlight the **Start logging** selection on the run screen if a data stream is being logged. See Figure 9.9 Run Screen.

4. Press the **Enter** key. The Pick a site screen is displayed.

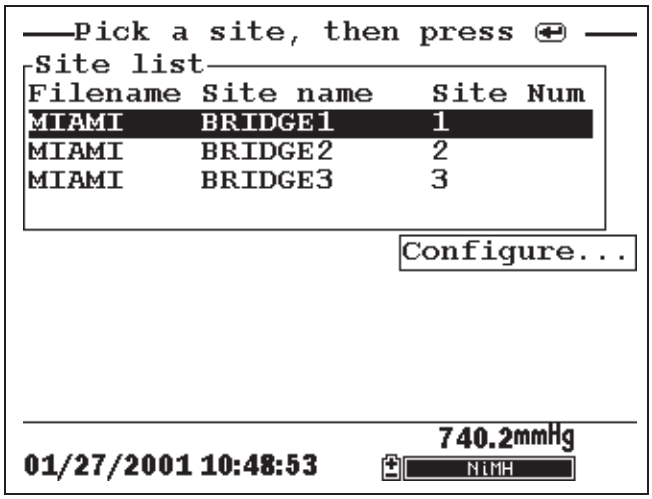


Figure 9.13 Pick a Site Screen

5. Use the arrow keys to highlight the **site** of your choice.

   NOTE: If the site of your choice is grayed out in the site list, refer to Section *9.8 Adding Data to Existing Files*.

   NOTE: Refer to Section *9.5 Editing a Site List* if you want to edit the site list.

6. Press the **Enter** key to start logging.

NOTE: If the parameter mismatch screen is displayed, refer to Section *9.8 Adding Data to Existing Files*.

7. If a single point is being logged, the header on the run screen changes momentarily from **Menu** to **Sample logged** to confirm that the point was successfully logged. See Figure 9.11 Sample Logged Screen. Skip to Step 9.

   If a continuous stream of points is being logged, the start logging entry in the run screen changes from **Start logging** to **Stop logging**. See Figure 9.12 Logging Screen.

8. At the end of the logging interval, press **Enter** to stop logging.

9. Refer to Section *8.3 View File* to view the data on the instrument display.

9.8 Adding Data to Existing Files

In order to add new data to an existing file, the current logging and sensor setup must be *exactly* the same as when the file was created. The following settings must be the same:

- **Sensors enabled** (refer to Section *4 Sensors*)
- **Store Barometer** (refer to Section *9.3 Storing Barometer Readings*)
- **Store Site Number** (refer to Section *9.4 Creating a Site List*)

If the current logging setup is not exactly the same as when the file was created, a parameter mismatch screen is displayed.

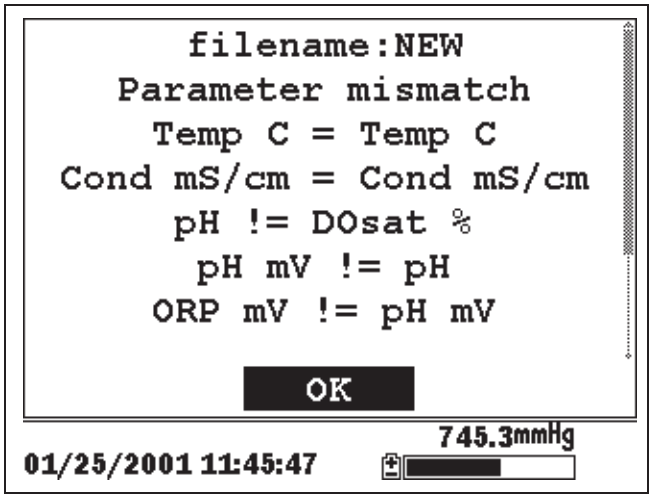


Figure 9.14 Parameter Mismatch Screen

NOTE: The right column shows parameters used when the file was created. The left column shows current parameters.

1. Press the **Down Arrow** key to scroll down and find the mismatch(es).

2. Use the following chart to resolve the mismatch(es).

Mismatch	Action	Reference
Sensor(s) missing from left column	Enable the missing sensor(s)	Section *4 Sensors*
Extra sensor(s) listed in left column	Disable the extra sensor(s)	Section *4 Sensors*
Barometer missing from left column, but present in right column	Enable the Store Barometer setting	Section *9.3 Storing Barometer Readings*
Barometer present in left column, but missing from right column	Disable the Store Barometer setting	Section *9.3 Storing Barometer Readings*
Store Site Number missing from left column, but present in right column	Enable the Store Site Number setting	Section *9.4 Creating a Site List*
Store Site Number present in left column, but missing from right column	Disable the Store Site Number setting	Section *9.4 Creating a Site List*

3. Return to Section *9.6 Logging Data Without a Site List* or *9.7 Logging Data With a Site List*.

10. System Setup

The YSI 556 MPS has a number of features that are user-selectable or can be configured to meet the user's preferences. Most of these choices are found in the **System setup** menu.

10.1 Accessing the System Setup Screen

1. Press the **On/off** key to display the run screen. See Figure 2.1 Front View of YSI 556 MPS.

2. Press the **Escape** key to display the main menu screen.

3. Use the arrow keys to highlight the **System setup** selection.

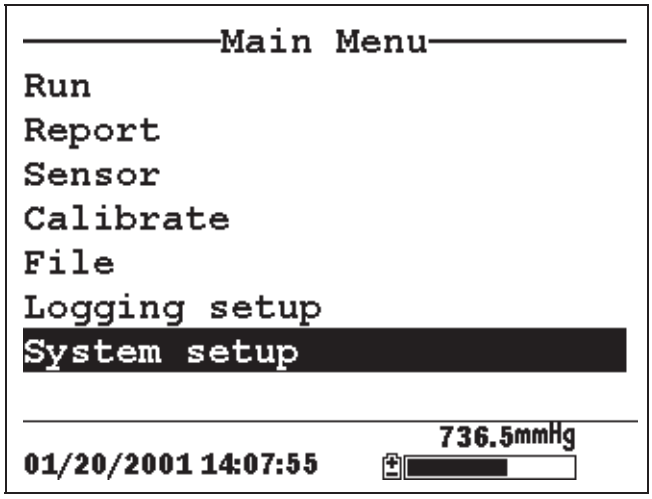


Figure 10.1 Main Menu

4. Press the **Enter** key. The system setup screen is displayed.

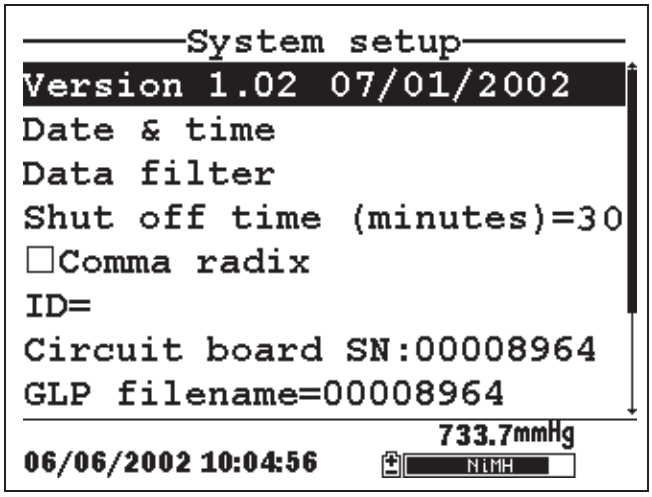


Figure 10.2 System Setup Screen

NOTE: The first line of the **System setup** menu shows the current software version of your YSI 556 MPS. As software enhancements are introduced, you will be able to upgrade your YSI 556 MPS from the YSI Web site. Refer to Section *11.2 Upgrading YSI 556 MPS* Software for details.

10.2 Date and Time Setup

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **Date & time** selection on the system setup screen. See Figure 10.2 System Setup Screen.

3. Press **Enter**. The date and time setup screen is displayed.

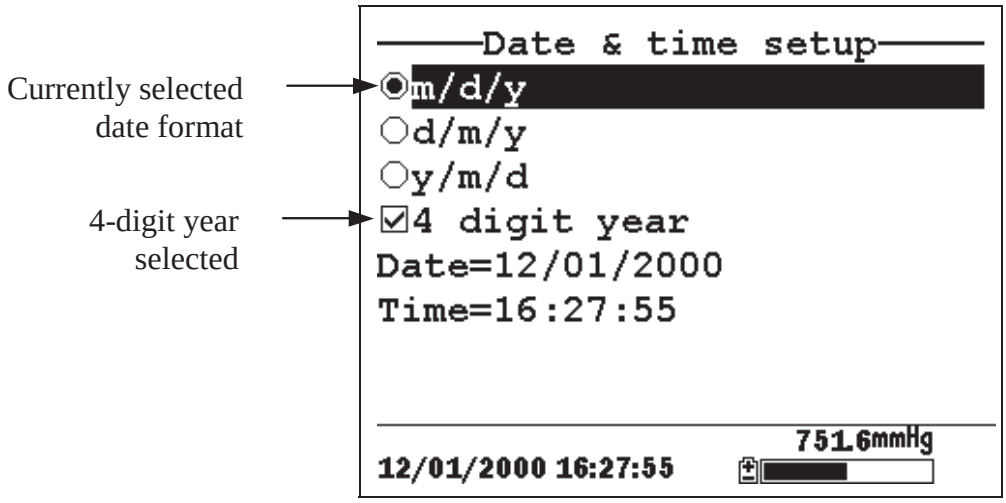


Figure 10.3 Date Setup Screen

NOTE: A black dot to the left of a date format indicates that format is selected.

4. Use the arrow keys to highlight your desired date format.

5. Press **Enter**.

6. Use the arrow keys to highlight the 4-digit year selection.

7. Press **Enter**. A check mark appears in the check box next to the 4-digit year selection.

NOTE: If unchecked, a 2-digit year is used.

8. Use the arrow keys to highlight the **Date** selection.

9. Press **Enter**. A cursor appears over the first number in the date.

10. Enter the proper number from the keypad for the highlighted date digit. The cursor moves automatically to the next date digit. Refer to Section *2.9 Keypad Use* for more keypad information.

11. Repeat Step 10 until all date digits are correct.

12. Press **Enter** to input the specified date.

13. Use the arrow keys to highlight the **Time** selection.

14. Press **Enter**. A cursor appears over the first number in the time selection.

15. Enter the proper number from the keypad for the highlighted time digit. The cursor moves automatically to the next time digit.

NOTE: Use military format when entering time. For example, 2:00 PM is entered as 14:00.

16. Repeat Step 15 until all time digits are correct.

17. Press **Enter** to input the correct time.

18. Press the **Escape** key repeatedly to return to the Main menu screen.

10.3 Data Filter

The Data Filter is a software filter that eliminates sensor noise and provides more stable readings.

NOTE: YSI recommends using the default values for the data filter for most field applications.

However, users who are primarily interested in a fast response from their dissolved oxygen sensor should consider a change of the default time constant setting of 8 seconds to one of 2 seconds. This change can be made according to the instructions in Section *10.3.1 Changing the Data Filter Settings* below. The disadvantage of lowering the time constant is that field pH readings may appear somewhat noisy if the cable is in motion.

10.3.1 Changing the Data Filter Settings

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **Data filter** selection. See Figure 10.1 Main Menu.

3. Press the **Enter** key. The Data filter setup screen is displayed.

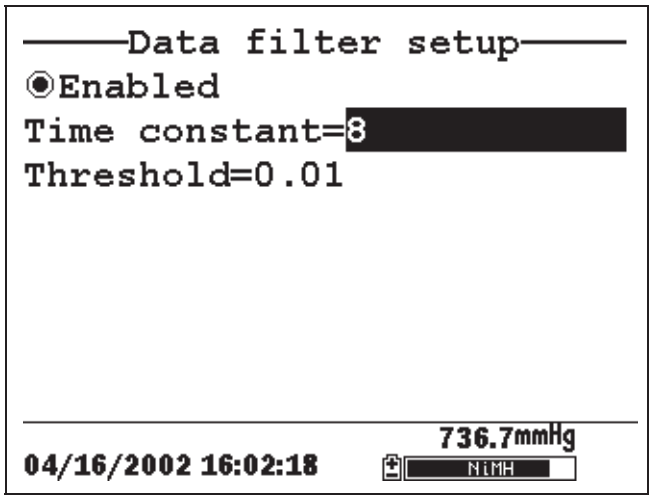


Figure 10.4 Data Filter Screen

4. With Enabled highlighted, press the **Enter** key to Enable or Disable the data filter. A black dot to the left of the selection indicates the data filter is enabled.

5. Use the arrow keys to highlight the **Time constant** field.

   NOTE: This value is the time constant in seconds for the software data filter. Increasing the time constant will result in greater filtering of the data, but will also slow down the apparent response of the sensors.

6. Use the keypad to enter a value. The default value is 8 and this value is ideal for most 556 field applications. As described in Section *10.3 Data Filter* above, users who wish to decrease the response time of the DO readings at the expense of some noise for the pH readings determined concurrently, should change the Time Constant to a value of 2.

7. Press the **Enter** key to enter the time constant.

8. Use the arrow keys to highlight the **Threshold** field.

   NOTE: This value determines when the software data filter will engage/disengage, speeding the response to large changes in a reading. When the difference between two consecutive readings is larger than the threshold, then the reading is displayed unfiltered. When the difference between two consecutive readings drops below the threshold, readings will be filtered again.

9. Use the keypad to enter a value. The default value is 0.01.

10. Press the **Enter** key to enter the threshold.

11. Press the **Escape** key repeatedly to return to the Main menu screen.

10.4 Shutoff Time

The YSI 556 MPS shuts off automatically after 30 minutes of inactivity. The shut off time may be changed as described below.

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **Shutoff time** selection on the system setup screen. See Figure 10.2 System Setup Screen.

3. Use the keypad to enter a value from 0 to 60 minutes. The default value is 30.

   NOTE: To disable the automatic shutoff feature, enter a zero (0).

4. Press the **Enter** key to enter the correct shutoff time.

5. Press the **Escape** key repeatedly to return to the main menu screen.

10.5 Comma Radix

The user can toggle between a period (default) and comma for the radix mark by selecting this item and pressing the **Enter** key as follows:

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **Comma radix** selection on the system setup screen. See Figure 10.2 System Setup Screen.

3. Press the **Enter** key. A check mark appears in the check box next to the comma radix selection indicating that the radix mark is a comma.

10.6 ID

This selection allows you to enter an identification name/number for your YSI 556 MPS. This ID name/number is logged in the header of each file.

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **ID** selection. See Figure 10.1 Main Menu.

3. Use the keypad to enter an alphanumeric ID up to 15 characters in length. Refer to Section *2.9 Keypad Use*.

4. Press the **Enter** key to enter the ID.

5. Press the **Escape** key repeatedly to return to the main menu screen.

10.7 GLP Filename

This selection allows you to enter a different filename for the YSI 556 MPS Calibration Record file.

NOTE: The default filename is the "556 PC board Serial Number.glp."

6. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

7. Use the arrow keys to highlight the **GLP Filename** selection. See Figure 10.1 Main Menu.

8. Use the keypad to enter a filename up to 8 characters in length. Refer to Section *2.9 Keypad Use*.

9. Press the **Enter** key to enter the new filename.

Press the **Escape** key repeatedly to return to the main menu screen.

10.8 TDS Constant

This selection allows you to set the constant used to calculate Total Dissolved Solids (TDS). TDS in g/L is calculated by multiplying this constant times the specific conductance in mS/cm.

10.8.1 Changing the TDS Constant

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **TDS Constant** selection. See Figure 10.1 Main Menu.

3. Use the keypad to enter a value. Refer to Section *2.9 Keypad Use*. The default value is 0.65.

4. Press the **Enter** key to enter the correct TDS constant.

5. Press the **Escape** key repeatedly to return to the main menu screen.

10.9 Barometer Units

The following information is only for instruments with the barometer option.

1. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

2. Use the arrow keys to highlight the **Barometer units** selection on the system setup screen. See Figure 10.2 System Setup Screen.

3. Press the **Enter** key. The Barometer units screen will appear.

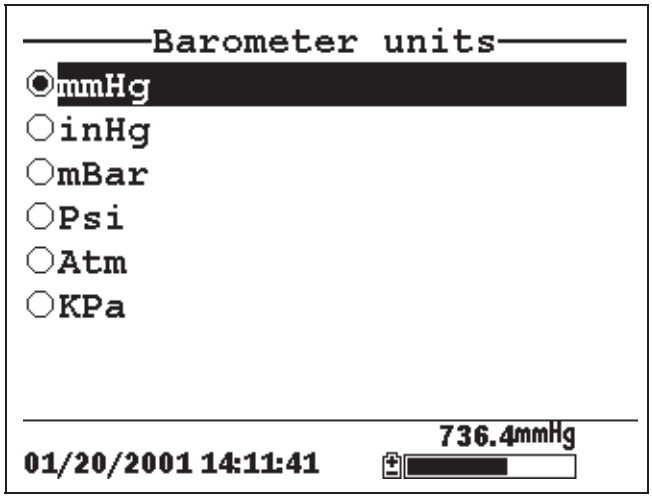


Figure 10.5 Barometer Units Screen

A black dot indicates the currently selected units.

4. Use the arrow keys to highlight your desired barometric unit.

5. Press the **Enter** key to select your choice. A black dot will appear in the circle next to your selected units.

6. Press the **Escape** key repeatedly to return to the main menu screen.

10.10 Calibrate Barometer

The optional barometer has been factory calibrated to provide accurate readings. However, some sensor drift may occur over time, requiring occasional calibration by the user, as follows:

1. Determine your local barometric pressure from an independent laboratory barometer or from your local weather service.

2. If the barometric pressure (BP) reading is from your local weather station, reverse the equation that corrects it to sea level.

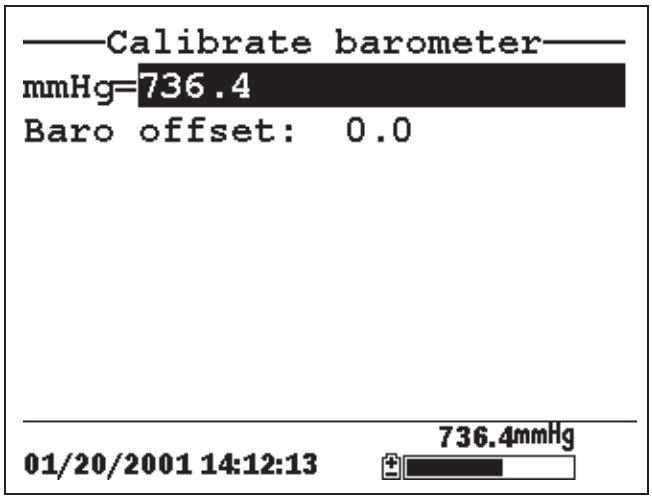
   NOTE: For this equation to be accurate, the barometric pressure units must be in mm Hg.

   True BP = (Corrected BP) – [2.5 * (Local Altitude/100)]

3. Go to the system setup screen as described in Section *10.1 Accessing the System Setup Screen*.

4. Use the arrow keys to highlight the **Calibrate barometer** selection on the system setup screen. See Figure 10.2 System Setup Screen.

5. Press the **Enter** key. The Calibrate Barometer screen is displayed.



6. Use the keypad to input the known barometric pressure value as determined in Step 2.

7. Press the **Enter** key. The new barometer reading is displayed as well as the approximate offset from the factory reading.

   NOTE: To return the sensor to the factory setting, subtract the offset amount from the current setting and repeat Steps 5 to 7.

8. Press the **Escape** key repeatedly to return to the main menu screen.

11. Maintenance

11.1 Sensor Care and Maintenance

Once the sensors have been properly installed, remember that periodic cleaning and DO membrane changes are required.

11.1.1 DO Sensor

For best results, we recommend that the KCl solution and the membrane cap be changed at least once every 30 days.

1. It is important to recognize that oxygen dissolved in the sample is consumed during sensor operation. It is therefore essential that the sample be continuously stirred at the sensor tip. If stagnation occurs, your readings will be artificially low. Stirring may be accomplished by mechanically moving the sample around the sensor tip, or by rapidly moving the sensor through the sample. The rate of stirring should be at least 1 foot per second.

2. Membrane life depends on usage. Membranes will last a long time if installed properly and treated with care. Erratic readings are a result of loose, wrinkled, damaged, or fouled membranes, or from large (more than 1/8" diameter) bubbles in the electrolyte reservoir. If erratic readings or evidence of membrane damage occurs, you should replace the membrane and the electrolyte solution. The average replacement interval is two to four weeks.

3. If the membrane is coated with oxygen consuming (e.g. bacteria) or oxygen producing organisms (e.g. algae), erroneous readings may occur.

4. Chlorine, sulfur dioxide, nitric oxide, and nitrous oxide can affect readings by behaving like oxygen at the sensor. If you suspect erroneous readings, it may be necessary to determine if these gases are the cause.

5. Avoid any environment that contains substances that may attack the probe module and sensor materials. Some of these substances are concentrated acids, caustics, and strong

solvents. The sensor materials that come in contact with the sample include FEP Teflon, acrylic plastic, EPR rubber, stainless steel, epoxy, polyetherimide and the PVC cable covering.

6. It is possible for the silver anode, which is the entire silver body of the sensor, to become contaminated. This will prevent successful calibration. To restore the anode, refer to Section *11.1.1 DO Sensor, Silver Anode Cleaning.*

7. For correct sensor operation, the gold cathode must always be bright. If it is tarnished (which can result from contact with certain gases), or plated with silver (which can result from extended use with a loose or wrinkled membrane), the gold surface must be restored. To restore the cathode, refer to Section *11.1.1 DO Sensor, Gold Cathode Cleaning.*

8. To keep the electrolyte from drying out, store the sensor in the transport/calibration cup with at least 1/8″ of water.

Silver Anode Cleaning

After extended use, a thick layer of AgCl builds up on the silver anode reducing the sensitivity of the sensor. The anode must be cleaned to remove this layer and restore proper performance. The cleaning can be chemical or mechanical:

Chemical Cleaning: Remove the membrane cap and soak the entire anode section in a 14% ammonium hydroxide solution for 2 to 3 minutes, followed by a thorough rinsing with distilled or deionized water. The anode should then be thoroughly wiped with a wet paper towel to remove the residual layer from the anode.

Mechanical Cleaning: Sand off the dark layer from the silver anode with 400 grit wet/dry sandpaper. Wrap the sandpaper around the anode and twist the sensor. Rinse the anode with clean water after sanding, followed by wiping thoroughly with a wet paper towel.

NOTE: After cleaning, a new membrane cap must be installed. Refer to Section *3.4.3 Membrane Cap Installation***.**

Turn the instrument on and allow the system to stabilize for at least 30 minutes. If, after several hours, you are still unable to calibrate, contact your dealer or YSI Customer Service. Refer to *Appendix E Customer Service*.

Gold Cathode Cleaning

For correct sensor operation, the gold cathode must be textured properly. It can become tarnished or plated with silver after extended use. The gold cathode can be cleaned by using the adhesive backed sanding disc and tool provided in the YSI 5238 Probe Reconditioning Kit.

Using the sanding paper provided in the YSI 5238 Probe Reconditioning Kit, wet sand the gold with a twisting motion about 3 times or until all silver deposits are removed and the gold appears to have a matte finish. Rinse the cathode with clean water after sanding, followed by wiping thoroughly with a wet paper towel. If the cathode remains tarnished, contact your dealer or YSI Customer Service. Refer to *Appendix E Customer Service*.

NOTE: After cleaning, a new membrane cap must be installed. Refer to Section *3.4.3 Membrane Cap Installation***.**

11.1.2 DO Sensor Replacement

1. Remove the probe sensor guard.

⚠ **CAUTION:** Thoroughly dry the sensor so that no water enters the probe module sensor port when the sensor is removed.

2. Insert the long end of the hex key wrench into the small hole in the side of the probe module bulkhead. Turn the wrench counterclockwise and remove the screw. (You do not have to remove the screw all the way to release the sensor.)

3. Pull the old DO sensor module straight out of the probe module body.

   NOTE: The DO sensor is not threaded, it is keyed, so it cannot be removed by twisting.

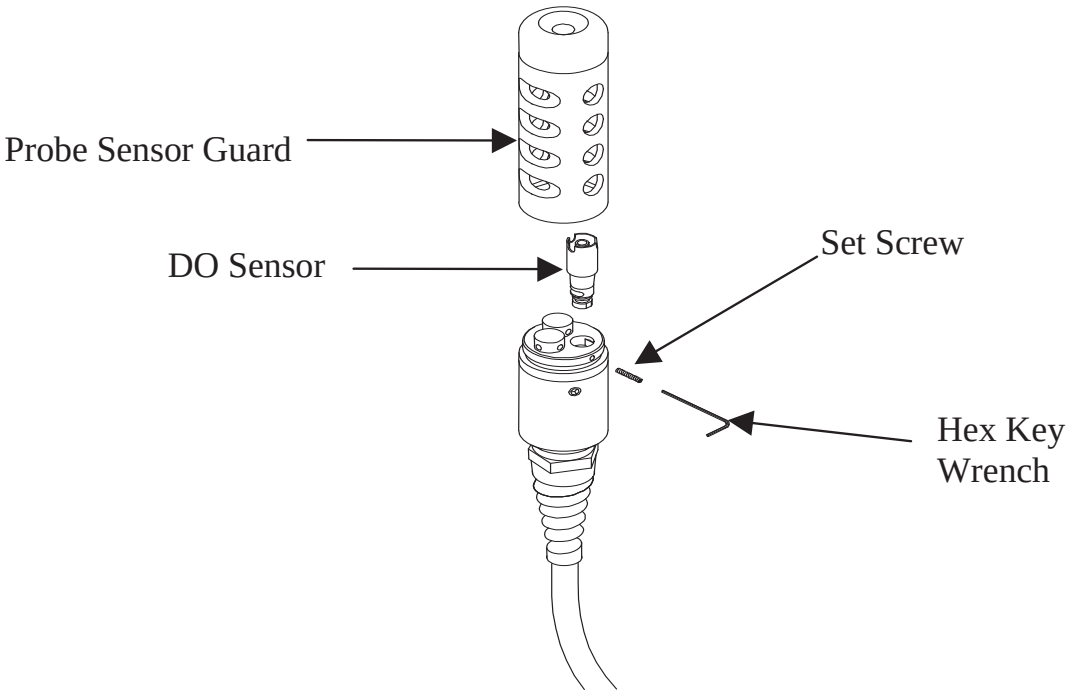


Figure 11.1 DO Sensor Replacement

4. Insert the new DO sensor module. Make sure that the inside of the probe module sensor port and the o-ring on the sensor are clean, with no contaminants, such as grease, dirt, or hair. The DO sensor is keyed, or has a flat side, so that it cannot be aligned improperly.

NOTE: Make sure the DO sensor bottoms out before the set screw is inserted.

5. Insert the set screw into the small hole in the side of the probe module bulkhead, and turn clockwise to rethread.

⚠ **CAUTION:** Make sure that you do not cross-thread the set screw. Use the hex key wrench to tighten the screw in properly, making sure that the screw does not stick out of the side of the probe module bulkhead. The probe sensor guard will not thread

on properly and damage may result if the screw is allowed to stick out.

NOTE: The YSI 5563 DO sensor is shipped dry. A shipping membrane was installed to protect the electrode. A new membrane cap must be installed before the first use. Refer to Section *3.4.1 Sensor Installation.*

11.1.3 YSI 5564 pH and 5565 Combination pH/ORP Sensor Cleaning

Cleaning is required whenever deposits or contaminants appear on the glass and/or platinum surfaces of these sensors or when the response of the sensor becomes slow.

1. Remove the sensor from the probe module.

2. Initially, simply use clean water and a soft clean cloth, lens cleaning tissue, or cotton swab to remove all foreign material from the glass bulb (YSI 5564 and YSI 5565) and platinum button (YSI 5565). Then use a moistened cotton swab to carefully remove any material that may be blocking the reference electrode junction of the sensor.

⚠ **CAUTION:** When using a cotton swab with the YSI 5564 or YSI 5565, be careful NOT to wedge the swab tip between the guard and the glass sensor. If necessary, remove cotton from the swab tip, so that the cotton can reach all parts of the sensor tip without stress.

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

1. Soak the sensor for 10-15 minutes in clean water containing a few drops of commercial dishwashing liquid.

2. GENTLY clean the glass bulb and platinum button by rubbing with a cotton swab soaked in the cleaning solution.

3. Rinse the sensor in clean water, wipe with a cotton swab saturated with clean water, and then re-rinse with clean water.

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

1. Soak the sensor for 30-60 minutes in one molar (1 M) hydrochloric acid (HCl). This reagent can be purchased from most distributors. Be sure to follow the safety instructions included with the acid.

2. GENTLY clean the glass bulb and platinum button by rubbing with a cotton swab soaked in the acid.

3. Rinse the sensor in clean water, wipe with a cotton swab saturated with clean water, and then re-rinse with clean water. To be certain that all traces of the acid are removed from the sensor crevices, soak the sensor in clean water for about an hour with occasional stirring.

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

1. Soak the sensor for approximately 1 hour in a 1 to 1 dilution of commercially available chlorine bleach.

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

11.1.4 Temperature/Conductivity Sensor Cleaning

The single most important requirement for accurate and reproducible results in conductivity measurement is a clean cell. A dirty cell will change the conductivity of a solution by contaminating it. The small cleaning brush included in the YSI 5511 Maintenance Kit is ideal for this purpose.

To clean the conductivity cell:

1. Dip the brush in clean water and insert it into each hole 15-20 times.

2. Rinse the cell thoroughly in deionized or clean tap water.

NOTE: In the event that deposits have formed on the electrodes, perform the following additional procedure:

1. Use a mild detergent solution in combination with the brush. Dip the brush in the solution and insert it into each hole 15-20 times.

2. Rinse the cell thoroughly in deionized or clean tap water.

   NOTE: After cleaning, check the response and accuracy of the conductivity cell with a calibration standard.

   NOTE: If this procedure is unsuccessful, or if sensor performance is impaired, it may be necessary to return the sensor to a YSI authorized service center for service, Refer to *Appendix E Customer Service*.

   The temperature portion of the sensor requires no maintenance.

11.2 Upgrading YSI 556 MPS Software

1. Access the YSI Environmental Software Downloads page as described in *Appendix G EcoWatch* Step 1 through 3.

2. Click on the **YSI Instruments Software Updates** link (or scroll down until you see YSI 556 MPS).

3. Click on the file icon to the right of the **YSI 556 MPS** listing and save the file to a temporary directory on your computer.

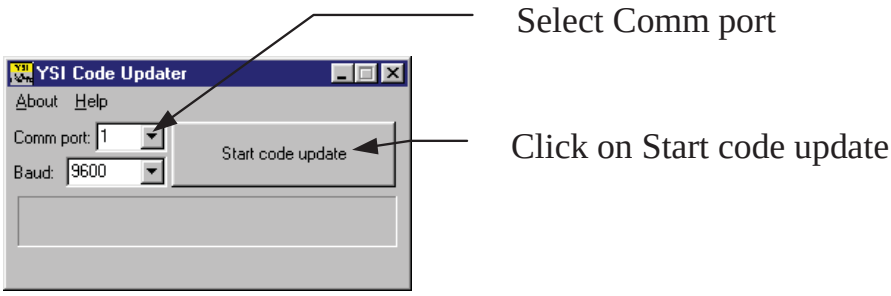
4. After the download is complete, run the file (that you just downloaded) and follow the on screen instructions to install the YSI Code Updater on your computer. If you encounter difficulties, contact YSI customer service for advice. Refer to *Appendix E Customer Service*.

5. If necessary, disconnect the YSI 5563 Probe Module from the YSI 556 MPS instrument.

6. Connect the YSI 556 MPS to a serial port of your computer via the 655173 PC interface cable. See Figure 8.6 Computer/Instrument Interface.

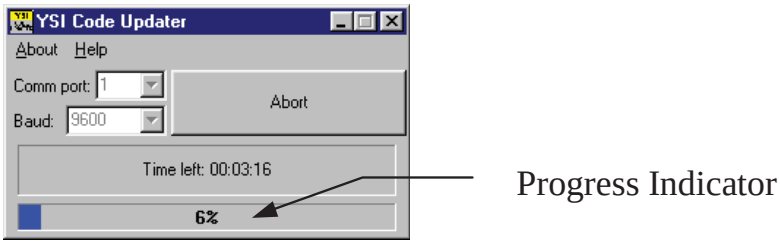
7. Press the **On/off** key on the YSI 556 MPS to display the run screen.

8. Run the YSI Code Updater software that you just installed on your computer. The following window will be displayed:

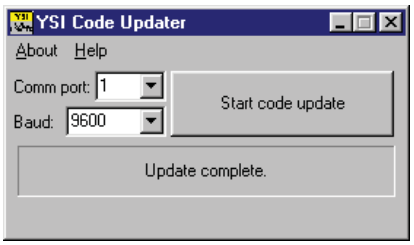


9. Set the Comm port number to match the port that you connected the 655173 PC Interface Cable to, then click on the **Start Code Update button**.

The YSI 556 MPS screen will blank out and a progress indicator will be displayed on the PC.



When the update is finished (indicated on the PC screen), the YSI 556 MPS will return to the Run screen. See Figure 7.1 Run Screen.



10. Close the YSI Code Updater window (on the PC) by clicking on the "X" in the upper right corner of the window.

11. Disconnect the YSI 556 MPS from the 655173 PC interface cable and reconnect it to the YSI 5563 Probe Module. Refer to Section *3.6 Instrument/Cable Connection*.

12. Storage

Proper storage between periods of usage will not only extend the life of the sensors, but will also ensure that the unit will be ready to use as quickly as possible in your next application.

12.1 General Recommendations for Short Term Storage

No matter what sensors are installed in the instrument, it is important to keep them moist without actually immersing them in liquid. Immersing them could cause some of them to drift or result in a shorter lifetime.

YSI recommends that short term storage of all multi-parameter instruments be done by placing approximately 1/2 inch of tap water in the transport/calibration cup that was supplied with the instrument, and by placing the probe module with all of the sensors installed into the cup. The use of a moist sponge instead of a 1/2 inch of tap water is also acceptable, as long as its presence does not compromise the attachment of the cup to the probe module. The transport/calibration cup should be sealed to prevent evaporation.

NOTE: Ensure that an o-ring is installed in the o-ring groove on the threaded end of the probe module body. See Figure 3.7 Transport/Calibration Cup Installation.

⚠ **CAUTION:** The water level has to be low enough so that none of the sensors are actually under water. Check the transport/calibration cup periodically to make certain that the water is still present or the sponge is still moist.

NOTE: If the storage water (tap water) is accidentally lost during field use, environmental water can be used.

12.2 General Recommendations for Long Term Storage

12.2.1 Probe Module Storage

1. Remove the pH or pH/ORP sensor from the probe module and store according to the individual sensor storage instructions found in Section *12.2.2 Sensor Storage*.

2. Seal the empty port with the provided port plug.

NOTE: Leave the conductivity/temperature sensor and dissolved oxygen sensor, with membrane cap still on, in the probe module.

3. Place 1/2″ of water, deionized, distilled or tap, in the transport/calibration cup.

⚠ **CAUTION:** The water level has to be low enough so that none of the sensors are actually under water. Check the transport/calibration cup periodically to make certain that the water is still present or the sponge is still moist.

4. Insert the probe module into the cup.

NOTE: Ensure that an o-ring is installed in the o-ring groove on the threaded end of the probe module body. See Figure 3.7 Transport/Calibration Cup Installation.

12.2.2 Sensor Storage

Temperature/Conductivity Sensor

No special precautions are required. Sensor can be stored dry or wet, as long as solutions in contact with the thermistor and conductivity electrodes are not corrosive (for example, chlorine bleach). However, it is recommended that the sensor be cleaned with the provided brush prior to long term storage. Refer to Section *11.1.4 Temperature/Conductivity Sensor Cleaning.*

pH and Combination pH/ORP Sensor

The key to sensor storage is to make certain that the reference electrode junction does not dry out. Junctions which have been allowed to dry out due to improper storage procedures can usually be rehydrated by soaking the sensor for several hours (overnight is recommended) in a solution which is 2 molar in potassium chloride. If potassium chloride solution is not available, soaking the sensor in tap water or commercial pH buffers may restore sensor function. However in some cases the sensor may have been irreparably damaged by the dehydration and will require replacement.

⚠ **CAUTION:** Do not store the sensor in distilled or deionized water as the glass sensor may be damaged by exposure to this medium.

1. Remove the pH or pH/ORP sensor from the probe module.

2. Seal the empty port with the provided port plug.

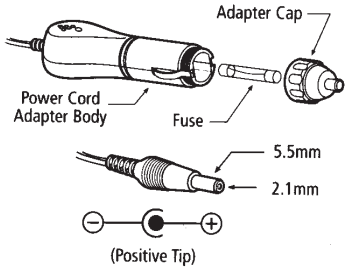
3. Place the sensor in the storage vessel (plastic boot or bottle) which was on the sensor at delivery. The vessel should contain a solution which is 2 molar in potassium chloride.

   NOTE: Make certain that the vessel is sealed to prevent evaporation of the storage solution.

13. Troubleshooting

The following sections describe problems you may encounter when using the YSI 556 MPS and provides suggestions to overcome the symptom.

PROBLEM	POSSIBLE SOLUTION
Display Problems	
No display is visible after pressing the on/off key.	If C cells are used, make certain that they are installed properly with regard to polarity and that good batteries are used. If a rechargeable battery pack is used, place the pack in the instrument and charge for 30 minutes.
Instrument software appears to be locked up as evidenced by no response to keypad entries or display not changing.	First, attempt to reset the instrument by simply turning off and then on again. If this fails, remove battery power from the instrument for 30 seconds and then reapply power. When using C cells, remove the battery lid and one of the batteries; when using the rechargeable battery pack, remove the pack completely from the instrument. After 30 seconds replace the battery or battery pack and check for instrument function.
The 556 display flashes and the instrument speaker makes a continuous clicking sound.	The battery voltage is low. Change to new C cells or recharge the 6117 battery pack.
Water Damage to Instrument	
Leakage detected in battery compartment when using C cells	Dispose of batteries properly. Dry the battery compartment using compressed air if possible. If corrosion is present on battery terminals, contact YSI Customer Service.
Water has contacted rechargeable battery pack	Remove battery pack immediately. Send battery pack to YSI Product Service for evaluation. **CAUTION**: DO NOT REUSE BATTERY PACK UNTIL YSI PRODUCT SERVICE HAS EVALUATED IT.
Leakage suspected into the main cavity of the instrument case	Remove the batteries immediately. Return the instrument to YSI Product Service.

PROBLEM	POSSIBLE SOLUTION
Optional Cigarette Lighter Charger	
Power cord fuse blown 	1. Unscrew adapter's cap, remove tip and pull out fuse. 2. Replace fuse with a new 2-amp fast-blow fuse from an electronics store such as Radio Shack. 3. Reassemble the adapter and securely screw the cap back onto the adapter body.
File Problems	
Upload of files from YSI 556 MPS to PC fails	1. Make sure that cable is connected properly to both 556 and PC. 2. Make certain that the proper Comm port is selected in EcoWatch for Windows.
Barometer data is not stored with sensor data file.	Make sure **Store barometer** is active in the 556 **Logging setup** menu.
Site Descriptions in the **Site List** are "grayed-out" and not available for appending files with additional data.	There is a parameter mismatch between the current 556 setup and that initially used. Change the current logging and sensor setup to match the setup that was initially used to create the file.
Sensor Problems	
Dissolved Oxygen reading unstable or inaccurate. Out of Range message appears during calibration.	Sensor not properly calibrated. Follow DO cal procedures.
	Membrane not properly installed or may be punctured. Replace membrane cap.
	DO sensor electrodes require cleaning. Follow DO cleaning procedure. Use 5511 Maintenance kit.
	Water in sensor connector. Dry connector; reinstall sensor.
	Algae or other contaminant clinging to DO sensor. Rinse DO sensor with clean water.
	Barometric pressure entry is incorrect. Repeat DO cal procedure.
	Calibrated at extreme temperature. Recalibrate at (or near) sample temperature.
	DO sensor has been damaged. Replace sensor.
	Internal failure. Return probe module for service.

PROBLEM	POSSIBLE SOLUTION
Sensor Problems	
pH or ORP readings are unstable or inaccurate. Out of Range message appears during calibration.	Sensor requires cleaning. Follow sensor cleaning procedure.
	Sensor requires calibration. Follow cal procedures.
	pH sensor reference junction has dried out from improper storage. Soak sensor in tap water or buffer until readings become stable.
	Water in sensor connector. Dry connector; reinstall sensor.
	Sensor has been damaged. Replace sensor.
	Calibration solutions out of spec or contaminated with other solution. Use new calibration solutions.
	ORP fails Zobell check. Take into account temperature dependence of Zobell solution readings.
	Internal failure. Return probe module for service.
Conductivity unstable or inaccurate. Out of Range message appears during calibration.	Conductivity improperly calibrated. Follow calibration procedure.
	Conductivity sensor requires cleaning. Follow cleaning procedure.
	Conductivity sensor damaged. Replace sensor.
	Calibration solution out of spec or contaminated. Use new calibration solution.
	Internal failure. Return probe module for service.
	Calibration solution or sample does not cover entire sensor. Immerse sensor fully.
Temperature, unstable or inaccurate	Water in connector. Dry connector; reinstall sensor.
	Sensor has been damaged. Replace the 5560 sensor.
Installed sensor has no reading	The sensor has been disabled. Enable sensor.
	Water in sensor connector. Dry connector; reinstall sensor.
	Sensor has been damaged. Replace the sensor.
	Report output improperly set up. Set up report output.
	Internal failure. Return probe module for service.

If these guidelines and tips fail to correct your problem or if any other symptoms occur, contact YSI Customer Service for Advice. Refer to *Appendix E Customer Service*.

14. Appendix A YSI 556 MPS Specifications

14.1 Sensor Specifications

Dissolved Oxygen		
Sensor Type		Steady state polarographic
Range:	*% air sat'n*	▪ 0 to 500% air saturation
	mg/L	▪ 0 to 50 mg/L
Accuracy:	*% air sat'n*	▪ 0 to 200% air saturation: ±2% of the reading or 2% air saturation; whichever is greater ▪ 200 to 500% air saturation: ±6% of the reading
	mg/L	▪ 0 to 20 mg/L: ±2% of the reading or 0.2 mg/L; whichever is greater ▪ 20 to 50 mg/L: ±6% of the reading
Resolution:	*% air sat'n*	▪ 0.1% air saturation
	mg/L	▪ 0.01 mg/L
Temperature		
Sensor Type:		YSI Precision™ thermistor
Range:		-5 to 45°C
Accuracy:		±0.15°C
Resolution:		0.01°C
Conductivity		
Sensor Type:		4-electrode cell with auto-ranging
Range:		0 to 200 mS/cm
Accuracy:		±0.5% of reading or ±0.001 mS/cm; whichever is greater–4 meter cable ±1.0% of reading or ±0.001 mS/cm; whichever is greater–20 meter cable
Resolution:		0.001 mS/cm to 0.1 mS/cm (range-dependent)
Salinity		
Sensor Type:		Calculated from conductivity and temperature
Range:		0 to 70 ppt
Accuracy:		±1.0% of reading or 0.1 ppt; whichever is greater
Resolution:		0.01 ppt

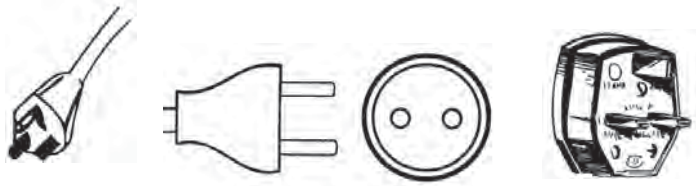
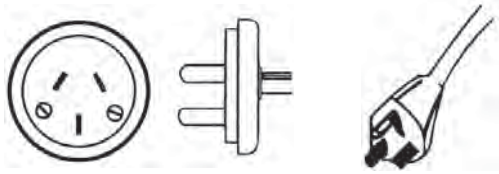
pH (optional)	
Sensor Type:	Glass combination electrode
Range:	0 to 14 units
Accuracy:	±0.2 units
Resolution:	0.01 units
ORP (optional)	
ORP Sensor Type:	Platinum button
Range:	-999 to +999 mV
Accuracy:	±20 mV
Resolution:	0.1 mV

Barometer (optional)	
Range:	500 to 800 mm Hg
Accuracy:	±3 mm Hg within ±15°C temperature range from calibration point
Resolution:	0.1 mm Hg

14.2 Instrument Specifications

Memory Size:	1.5 MB Flash Memory 49,000 data sets (@ 6 parameters per set plus time stamp) 100 Sites
Size:	11.9 cm width x 22.9 cm length (4.7 in. x 9 in.)
Weight with batteries:	0.92 kg (2.1 lbs)
Power:	4 alkaline C-cells; optional rechargeable pack
Cables:	4, 10, and 20 m (13.1, 32.8, 65.6 ft.) lengths
Warranty:	3-Years for the instrument; 1-Year for the probe modules and cable

15. Appendix B Instrument Accessories

ITEM #	ACCESSORY
5563-4	4m Cable with DO/temp/conductivity
5563-10	10m Cable with DO/temp/conductivity
5563-20	20m Cable with DO/temp/conductivity
5564	pH Kit
5565	pH/ORP Kit
6118	Rechargeable Battery Pack Kit for use in US
5094	Rechargeable Battery Pack Kit with universal charger and three adapter cables for use in international applications 
5095	Rechargeable Battery Pack Kit with universal charger and two adapter cables for use in international applications 
5083	Flow Cell – probe module is secured in the flow cell and groundwater is pumped through it
616	Charger, Cigarette Lighter – used to power up the instrument from a car's cigarette lighter
4654	Tripod
614	Ultra Clamp, C Clamp –used to clamp the instrument to a table top or car dashboard
6081	Large Carrying Case, Hard-sided
5085	Hands-free Harness
5065	Carrying Case, Form-fitted, for use in the field – has a clear vinyl window, shoulder strap, belt loop strap and hand strap

16. Appendix C Required Federal Communications Notice

The Federal Communications Commission defines this product as a computing device and requires the following notice.

This equipment generates and uses radio frequency energy and if not installed and used properly, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class A or Class B computing device in accordance with the specification in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient the receiving antenna
- Relocate the computer with respect to the receiver
- Move the computer away from the receiver
- Plug the computer into a different outlet so that the computer and receiver are on different branch circuits.

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet, prepared by the Federal Communications Commission, helpful: "How to Identify and Resolve Radio-TV Interference Problems". This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock No.0004-000-00345-4.

17. Appendix D Health and Safety

YSI Conductivity solutions: 3161, 3163, 3165, 3167, 3168, 3169

INGREDIENTS:

- ❑ Iodine
- ❑ Potassium Chloride
- ❑ Water

WARNING: INHALATION MAY BE FATAL.

⚠ ***CAUTION*: AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY EVOLVE TOXIC FUMES IN FIRE.**

Harmful if ingested or inhaled. Skin or eye contact may cause irritation. Has a corrosive effect on the gastro-intestinal tract, causing abdominal pain, vomiting, and diarrhea. Hyper-sensitivity may cause conjunctivitis, bronchitis, skin rashes etc. Evidence of reproductive effects.

FIRST AID:
INHALATION: Remove victim from exposure area. Keep victim warm and at rest. In severe cases seek medical attention.
SKIN CONTACT: Remove contaminated clothing immediately. Wash affected area thoroughly with large amounts of water. In severe cases seek medical attention.
EYE CONTACT: Wash eyes immediately with large amounts of water, (approx. 10 minutes). Seek medical attention immediately.
INGESTION: Wash out mouth thoroughly with large amounts of water and give plenty of water to drink. Seek medical attention immediately.

YSI pH 4.00, 7.00, and 10.00 Buffer Solutions: 3821, 3822, 3823

pH 4 INGREDIENTS:

- ❑ Potassium Hydrogen Phthalate
- ❑ Formaldehyde
- ❑ Water

pH 7 INGREDIENTS:

- ❑ Sodium Phosphate, Dibasic
- ❑ Potassium Phosphate, Monobasic
- ❑ Water

pH 10 INGREDIENTS:

- ❑ Potassium Borate, Tetra
- ❑ Potassium Carbonate
- ❑ Potassium Hydroxide
- ❑ Sodium (di) Ethylenediamine Tetraacetate
- ❑ Water

⚠ ***CAUTION*** **- AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.**

Inhalation may cause severe irritation and be harmful. Skin contact may cause irritation; prolonged or repeated exposure may cause Dermatitis. Eye contact may cause irritation or conjunctivitis. Ingestion may cause nausea, vomiting and diarrhea.

FIRST AID:

INHALATION - Remove victim from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Keep victim warm and at rest. Seek medical attention immediately.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes). Seek medical attention immediately.

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - If victim is conscious, immediately give 2 to 4 glasses of water and induce vomiting by touching finger to back of throat. Seek medical attention immediately.

YSI Zobell Solution: 3682

INGREDIENTS:

- ❑ Potassium Chloride
- ❑ Potassium Ferrocyanide Trihydrate
- ❑ Potassium Ferricyanide

⚠ ***CAUTION*** **- AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.**

May be harmful by inhalation, ingestion, or skin absorption. Causes eye and skin irritation. Material is irritating to mucous membranes and upper respiratory tract. The chemical, physical, and toxicological properties have not been thoroughly investigated.

Ingestion of large quantities can cause weakness, gastrointestinal irritation and circulatory disturbances.

FIRST AID:

INHALATION - Remove victim from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Keep victim warm and at rest. Seek medical attention immediately.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes). Seek medical attention immediately.

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - If victim is conscious, immediately give 2 to 4 glasses of water and induce vomiting by touching finger to back of throat. Seek medical attention immediately.

18. Appendix E Customer Service

For information on Authorized Service Centers, refer to *Authorized Service Centers* in this appendix.

Equipment exposed to biological, radioactive, or toxic materials must be cleaned and disinfected before being returned or presented for service. A cleaning certificate must accompany the equipment. Refer to *18.2 Cleaning Instructions* in this appendix.

18.1 YSI Environmental Authorized Service Centers

For information on the nearest authorized service center, please contact:

YSI Technical Support • 1725 Brannum Lane
Yellow Springs, Ohio • 45387 • Phone: +1 (937) 767-7241
Phone: 800-897-4151 (US) • Email: environmental@ysi.com

or visit our website for the most current information:

www.ysi.com

18.2 Cleaning Instructions

Equipment exposed to biological, radioactive, or toxic materials must be cleaned and disinfected before being serviced. Biological contamination is presumed for any instrument, probe, or other device that has been used with body fluids or tissues, or with wastewater. Radioactive contamination is presumed for any instrument, probe or other device that has been used near any radioactive source.

If an instrument, probe, or other part is returned or presented for service without a Cleaning Certificate, and if in our opinion it represents a potential biological or radioactive hazard, our service personnel reserve the right to withhold service until appropriate cleaning, decontamination, and certification has been completed. We will contact the sender for instructions as to the disposition of the equipment. Disposition costs will be the responsibility of the sender.

When service is required, either at the user's facility or at a YSI Service Center, the following steps must be taken to ensure the safety of service personnel.

- In a manner appropriate to each device, decontaminate all exposed surfaces, including any containers. 70% isopropyl alcohol or a solution of 1/4-cup bleach to 1-gallon tap water is suitable for most disinfecting. Instruments used with wastewater may be disinfected with .5% Lysol if this is more convenient to the user.
- The user shall take normal precautions to prevent radioactive contamination and must use appropriate decontamination procedures should exposure occur.
- If exposure has occurred, the customer must certify that decontamination has been accomplished and that no radioactivity is detectable by survey equipment.
- Any product being returned to the YSI Repair Center should be packed securely to prevent damage.
- Cleaning must be completed and certified on any product before returning it to YSI.

18.3 Packing Procedure

- Clean and decontaminate items to ensure the safety of the handler.
- Complete and include the Cleaning Certificate.
- Place the product in a plastic bag to keep out dirt and packing material.
- Use a large carton, preferably the original, and surround the product completely with packing material.
- Insure for the replacement value of the product.

18.4 Cleaning Certificate

Organization _____

Department _____

Address _____

City _____ State __ Zip _____

Country _____ Phone _____

Model No. of Device __ Lot Number _____

Contaminant (if known) _____

Cleaning Agent(s) used _____

Radioactive Decontamination Certified?

(Answer only if there has been radioactive exposure)

_____ Yes _____ No

Cleaning Certified By _____

Name Date

18.5 Warranty

The instrument is warranted for three years against defects in workmanship and materials when used for its intended purposes and maintained according to instructions. The probe module and cables are warranted for one year. The dissolved oxygen, temperature/conductivity, pH, and pH/ORP combination sensors are warranted for one year. Damage due to accidents, misuse, tampering, or failure to perform prescribed maintenance is not covered. The warranty period for chemicals and reagents is determined by the expiration date printed on their labels. Within the warranty period, YSI will repair or replace, at its sole discretion, free of charge, any product that YSI determines to be covered by this warranty.

To exercise this warranty, write or call your local YSI representative, or contact YSI Customer Service in Yellow Springs, Ohio. Send the product and proof of purchase, transportation prepaid, to the Authorized Service Center selected by YSI. Repair or replacement will be made and the product returned transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days from date of repair or replacement.

Limitation of Warranty

This Warranty does not apply to any YSI product damage or failure caused by (i) failure to install, operate or use the product in accordance with YSI's written instructions, (ii) abuse or misuse of the product, (iii) failure to maintain the product in accordance with YSI's written instructions or standard industry procedure, (iv) any improper repairs to the product, (v) use by you of defective or improper components or parts in servicing or repairing the product, or (vi) modification of the product in any way not expressly authorized by YSI.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. YSI'S LIABILITY UNDER THIS WARRANTY IS LIMITED TO REPAIR OR REPLACEMENT OF THE PRODUCT, AND THIS SHALL BE YOUR SOLE AND EXCLUSIVE REMEDY FOR ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY. IN NO EVENT SHALL YSI BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY.

19. Appendix F Ferrite Bead Installation

⚠ **WARNING:** If you are using your YSI 556 in a European Community (CE) country or in Australia or New Zealand, you must attach a ferrite bead to the 655173 PC Interface Cable and the YSI 6117 Charger Adapter Cable in order to comply with the Residential, Commercial and Light Industrial Class B Limits for radio-frequency emissions specified in EN55011 (CISPR11) for Industrial, Scientific and Medical laboratory equipment. These ferrite assemblies are supplied as part of cable kits.

1. Make a small loop (approximately 5 cm in diameter) in the cable near the YSI 556 MS-19 connector.

2. Lay the open ferrite bead assembly under the loop with the cable cross-over position within the cylinder of the ferrite bead.

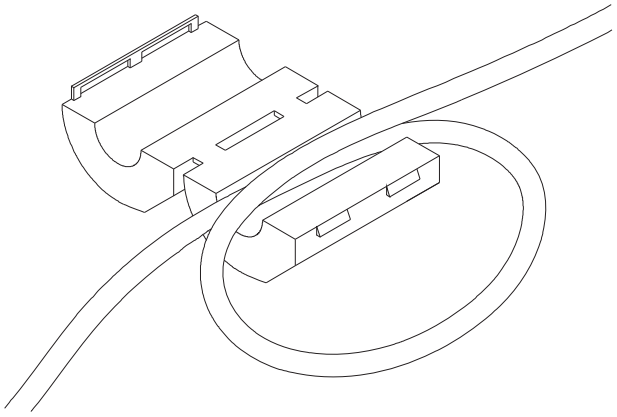


Figure 19.1 Ferrite Bead Installation

3. Snap the two pieces of the bead together making certain that the tabs lock securely.

4. When the installation is complete, the 655173 and YSI 6117 cables should resemble the following drawings.

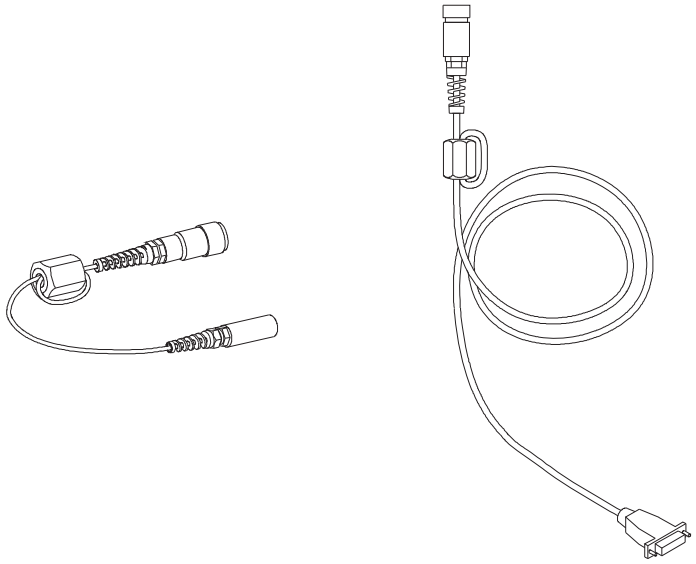


Figure 19.2 Cables with Ferrite Beads

20. Appendix G EcoWatch

EcoWatch™ for Windows™ must be used as the PC software interface to the YSI 556 MPS. EcoWatch is a powerful tool that can also be used with YSI 6-series sondes. Many features of the software will only be utilized by advanced users or are not relevant to the 556 MPS at all. This section is designed in tutorial format to familiarize you with the commonly used features of EcoWatch so that it will be possible to:

- Upload data from a 556 MPS to a PC
- Assemble plots and reports of your data
- Zoom in on certain segments of the plots of your data to facilitate analysis
- Show statistical data for your studies
- Export data in spreadsheet-compatible formats
- Print plots and reports

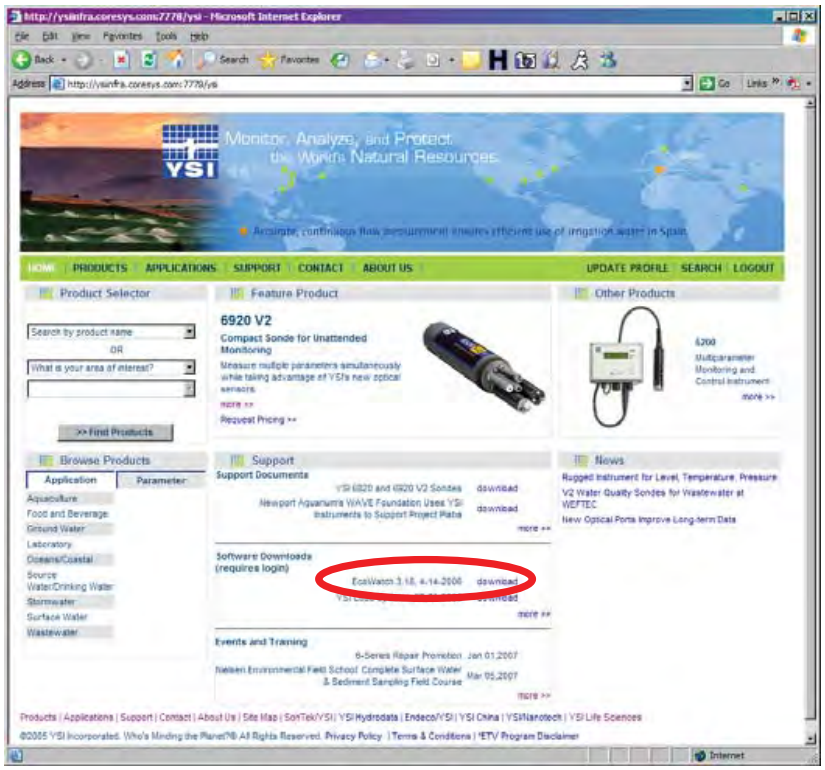
The advanced features of EcoWatch can be explored by downloading a 6-series manual from the YSI Web Site (www.ysi.com), purchasing a hard copy of the manual through YSI Customer Service (Item # 069300), or utilizing the on-line help feature of the software.

20.1 Installing EcoWatch for Windows

EcoWatch for Windows is available at no cost via a download from the YSI Web Site.

1. Access the YSI Web Site at www.ysi.com.

2. Click on the **Login** link and login (or register if you have not previously registered).



3. Click on the EcoWatch link and save the file to a directory on your computer.

4. After the download is complete, run the EcoWatch file (that you just downloaded) and follow the on screen instructions to install the software on your computer.

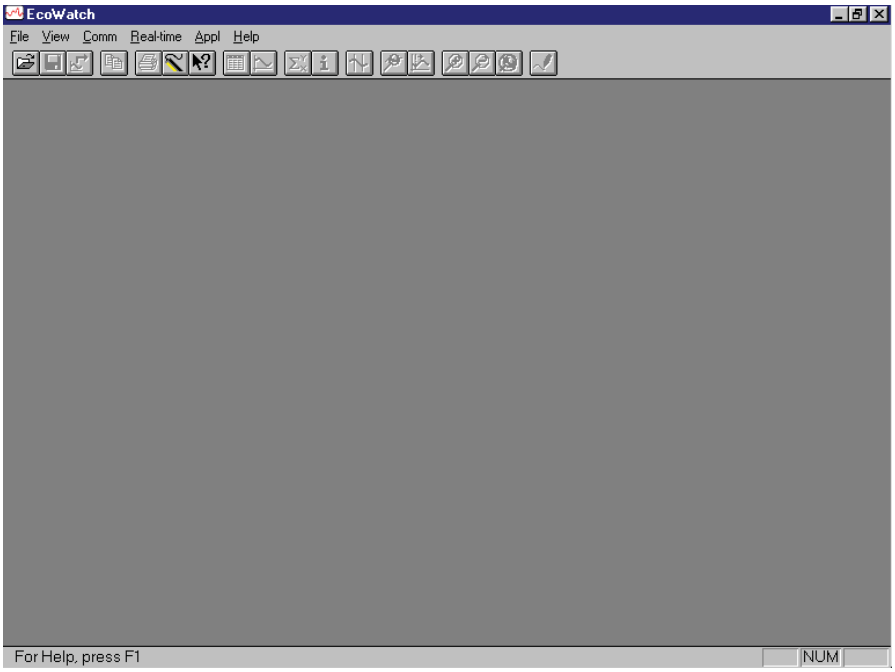
If you encounter difficulties in the download procedure, contact YSI Customer Service. Refer to ***Appendix E Customer Service***. Alternatively, you may purchase the software on CD ROM (Item #006075) by contacting YSI Customer Service.

20.2 EcoWatch Tutorial

This EcoWatch tutorial is designed to teach you the commonly used operations associated with the software when used with your 556 MPS.

After you have uploaded a file, Refer to Section 8.4 Upload to PC, you will see two files in the C:\ECOWWIN\DATA directory; the file you transferred and a file supplied by YSI designated SAMPLE.DAT. This SAMPLE.DAT file is referred to in the remainder of this tutorial section. After following the instructions below for the analysis of SAMPLE.DAT, you apply the same analysis to the data file which was uploaded from your 556 MPS to assure that you are familiar with the basic features and capabilities of EcoWatch for Windows.

To start the analysis of the SAMPLE.DAT file, note that a shortened menu bar is visible and many of the tools in the toolbar appear dimmed or “grayed out” before any file is opened (see below).



Full activation of EcoWatch features will be realized after a file is opened.

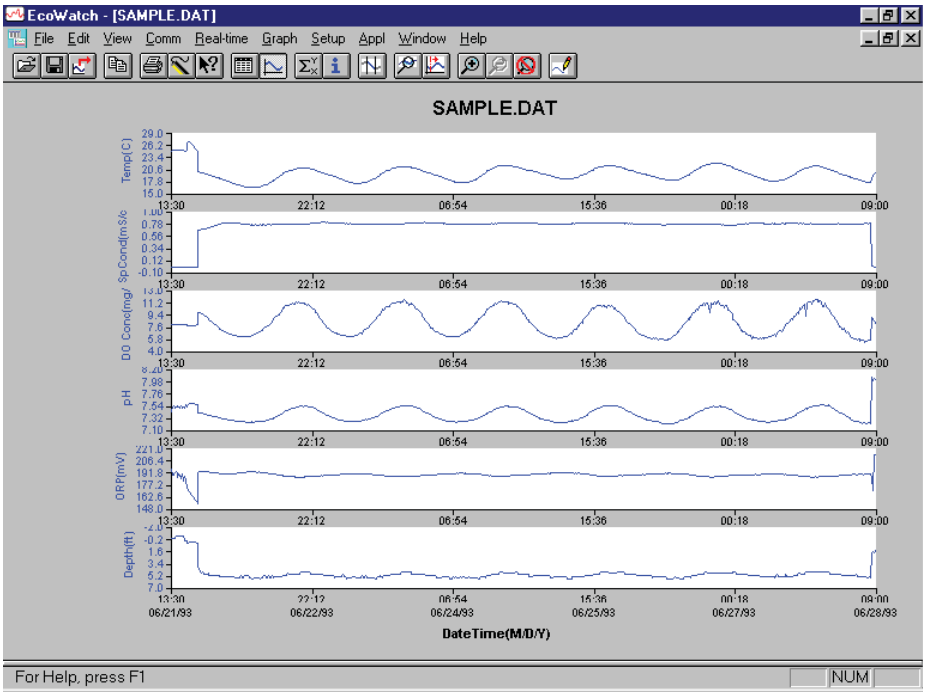
To open the sample data file:

5. 1. Click the **File** menu  button in the toolbar.

6. 2. Select the **SAMPLE.DAT** file.

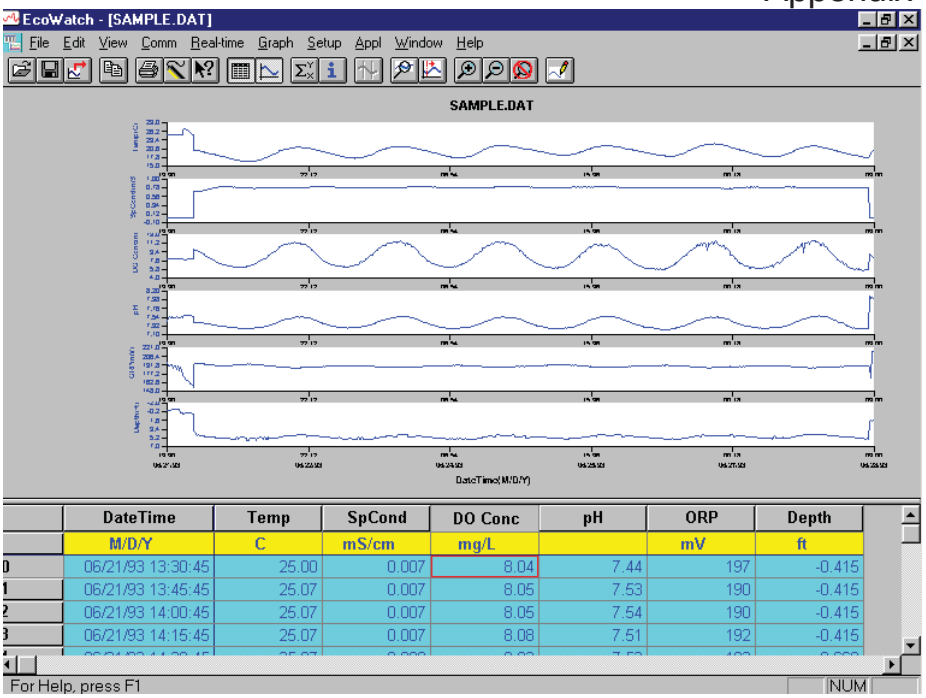
7. 3. Click **OK** to open the file.

The following display will appear:



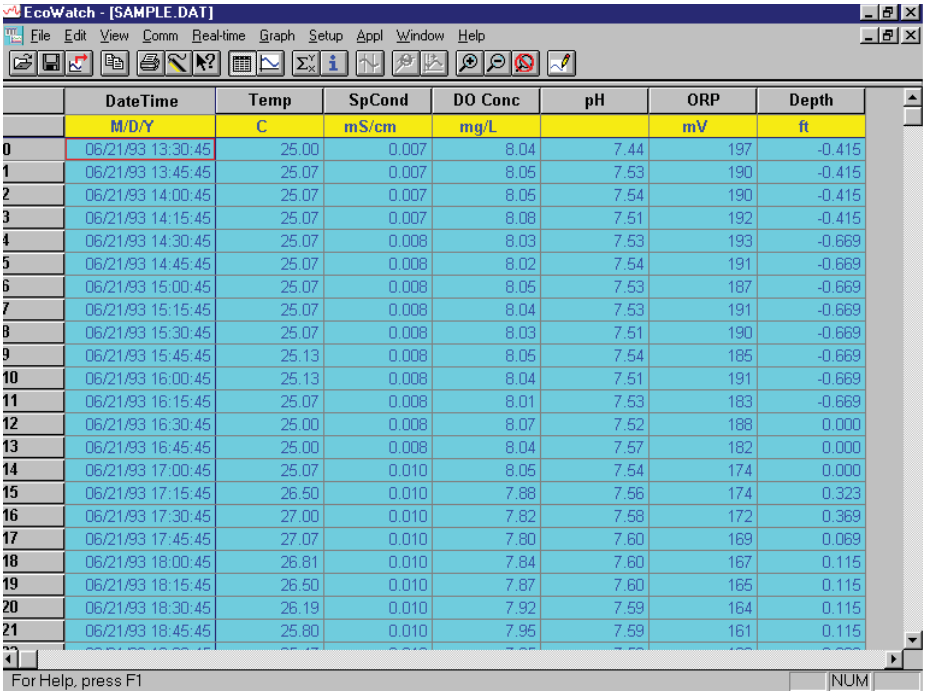
Note that the data in this file appears as a graph of temperature, specific conductance, dissolved oxygen, pH, ORP, and depth, all versus time. The graphs are scaled automatically so that all data fits comfortably on the computer screen. Note also that this data file was obtained with a 6-series sonde for which a depth sensor is available. Depth is NOT a current parameter for the 556 MPS.

The **Table**  and **Graph**  buttons on the toolbar are on/off switches that are used to display or hide the graph and table pages respectively. When displaying a graph and a table at the same time, you can control the relative size of the two pages by placing the cursor over the small bar that separates them and then dragging it to the desired location. Click the **Table**  button to generate the following dual display of data.



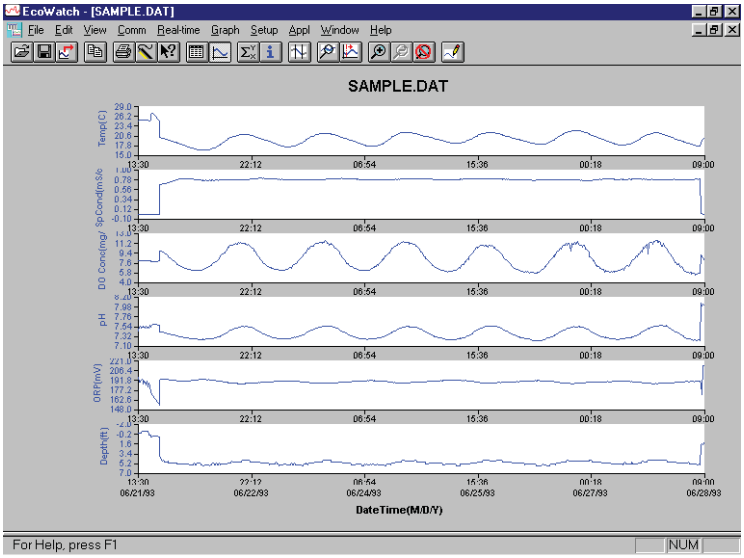
	DateTime	Temp	SpCond	DO Conc	pH	ORP	Depth
	M/D/Y	C	mS/cm	mg/L		mV	ft
0	06/21/93 13:30:45	25.00	0.007	8.04	7.44	197	-0.415
1	06/21/93 13:45:45	25.07	0.007	8.05	7.53	190	-0.415
2	06/21/93 14:00:45	25.07	0.007	8.05	7.54	190	-0.415
3	06/21/93 14:15:45	25.07	0.007	8.08	7.51	192	-0.415

Now click the **Graph**  button (turn it off) to display only a report of your data as shown below. Note that the size of the report can be varied by clicking on the  and  buttons in the Toolbar.

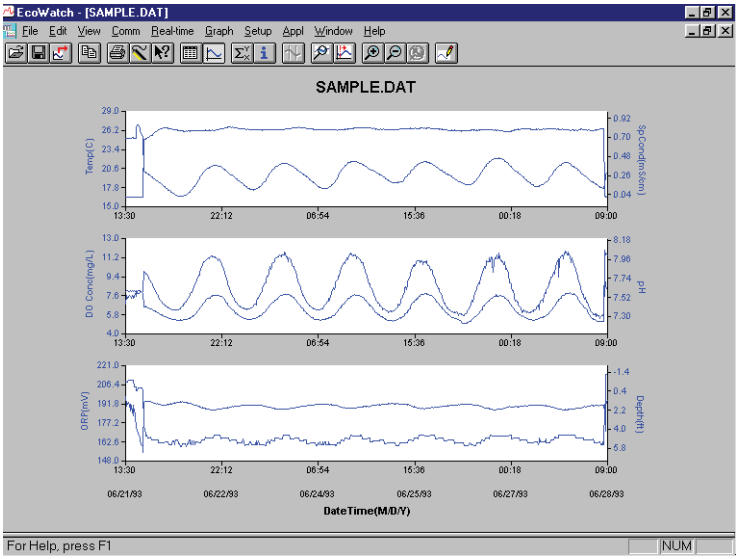


	DateTime	Temp	SpCond	DO Conc	pH	ORP	Depth
	M/D/Y	C	mS/cm	mg/L		mV	ft
0	06/21/93 13:30:45	25.00	0.007	8.04	7.44	197	-0.415
1	06/21/93 13:45:45	25.07	0.007	8.05	7.53	190	-0.415
2	06/21/93 14:00:45	25.07	0.007	8.05	7.54	190	-0.415
3	06/21/93 14:15:45	25.07	0.007	8.08	7.51	192	-0.415
4	06/21/93 14:30:45	25.07	0.008	8.03	7.53	193	-0.669
5	06/21/93 14:45:45	25.07	0.008	8.02	7.54	191	-0.669
6	06/21/93 15:00:45	25.07	0.008	8.05	7.53	187	-0.669
7	06/21/93 15:15:45	25.07	0.008	8.04	7.53	191	-0.669
8	06/21/93 15:30:45	25.07	0.008	8.03	7.51	190	-0.669
9	06/21/93 15:45:45	25.13	0.008	8.05	7.54	185	-0.669
10	06/21/93 16:00:45	25.13	0.008	8.04	7.51	191	-0.669
11	06/21/93 16:15:45	25.07	0.008	8.01	7.53	183	-0.669
12	06/21/93 16:30:45	25.00	0.008	8.07	7.52	188	0.000
13	06/21/93 16:45:45	25.00	0.008	8.04	7.57	182	0.000
14	06/21/93 17:00:45	25.07	0.010	8.05	7.54	174	0.000
15	06/21/93 17:15:45	26.50	0.010	7.88	7.56	174	0.323
16	06/21/93 17:30:45	27.00	0.010	7.82	7.58	172	0.369
17	06/21/93 17:45:45	27.07	0.010	7.80	7.60	169	0.069
18	06/21/93 18:00:45	26.81	0.010	7.84	7.60	167	0.115
19	06/21/93 18:15:45	26.50	0.010	7.87	7.60	165	0.115
20	06/21/93 18:30:45	26.19	0.010	7.92	7.59	164	0.115
21	06/21/93 18:45:45	25.80	0.010	7.95	7.59	161	0.115

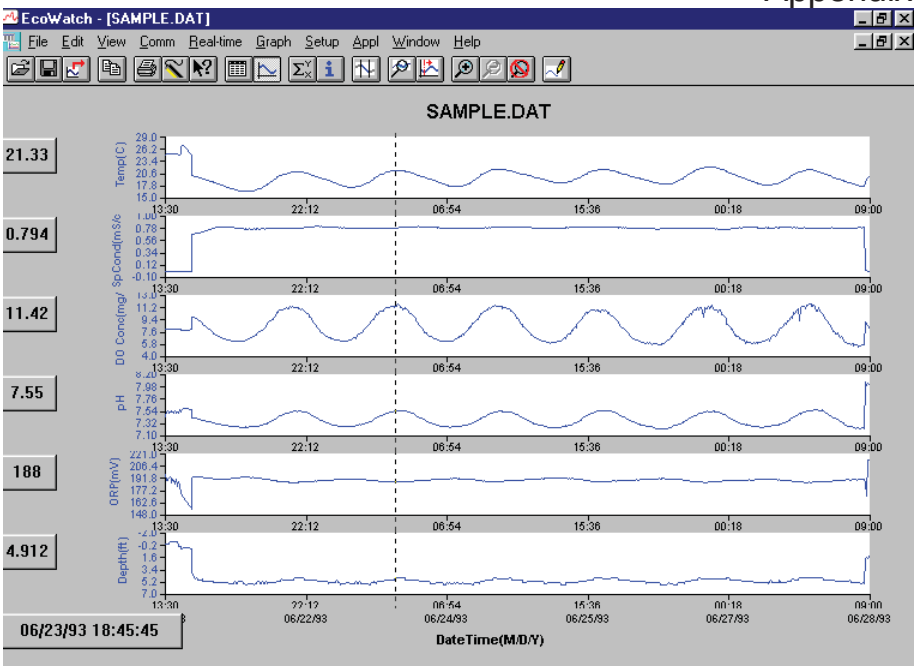
Now return to the original graphic display by toggling the **Table**  button "off" and **Graph**  button "on".



From the **Setup** menu, click **Graph**. Click **2 Traces per Graph** and notice that the parameters are now graphed in pairs for easy comparison of parameters.

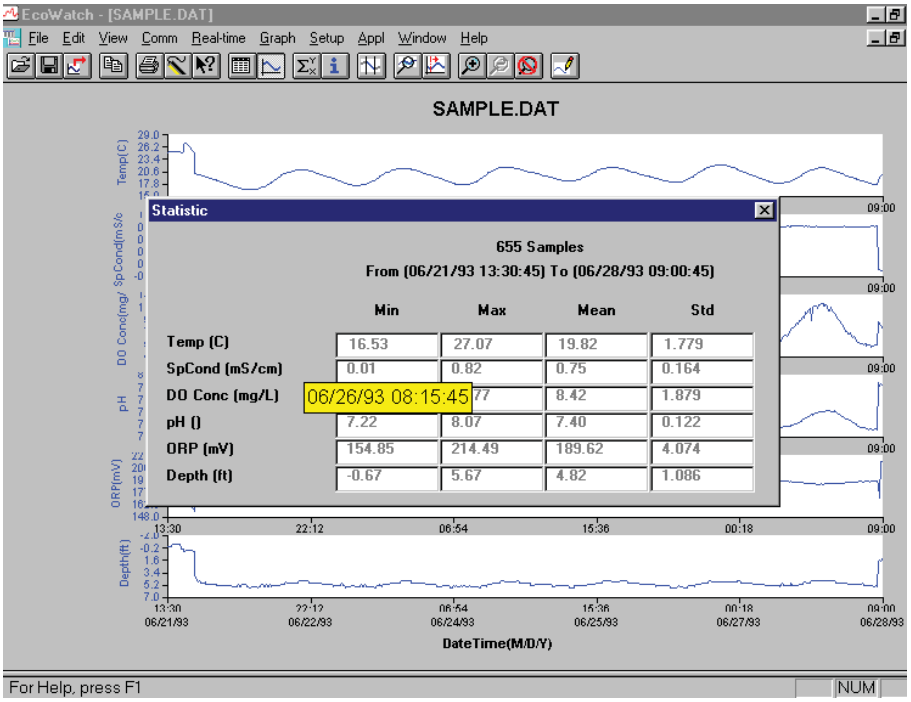


Click **1 Trace per Graph** to return the display to the original setting. Move the cursor to any position in the graph, then click and hold the right mouse button.



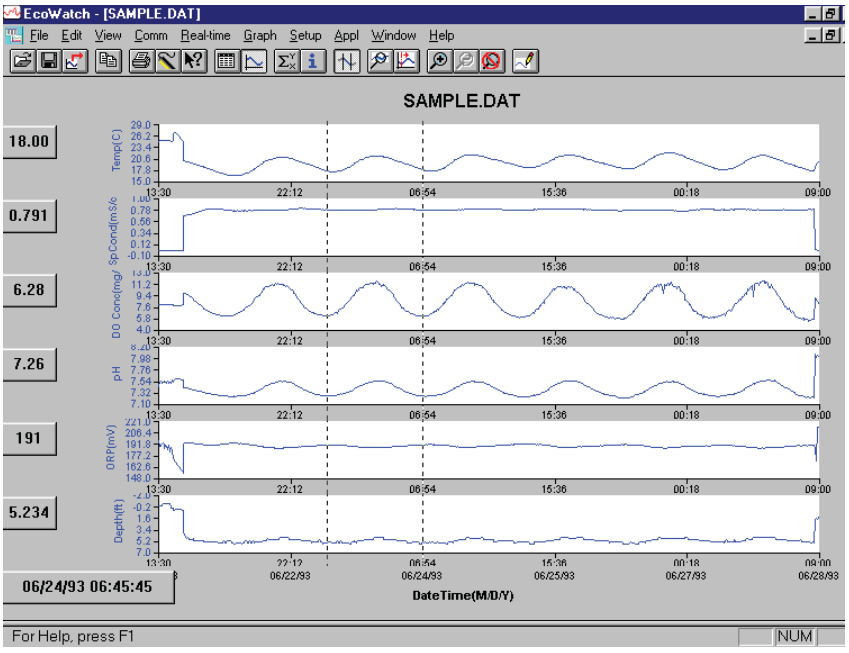
Note that the exact measurements for this point in time are displayed to the left of the graph. While holding down the right mouse button, move to another area on the graph. Notice how the measurements change as you move. When you release the mouse button, the display returns to normal.

To view statistical information for the study, click the **Statistics**  button on the toolbar. On the statistics window, click on any min or max value to display the time when it occurred.

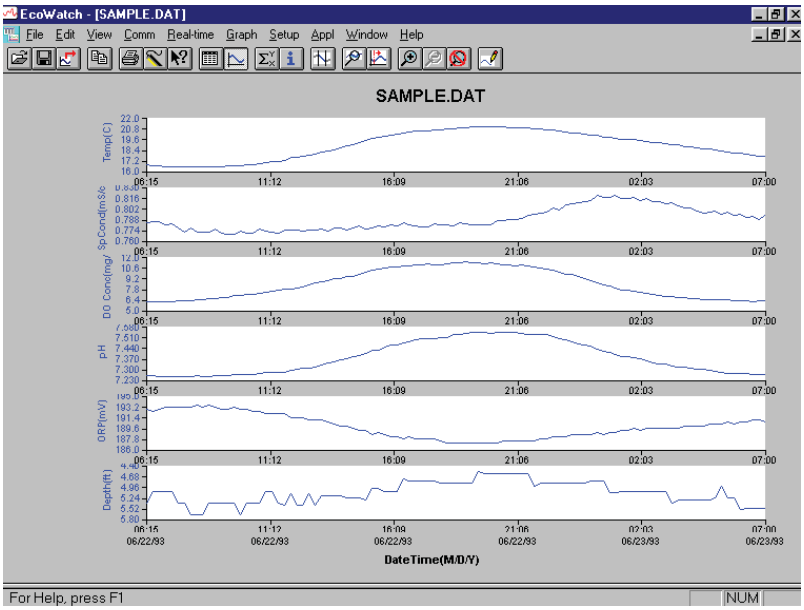


After viewing statistics, click the “x” at the upper right to close the window and return to the normal display.

Now click on the delimiter  icon in the toolbar and then move the displayed icon to the graph. Click at the two points shown by dotted lines in the display below, being sure that the first click is to the left of the second.

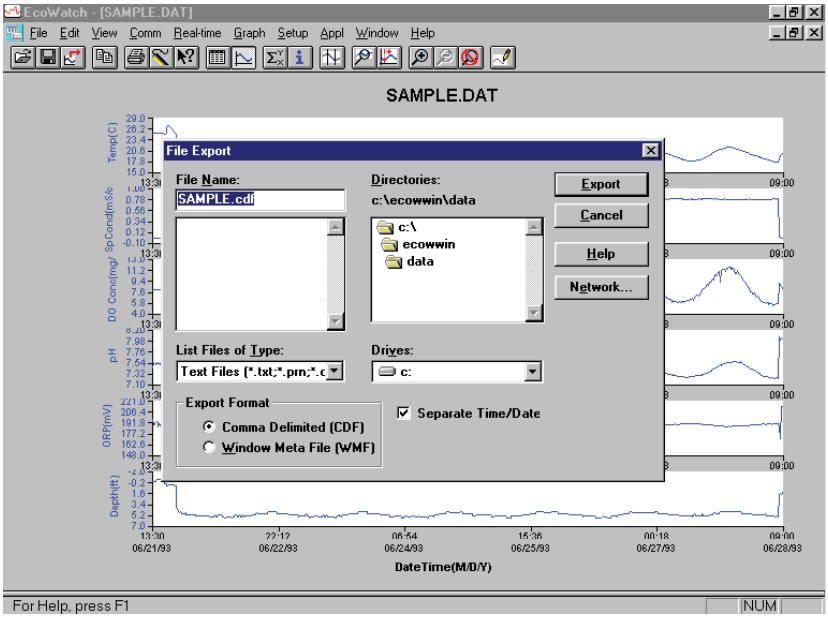


The data between the two selected points will then be graphed in higher resolution as shown below.

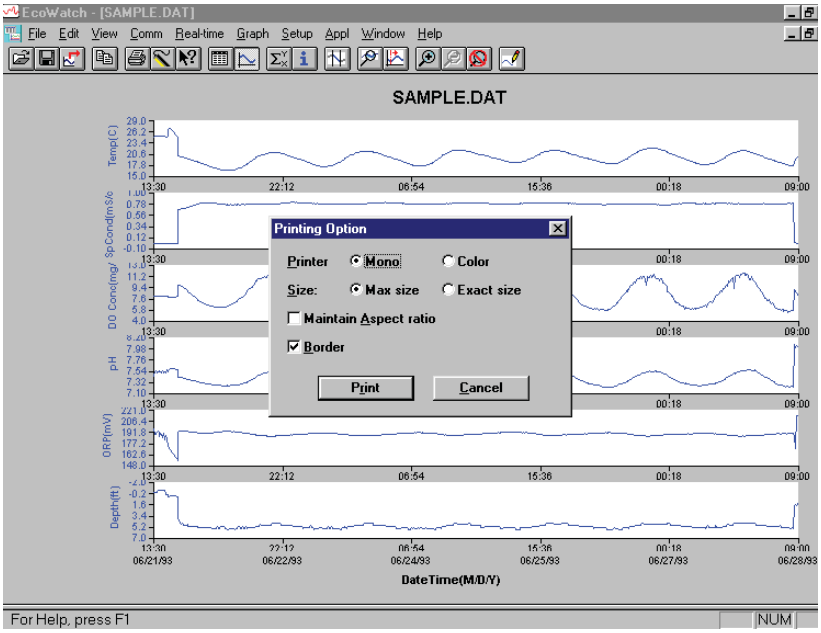


To return to the complete data set, select **Graph** from the toolbar and then click **Cancel Limits**.

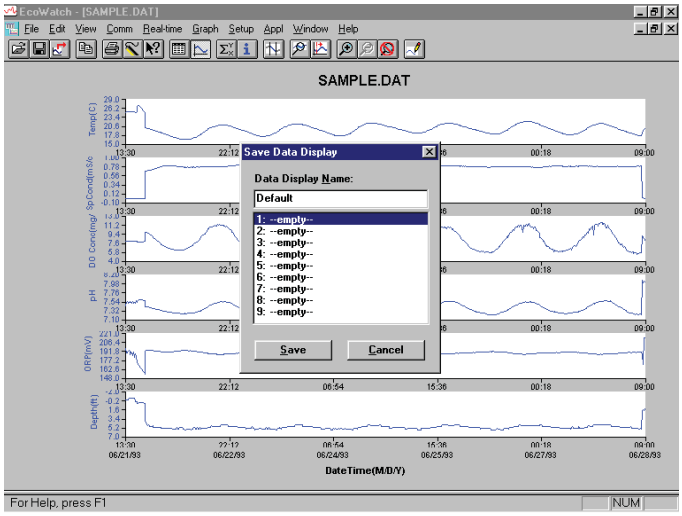
Now select the  icon from the Toolbar to create a new data file which will allow your data to be imported into spreadsheets. Select the default export settings for a Comma Delimited File (.CDF) and click OK. A new spreadsheet-importable file (SAMPLE.CDF) is now present in the same folder as the SAMPLE.DAT file.



Now select the  icon from the toolbar to print the plot. Accept the default settings and click OK to complete the printing operation.



Finally, end the tutorial by saving the **Data Display** in the format shown. From the **File** menu, click **Save Data Display**.



Then type “Default” for the file name and click **Save**. The parameters, colors, format, and x-axis time interval associated with the current display are now saved and can be accessed any time in the future. Nine different data displays may be saved for any data file. You can easily switch between various displays of the data. The data files can be accessed by clicking **Load Data Display** from the file menu and then selecting the desired presentation.

20.2.1 Summary of Toolbar Capability

The EcoWatch toolbar includes buttons for some of the most common commands in EcoWatch, such as **File Open**. To display or hide the toolbar, open the **View** menu and click on the **Toolbar** command. A check mark appears next to the menu item when the toolbar is displayed.

The toolbar is displayed across the top of the application window, below the menu bar.



Click To:



Open an existing data file (.DAT). EcoWatch displays the **Open** dialog box, in which you can locate and open the desired file.

 Save the working Data Display of the active data file. EcoWatch displays the **Save Data Display** dialog box in which you can overwrite existing Data Display or save to a new one.

 Export data as a graph in Window Meta File (.WMF) format or as data in Comma Delimited (.CDF) format.

 Copy the whole graph page or data from the selection on the table to the clipboard.

 Print the active graph page or table page depending on which one is currently active.

 Open a new terminal window to communicate with the sonde.

 Access context sensitive help (Shift+F1).

 Toggle table window during file processing.

 Toggle graph window during file processing.

 Display study statistics.

 Display study info.

 Limit the data to be processed in a study.

 Enlarge a selective portion of graph.

 Center the graph under the cursor.

 Enlarge graph or table 20%.

 Reduce graph or table 20%.

 Return graph or table to its normal state (unzoom)

 Redraw the graph.

20.2.2 Other Capabilities

The above tutorial and function list for the toolbar provide basic information to allow you to view and analyze the field data which was stored in your 556 MPS. Some of the other commonly used capabilities of EcoWatch which the user may want to explore are listed below:

- Customize the units for each parameter, e.g., report uS/cm instead of mS/cm for conductivity.
- Customize the order of parameters in each plot or report.
- Customize the colors and fonts of each data display.
- Manually scale the y-axis sensitivity for each parameter.
- Merging of two or more data files with compatible parameter formats
- View information about the study such as number of points, instrument serial number, etc. which was stored in the 556 with the data.
- Print data reports in different statistical formats.
- Create plots of parameter vs. parameter rather than parameter vs. time.

These additional features of EcoWatch for Windows are explained in detail in the YSI 6-series manual (which can be downloaded at no cost from the YSI Web Site as described above) and the Help selection in the EcoWatch menubar. To purchase a hard copy of the 6-series manual, contact YSI Customer Service using the contact information in *Appendix E Customer Service*.

21. Appendix H Calibration Record Information

When your YSI 556 MPS sensors are initially calibrated, relevant information about the sensors will be stored in a separate file in the YSI 556 MPS memory.

NOTE: This file, by default, will have the name "556 Circuit Board Serial Number.glp." The circuit board serial number is assigned at the factory and has a hexadecimal format such as 000080A4. Thus the default calibration record file would be designated 00080A4.glp. Refer to Section *10.7 GLP Filename* to change the filename.

The information in the calibration record will track the sensor performance of your instrument and should be particularly useful for programs operating under Good Laboratory Practices (GLP) protocols.

21.1 Viewing the Calibration Record (.glp) File

NOTE: Make certain that you have performed a calibration on at least one of the sensors associated with your YSI 556 MPS.

1. Follow the procedures outlined in Section *8.3 View File*.

21.2 Uploading the Calibration Record (.glp) File

NOTE: Make certain that you have performed a calibration on at least one of the sensors associated with your YSI 556 MPS.

1. Follow the procedures outlined in Section *8.4 Upload to PC*.

21.3 Understanding the Calibration Record (.glp) File

1. Open a calibration record file. Refer to Section *8.3 View File*.

2. Use the arrow keys to scroll horizontally and/or vertically to view all the data.

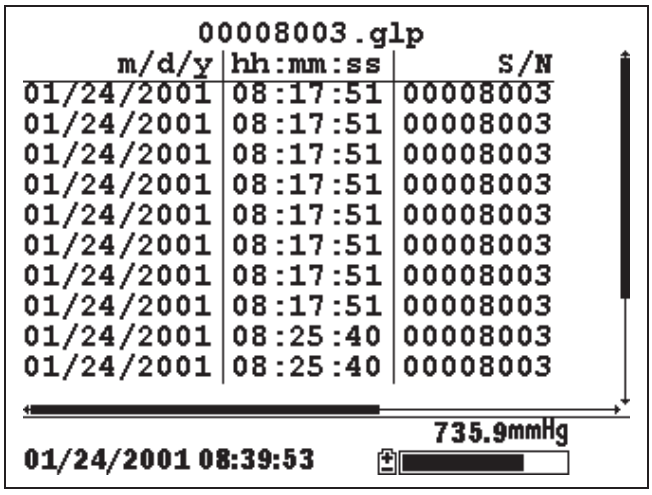


Figure 21.1 Calibration Record Screen 1

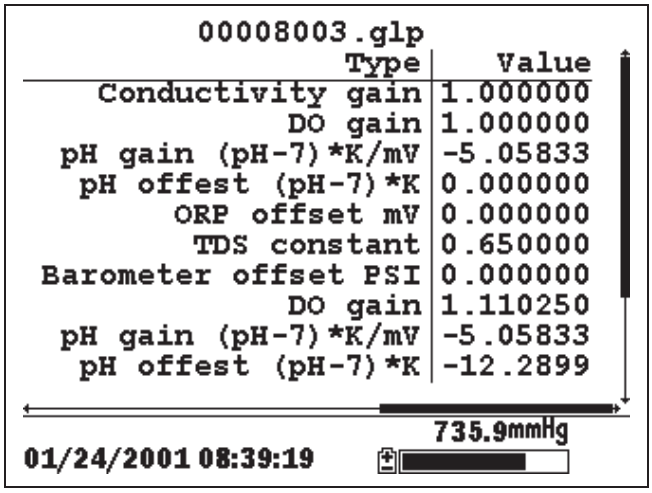


Figure 21.2 Calibration Record Screen 2

NOTE: Each sensor (not parameter) is characterized by either 1 line (Conductivity, Dissolved Oxygen, ORP, TDS, or Barometer (Optional)) or 2 lines (pH) of calibration documentation.

The left hand portion of each calibration entry shows the date and time that a calibration of a particular sensor was performed. In addition, each calibration entry is characterized by the instrument serial number, as defined by YSI. See Figure 21.1 Calibration Record Screen 1. The right hand portion shows the YSI designation of the calibration constants and their values after their calibration has been performed. A more detailed description of the calibration constants is provided below:

- **Conductivity Gain** – A relative number which describes the sensitivity of the sensor. Basically, the value represents the calculated cell constant divided by the typical value of the cell constant (5 cm^{-1}).

- **DO Gain** – A relative number which describes the sensitivity of the sensor. Basically, the value represents the sensor current at the time of calibration divided by the typical value of the sensor current (15 uA).

- **pH Gain** – A number which basically represents the sensitivity of the pH sensor. To remove the effect of temperature on the slope of the relationship of probe output in mv versus pH, the value of pH/mv is multiplied by the temperature in degrees Kelvin (K).

- **pH Offset** – A number which basically represents the offset (or intercept) of the relationship of probe output in mv versus pH, the value of pH is multiplied by the temperature in degrees Kelvin (K).

Anytime you perform a calibration, information concerning the calibration constants will be logged to the Calibration Record file (.glp file). However, if the **Delete All Files** command is used, Refer to Section *8.6 Delete All Files*, the Calibration Record file will also be lost. It is critical that this file should be uploaded to your PC prior to issuing a **Delete All Files** command. Refer to Section *8.4 Upload to PC*.

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STANDARD OPERATING PROCEDURE 005

Low-Flow Groundwater Sampling from Monitoring Wells – EPA Region I and III

I. Purpose and Scope

This SOP presents general guidelines for the collection of groundwater samples from monitoring wells using low-flow purging and sampling procedures. Operations manuals should be consulted for specific calibration and operating procedures.

II. Equipment and Materials

- Adjustable-rate positive-displacement pump, submersible pump, or peristaltic pump
- Horiba® U-22 or equivalent water quality meters to monitor pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature
- Flow-through cell with inlet/outlet ports for purged groundwater and watertight ports for each probe
- Generator or alternate power source depending on pump type
- Water-level indicator
- Disposable Teflon, Teflon-lined polyethylene tubing or polyethylene tubing for metals and other inorganics
- Plastic sheeting
- Well-construction information
- Calibrated container and stopwatch to determine flow rate
- Sample containers
- In-line disposable 0.45µm filters (QED® FF8100 or equivalent)
- Shipping supplies (labels, coolers, and ice)
- Field book

III. Procedures and Guidelines

A. Setup and Purging

1. Obtain information on well location, diameter(s), depth, and screen interval(s), and the method for disposal of purged water.

2. Calibrate instruments according to manufacturer's instructions.

3. The well number, site, date, and condition are recorded in the field logbook.

4. Plastic sheeting is placed on the ground, and the well is unlocked and opened. All decontaminated equipment to be used in sampling will be placed only on the plastic sheeting until after the sampling has been completed. To avoid cross-contamination, do not let any downhole equipment touch the ground.

5. All sampling equipment and any other equipment to be placed in the well is cleaned and decontaminated before sampling in accordance with SOP *Decontamination of Personnel and Equipment*.

6. Water level measurements are collected in accordance with the *Water Level Measurements* SOP. **Do not measure the depth to the bottom of the well at this time**; this reduces the possibility that any accumulated sediment in the well will be disturbed. Obtain depth to bottom information from well construction log.

7. Attach and secure the tubing to the low-flow pump. Lower the pump slowly into the well and set it at approximately the middle of the screen. Place the pump intake in the middle of the saturated screen length and should be at least two feet above the bottom of the well to avoid mobilization of any sediment present in the bottom.

8. Insert the measurement probes into the flow-through cell. The purged groundwater is directed through the cell, allowing measurements to be collected before the water contacts the atmosphere.

9. If using a generator, locate it 30 feet downwind from the well to avoid exhaust fumes contaminating the samples.

10. Start purging the well at 0.2 to 0.5 liters per minute. Avoid surging. Purging rates for more transmissive formations could be started at 0.5-liter to 1 liter per minute. The initial field parameters of pH, specific conductance, dissolved oxygen, ORP, turbidity, and temperature of water are measured and recorded in the field logbook.

11. The water level should be monitored during purging, and, ideally, the purge rate should equal the well recharge rate so that there is little or no drawdown in the well (i.e., less than 0.3-foot). The water level should stabilize for the specific purge rate. There should be at least 1 foot of water over the pump intake so there is no risk of the pump suction being broken, or entrainment of air in the sample. Record adjustments in the purge rate and changes in depth to water in the logbook. Purge rates should, if needed, be decreased to the minimum capabilities of the pump (0.1- to 0.2-liter per minute) to avoid affecting well drawdown.

12. During purging, the field parameters are measured frequently (every 5 minutes) until the parameters have stabilized. Field parameters are considered stable when measurements meet the following criteria:

    - pH: within 0.1 pH units
    - Specific conductance: within 3 percent

- Dissolved oxygen: within 10 percent
- Turbidity: within 10 percent for values greater than 5 NTU; if 3 turbidity values are less than 5 NTU, consider the values as stabilized
- ORP: within 10 mV
- Temperature: within 3 percent

B. Sample Collection

Once purging is complete the well is ready to sample. The elapsed time between completion of purging and collection of the groundwater sample should be minimized. Typically, the sample is collected immediately after the well has been purged, but this is also dependent on well recovery.

Samples will be placed in sample containers that have been cleaned to laboratory standards and are preserved in accordance with the analytical method. The containers are typically pre-preserved, if required.

VOC samples are normally collected first and directly into pre-preserved sample containers.

During purging and sampling, the centrifugal/peristaltic pump tubing must remain filled with water to avoid aeration of the groundwater. It is recommended that ¼ or 3/8 inch inside diameter tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, collect non-VOC dissolved gasses samples first, then increase flow rate slightly until water completely fills the tubing and collect the VOC/dissolved gases samples. Record new flow rate and drawdown depth.

The steps to be followed for sample collection are as follows:

1. The cap is removed from the sample bottle, and the bottle is tilted slightly.
2. The sample is slowly poured from the bailer or discharged from the pump so that it runs down the inside of the sample bottle with a minimum of splashing. The pumping rate should be reduced to approximately 100 ml per minute when sampling VOCs.
3. Inorganics, including metals, may be collected and preserved in the filtered form as well as the unfiltered form. Disposable in-line filters (0.45 micron filter), connected to the end of the sample tubing,, are typically used for field filtration. Samples are field filtered as the water is being placed into the sample container. If a bailer is used, filtration may be driven by a peristaltic pump.
4. Adequate space is left in the bottle to allow for expansion, except for VOC vials, which are filled to the top with a positive meniscus.

5. The bottle is capped and clearly labeled.

6. Samples are placed in appropriate containers and, if necessary, packed with ice in coolers as soon as practical.

7. Nondedicated equipment is cleaned and decontaminated in accordance with the *Decontamination of Personnel and Equipment* SOP.

The following information, at a minimum, will be recorded in the log book:

1. Sample identification (site name, location, and project number; sample name/number and location; sample type and matrix; time and date; sampler's identity)

2. Sample source and source description

3. Field observations and measurements (appearance, volatile screening, field chemistry, sampling method), volume of water purged prior to sampling, number of well volumes purged, and field parameter measurements

4. Sample disposition (preservative; laboratory name, date and time sent; laboratory sample number, chain-of-custody number, sample bottle lot number)

5. Additional remarks

C. Additional remarks

1. If the well goes dry during purging, wait until it recovers sufficiently to remove the required volumes to sample all parameters. It may be necessary to return periodically to the well but a particular sample (e.g., large amber bottles for semivolatile analysis) should be filled at one time rather than over the course of two or more visits to the well.

2. Disposable tubing is disposed of with PPE and other site trash.

IV. Attachments

White paper on reasons and rationale for low-flow sampling.

V. Key Checks and Preventative Maintenance

- The drawdown in the well should be minimized as much as possible (preferably no more than 0.5-foot to 1 foot) so that natural groundwater-flow conditions are maintained as closely as possible.

- The highest purging rate should not exceed 1 liter per minute. This is to keep the drawdown minimized.

- Stirring up of sediment in the well should be avoided so that turbidity containing adsorbed chemicals is not suspended in the well and taken in by the pump.

- Overheating of the pump should be avoided to minimize the potential for losing VOCs through volatilization.
- Keep the working space clean with plastic sheeting and good housekeeping.
- Maintain field equipment in accordance with the manufacturer's recommendations. This will include, but is not limited to:
    - Inspect sampling pump regularly and replace as warranted
    - Inspect quick-connects regularly and replace as warranted
    - Verify battery charge, calibration, and proper working order of field measurement equipment prior to initial mobilization and daily during field efforts

Attachment to the SOP on Low-Flow Sampling Groundwater Sampling from Monitoring Wells

White Paper on Low-Flow Sampling

EPA recommends low-flow sampling as a means of collecting groundwater samples in a way that minimizes the disturbance to the natural groundwater flow system and minimizes the introduction of contamination into the samples from extraneous sources. The following are details about these issues.

When a pump removes groundwater from the well at the same rate that groundwater enters the well through the screen, the natural groundwater-flow system around the well experiences a minimum of disturbance. Some disturbance is bound to occur because you are causing groundwater to flow to the well in a radial fashion that otherwise would have flowed past it. However, the resulting low-flow sample provides the most-representative indication we can get of groundwater quality in the immediate vicinity of the well.

Normally, when a well is pumped at an excessive rate that drops the water level in the well below the water level in the aquifer, the water cascades down the inside of the well screen when it enters the well. The turbulence from this cascading causes gases such as oxygen and carbon dioxide to mix with the water in concentrations that are not representative of the native groundwater and are higher than expected. This causes geochemical changes in the nature of the water that can change the concentrations of some analytes, particularly metals, in the groundwater sample, not mention its effect on the dissolved oxygen levels that then will be measured in the flow-through cell. Such turbulence also may cause lower-than-expected concentrations of volatile organic compounds due to volatilization.

For wells in which the water level is above the top of the screen, the water up in the riser is out of the natural circulation of the groundwater and, therefore, can become stagnant. This stagnant water is no longer representative of natural groundwater quality because its pH, dissolved-oxygen content, and other geochemical characteristics change as it contacts the air in the riser. If we minimize the drawdown in the well when we pump, then we minimize the amount of this stagnant water that is brought down into the well screen and potentially into the pump. As a result, a more-representative sample is obtained.

Typically, wells contain some sediment in the bottom of the well, either as a residue from development that has settled out of the water column or that has sifted through the sand pack and screen since the well was installed. This sediment commonly has adsorbed on it such analytes as metals, SVOCs, and dioxins that normally would not be dissolved in the groundwater. If these sediments are picked up in the groundwater when the well is disturbed by excessive pumping, they can:

- Make filtering the samples for metals analysis more difficult
- Add unreasonably to the measured concentration of SVOCs and other organic compounds

The SOP for low-flow sampling has been modified recently and should be consulted for additional information about low-flow sampling and ways of dealing with wells in which the water level cannot be maintained at a constant level.

STANDARD OPERATING PROCEDURE 006

Sampling Contents of Tanks and Drums

I. Scope and Application

This procedure provides an overview approach and guidelines for the routine sampling of drums and tanks. Its purpose is to describe standard procedures and precautions which are applied in sampling drums and tanks. Procedures for opening drums with the individual instruments are included in Attachment D.

The samples obtained may be used to obtain physical chemical or radiological data. The resulting data may be qualitative or quantitative in nature, and are appropriate for use in preliminary surveys as well as confirmatory sampling.

II. Summary of Methods

Drums are generally sampled by means of sampling tubes such as glass sample tubes or COLIWASA samplers. In either case, the sampling tube is manually inserted into the waste material. A sample of the drum contents is withdrawn by the sampling device. Should a drum contain bottom sludge, a glass tube will be used to retrieve a sample of this as well.

Storage tank and tank trailers, because of their greater depths, require sampling devices that can be lowered from the top, filled at a particular depth, then withdrawn. Such devices are a COLIWASA, a Kemmerer depth sampler, or a Bacon Bomb. Where samples of bottom sludge are desired, a gravity corer can be utilized. This heavy tube with a tapered nose piece will penetrate the sludge as it free falls through the tank.

III. Comments

The sampling of tanks, containers, and drums present unique problems not associated with environmental samples. Containers of this sort are generally closed except for small access ports, manways, or hatches on the larger vessels, or taps and bungs on smaller drums. The physical size, shape, construction material, and location of access limit the types of equipment and methods of collection that can be used.

When liquids are contained in sealed vessels, gas vapor pressure can build up, sludges can settle out, and density layerings (stratification) can develop. Bulging drums may be under pressure and extreme caution should be exercised. The potential exists for explosive reactions or the release of noxious gases when containers are opened. All vessels should be opened with extreme caution. Check the HSP for the level of personnel protection to be worn. A preliminary sampling of any headspace gases is warranted. As a minimum, a preliminary check with an

explosimeter and an organic vapor analyzer may be of aid in selecting a sampling method.

In most cases it is impossible to observe the contents of these sealed or partially sealed vessels. Since some layering or stratification is likely in any solution left undisturbed over time, a sample must be taken that represents the entire depth of the vessel.

IV. Required Equipment and Apparatus

A. **Health and safety equipment/materials**: As listed in the site safety plan.

B. **Sampling equipment**: COLIWASA, glass sample tubes, Kemmerer depth sampler, Bacon Bomb, gravity corer.

C. **Tools**: Rubber mallet, bung wrench, speed wrench with socket, etc., (all non-sparking), paint marker.

D. **Heavy equipment**: Backhoe equipped with explosion shield, drum grappler, and 3-foot copper-beryllium (non-sparking) spike with 6-inch collar (to puncture top of drums for sampling, if necessary).

E. **Sample Containers**: As specified in the field sampling plan.

V. Procedures

A. Drums

NOTE: DO NOT open more than one drum at a time. Each drum must be handled and sampled as a separate entity to reduce vapors in the sampling area.

1. Drums will be sampled on an area-by-area basis. Drums will be sampled after they have been placed in overpack drums but before they are transferred from the excavation to the onsite storage area.

2. Record, in logbook, all pertinent information from visual inspection of drum (e.g., physical condition, leaks, bulges, and labels). Label each drum with a unique identifying number.

3. If possible, stage drums for easy access.

4. If necessary, attach ground strap to drums and grounding point.

5. Remove any standing material (water, etc.) from container top.

6. Using non-sparking tools, carefully remove the bung or lid while monitoring air quality with appropriate instruments. If necessary (and as a last resort), the non-sparking spike affixed to the backhoe can also be used to puncture the drum for sampling. See Attachment D for method of drum opening. Record air-quality monitoring results.

7. When sampling a previously sealed vessel, a check should be made for the presence of bottom sludge. This is accomplished by measuring the depth to apparent bottom, then comparing it to the known interior depth.

8. Agitation to disrupt the layers and rehomogenize the sample is physically difficult and almost always undesirable. If the vessel is greater than 3 feet in depth (say, a 55-gallon drum), the appropriate sampling method is to slowly lower the sampling device (i.e., suction line of peristaltic pump, glass tube) in known increments of length. Discrete samples can be collected from various depths, then combined or analyzed separately. If the depth of the vessel is greater than the lift capacity of the pump, an at-depth water sampler, such as the Kemmerer or Bacon Bomb type, may be required.

9. Extract a representative sample from the drum using a glass rod, COLIWASA, Bacon Bomb, Kemmerer bottle, or gravity corer (See Attachments). Ensure that the entire depth of material is penetrated. Depending on the size of the opening of the drum, three to four takes should be collected from random locations across the drum surface, to ensure a representative sample. Any observed stratification must be recorded in logbook, including number and thickness of the layers and a conceptualized sketch.

10. Record a visual description of the sample (e.g., liquid, solid, color, viscosity, and percent layers).

11. When possible, sampling equipment (like glass tubes) should be expendable and be left inside the drum for disposal with drum contents, once sampling is completed.

12. Place lid, bung, cap, etc., back in place on drum. Tighten hand tight. If necessary, the sampling port can be sealed using a cork.

13. Wipe up spilled material with lab wipes. Wipe off sample containers.

14. Mark the drum with a unique sample identification number and date using a paint marker.

15. Samples will be handled as high hazard samples. Samples will be placed in containers defined according to the analytical needs, wiped clean, and then packed in paint cans for shipping. Packaging, labeling, and preparation for shipment procedures will follow procedures as specified in the field sampling plan.

B. Underground Storage Tanks

1. A sampling team of at least two people is required for sampling—one will collect samples, the other will relay required equipment and implements.

2. Sampling team will locate a sampling port on the tank. Personnel should be wearing appropriate protective clothing at this time and carrying sampling gear.

3. Do not attempt to climb down into tank. Sampling MUST BE accomplished from the top.

4. Collect a sample from the upper, middle, and lower section of the tank contents with one of the recommended sampling devices.

5. If compositing is necessary, ship samples to laboratory in separate containers for laboratory compositing.

6. Samples will be handled as hazardous. Samples will be placed in appropriate containers and packed with ice in a cooler. Packaging, labeling, and preparation for shipment will follow procedures specified in the field sampling plan.

C. Tank Trailers or Above-Ground Storage Tanks

1. A sampling team of two is required. One will collect samples, the other will relay required equipment and implements.

2. Samples will be collected through the manhole (hatch) on top of the tanker or the fill port. Do not open valves at the bottom. Before opening the hatch, check for a pressure gauge or release valve. Open the release valve slowly to bring the tank to atmospheric pressure.

3. If tank pressure is too great, or venting releases large amounts of toxic gas, discontinue venting and sampling immediately. Measure vented gas with organic vapor analyzer and explosimeter.

4. If no release valve exists, slowly loosen hatch cover bolts to relieve pressure in the tank. (Again, stop if pressure is too great.)

5. Once pressure in tank has been relieved, open the hatch and withdraw sample using one of the recommended sampling devices.

6. Sample each trailer compartment.

7. If compositing is necessary, ship samples to laboratory in separate containers for laboratory compositing.

8. Samples will be handled as hazardous. Samples will be placed in appropriate containers and packed with ice in a cooler. Packaging, labeling, and preparation for shipment will follow procedures specified in the field sampling plan.

D. Refer to Attachment B for procedures for sampling with appropriate devices as follows:

Drum

Glass tube	—	Procedure 1
COLIWASA	—	Procedure 2

Storage Tank and Tank Trailer

COLIWASA	—	Procedure 2
Bacon Bomb	—	Procedure 3
Gravity Corer (for bottom sludge)	—	Procedure 4

VI. Contamination Control

Sampling tools, instruments, and equipment will be protected from sources of contamination prior to use and decontaminated after use as specified in SOP *Decontamination of Personnel and Equipment*. Liquids and materials from decontamination operations will be handled in accordance with the waste management plan. Sample containers will be protected from sources of contamination. Sampling personnel shall wear chemical resistant gloves when handling any samples. Gloves will be decontaminated or disposed of between samples.

VIII. Attachments

A. Collection of Liquid-Containerized Wastes Using Glass Tubes

B. Sampling Containerized Wastes Using the Composite Liquid Waste Sample (COLIWASA)

C. Sampling Containerized Wastes Using the Bacon Bomb Sampler

D. Gravity Corer for sampling Sludges in Large Containers

E. Construction of a Typical COLIWASA

F. Drum Opening Techniques and Equipment

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X. Field Checklist

_____ Sampling Instruments

_____ Tools

_____ Rubber Mallet

_____ Logbook

_____ Safety Glasses or Monogoggles

_____ Safety Shoes

_____ Ice/Cooler, as required

_____ Custody Seals, as required

_____ Chain-of-Custody Forms

_____ Drum Labels, as required

_____ Paint Marker, if drum sampling

_____ Black Indelible Pen

_____ Monitoring Instruments

_____ Labels

_____ Sampling and Analysis Plan

_____ Health and Safety Plan

_____ Decontamination Equipment

_____ Lab Wipes

_____ Lab Spatulas or Stainless Steel Spoons

_____ Chemical Preservatives, as required

_____ Appropriate Containers for Waste and Equipment

_____ Duct Tape

_____ Plastic Sheeting

Attachment A Collection of Liquid-Containerized Wastes Using Glass Tubes

Discussion

Liquid samples from opened containers (i.e., 55-gallon drums) are collected using lengths of glass tubing. The glass tubes are normally 122 centimeters long and 6 to 16 millimeters inside diameter. Larger diameter tubes may be used for more viscous fluids if sampling with the small diameter tube is not adequate. The tubing is broken and discarded in the container after the sample has been collected, eliminating difficult cleanup and disposal problems. This method should not be attempted with less than a two-person sampling team.

Uses

This method provides for a quick, relatively inexpensive means of collecting concentrated containerized wastes. The major disadvantage is from potential sample loss that is especially prevalent when sampling low-viscosity fluids. Splashing can also be a problem and proper protective clothing should always be worn.

Note: A flexible tube with an aspirator attached is an alternative method to the glass tube, and allows various levels to be sampled discretely.

Procedures for Use

1. Remove cover from sample container.
2. Insert glass tubing almost to the bottom of the container. Tubing should be of sufficient length so that at least 30 centimeters extend above the top of the container.
3. Allow the waste in the drum to reach its natural level in the tube.
4. Cap the top of the tube with a safety-gloved thumb or a stopper.
5. Carefully remove the capped tube from the drum. If the tube has passed through more than one layer, the boundary should be apparent in the glass tube.
6. Insert the bottom, uncapped end into the sample container.
7. Partially release the thumb or stopper on the top of the tube and allow the sample to slowly flow into the sample container. If separation of phases is desired, cap off tube before the bottom phase has completely emptied. It may be advisable to have an extra container for "waste," so that the fluid on either side of the phase boundary can be directed into a separate container, allowing collection of pure phase liquids in the sample containers. The liquid remaining after the boundary fluid is removed is collected in yet a third container. NOTE: It is not necessary to put phases in separate containers if analysis of separate phases is not desired.
8. Repeat steps 2 through 6 if more volume is needed to fill the sample container.
9. Remove the tube from the sample container and replace the tube in the drum, breaking it, if necessary, in order to dispose of it in the drum.

Optional Method (if sample of bottom sludge is desired)

1. Remove the cover from the container opening.
2. Insert glass tubing slowly almost to the bottom of the container. Tubing should be of sufficient length so that at least 30 cm extends above the top of the container.
3. Allow the waste in the drum to reach its natural level in the tube.
4. Gently push the tube towards the bottom of the drum into the sludge layer. Do not force it.
5. Cap the top of the tube with a safety-gloved thumb or stopper.
6. Carefully remove the capped tube from the drum and insert the uncapped end into the sample container.
7. Release the thumb or stopper on the top of the tube and allow the sample container to fill to approximately 90 percent of its capacity. If necessary, the sludge plug in the bottom of the tube can be dislodged with the aid of the stainless steel laboratory spatula.
8. Repeat if more volume is needed to fill sample container and recap the tube.

Note:

1. If a reaction is observed when the glass tube is inserted (violent agitation, smoke, light, etc.), the investigators should leave the area immediately.
2. If the glass tube becomes cloudy or smoky after insertion into the drum, the presence of hydrofluoric acid maybe indicated, and a comparable length of rigid plastic tubing should be used to collect the sample.
3. When a solid is encountered in a drum (either layer or bottom sludge) the optional method described above may be used to collect a core of the material, or the material may be collected with a disposable scoop attached to a length of wooden or plastic rod.

Attachment B: Sampling Containerized Wastes using the Composite Liquid Waste Sampler (COLIWASA)

Discussion

The COLIWASA is a much-cited sampler designed to permit representative sampling of multiphase wastes from drums and other containerized wastes. The sampler is commercially available or can be easily fabricated from a variety of materials, including PVC, glass, or Teflon. In its usual configuration it consists of a 152 cm by 4 cm (inside diameter) section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper. See Attachment E: Construction of a COLIWASA.

Uses

The COLIWASA is primarily used to sample containerized liquids. The PVC COLIWASA is reported to be able to sample most containerized liquid wastes except for those containing ketones, nitrobenzene, dimethylforamide, mesityloxide, and tetrahydrofuran. A glass COLIWASA is able to handle all wastes unable to be sampled with the plastic unit except strong alkali and hydrofluoric acid solutions. Due to the unknown nature of many containerized wastes, it would therefore be advisable to eliminate the use of PVC materials and use samplers composed of glass or Teflon.

The major drawback associated with using a COLIWASA is concern for decontamination and costs. The sampler is difficult, if not impossible, to decontaminate in the field, and its high cost in relation to alternative procedures (glass tubes) makes it an impractical throwaway item. It still has applications, however, especially in instances where a true representation of a multiphase waste is absolutely necessary.

Procedures for Use

1. Check to make sure the sampler is functioning properly. Adjust the locking mechanism, if present, to make sure the neoprene rubber stopper provides a tight closure.

2. Put the sampler in the open position by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block.

3. Slowly lower the sampler into the liquid waste. Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sample tube is lower than that outside the sampler, the sampling rate is too fast and will result in a non-representative sample.

4. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.

5. Slowly withdraw the sampler from the waste container with one hand while wiping the sampler tube with a laboratory wipe with the other hand. A phase boundary, if present, can be observed through the tube.

6. Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container.

7. Unscrew the T-handle of the sampler and disengage the locking block.

Attachment C: Sampling Containerized Wastes using the Bacon Bomb Sampler

Discussion

The Bacon Bomb is designed for the withdrawal of samples from various levels within a storage tank. It consists of a cylindrical body with an internal tapered plunger that acts as a valve to admit the sample. A line attached to the top of the plunger is used to open and close the valve. A removable cover provides a point of attachment for the sample line and has a locking mechanism to keep the plunger closed after sampling. The Bacon Bomb is usually constructed of chrome-plated brass and bronze with a rubber O-ring acting as the plunger-sealing surface. Stainless steel versions are also available. The volumemetric capacity is 8, 16, or 32 oz (237, 473, or 946 ml).

Uses

The Bacon Bomb is a heavy sampler suited best for viscous materials held in large storage tanks or in lagoons. If a more non-reactive sampler is needed, the stainless steel version would be used, or any of the samplers could be coated with Teflon.

Procedures for Use

1. Attach the sample line and the plunger line to the sampler.
2. Measure and then mark the sampling line at the desired depth.
3. Gradually lower the sampler by the sample line until the desired level is reached.
4. When the desired level is reached, pull up on the plunger line and allow the sampler to fill for a sufficient length of time before releasing the plunger line to seal off the sampler.
5. Retrieve the sampler by the sample line, being careful not to pull up on the plunger line, thereby accidentally opening the bottom valve.
6. Wipe off the exterior of the sampler body.
7. Position the sampler over the sample container and release its contents by pulling up on the plunger line.

Attachment D: Gravity Corer for Sampling Sludges in Large Containers

Discussion

A gravity corer is a metal tube with a replaceable tapered nosepiece on the bottom and a ball or other type of check valve on the top. The check valve allows water to pass through the corer on descent but prevents a washout during recovery. The tapered nosepiece facilitates cutting and reduces core disturbance during penetration. Most corers are constructed of brass or steel and many can accept plastic liners and additional weights.

Uses

Corers are capable of collecting samples of most sludges and sediments. They collect essentially undisturbed samples that represent the strata profile that may develop in sediments and sludges during variations in the deposition process. Depending on the density of the substrate and the weight of the corer, penetration to depths of 75 cm (30 in.) can be attained. Exercise care when using gravity corers in vessels or lagoons that have liners because penetration depths could exceed those of the substrate; this could result in damage to the liner material.

Procedures for Use

1. Attach a precleaned corer to the required length of sample line. Solid braided 5-mm (3/16-in.) nylon line is sufficient; however, 20-mm (3/4-in.) nylon is easier to grasp during hand hoisting. An additional weight can be attached to the outside of the corer if necessary.
2. Secure the free end of the line to a fixed support to prevent accidental loss of the corer.
3. Allow corer to free fall through the liquid to the bottom.
4. Retrieve corer with a smooth, continuous, up-lifting motion. Do not bump corer because this may result in some sample loss.
5. Remove nosepiece from corer and slide sample out of corer into stainless steel or Teflon pan (preferred).
6. Transfer sample into appropriate sample bottle with a stainless steel lab spoon or laboratory spatula.

Attachment E: Construction of a Typical COLIWASA

The sampling tube consists of a 1.52-m (5-ft) by 4.13-cm (1-5/8 in) I.D. translucent plastic pipe, usually polyvinyl chloride (PVC) or borosilicate glass plumbing tube. The closure-locking mechanism consists of a short-length, channeled aluminum bar attached to the sampler's stopper rod by an adjustable swivel. The aluminum bar serves both as a T-handle and lock for the samplers' closure system. When the sampler is in the open position, the handle is placed in the T-position and pushed down against the locking block. This manipulation pushes out the neoprene stopper and opens at the sampling tube. In the closed position, the handle is rotated until one leg of the T is squarely perpendicular against the locking block. This tightly seats the neoprene stopper against the bottom opening of he sampling tube and positively locks the sampler in the closed position. The closure tension can be adjusted by shortening or lengthening the stopper rod by screwing it in or out of the T-handle swivel. The closure system of the sampler consists of a sharply tapered neoprene stopper attached to a 0.95-cm (3/8-in) O.D. rod, usually PVC. The upper end of the stopper rod is connected to the swivel of the aluminum T-handle. The sharply tapered neoprene stopper can be fabricated according to specifications by plastic-products manufacturers at an extremely high price, or it can be made in-house by grinding down the inexpensive stopper with a shop grinder.

COLIWASA samplers are typically made out of plastic or glass. The plastic type consists of translucent plastic (usually PVC) sampling tube. The glass COLIWASA uses borosilicate glass plumbing pipe as the sampling tube and a Teflon plastic stopper rod. For purpose of multiphase sampling, clear plastic or glass is desirable in order to observe the profile of the multiphase liquid.

The sampler is assembled as follows:

a. Attach the swivel to the T-handle with the 3.18-cm (1-1/4 in) long bolt and secure with the 0.48-cm (3/16-in) National Coarse (NC) washer and lock nut.

b. Attach the PFTE stopper to one end of the stopper rod and secure with the 0.95-cm (3/8-in) washer and lock nut.

c. Install the stopper and stopper rod assembly in the sampling tube.

d. Secure the locking block sleeve on the block with glue or screw. This block can also be fashioned by shaping a solid plastic rod on a lathe to the required dimension.

e. Position the locking block on top of the sampling tube such that the sleeveless portion of the block fits inside the tube, the sleeve sits against the top end of the tube, and the upper end of the stopper rod slips though the center hole of the block.

f. Attach the upper end of the stopper rod to the swivel of the T-handle.

g. Place the sampler in the close position and adjust the tension on the stopper by screwing the T-handle in or out.

Attachment F: Drum Opening Techniques and Equipment [1]

I. Introduction

The opening of closed drums prior to sampling entails considerable risk if not done with the proper techniques, tools, and safety equipment. The potential for vapor exposure, skin exposure due to splash or spraying, or even explosion resulting from sparks produced by friction of the tools against the drum, necessitate caution when opening any closed container. Both manual drum opening and remote drum opening will be discussed in the following paragraphs. When drums are opened manually risks are greater than when opened remotely; for this reason, the remote opening of drums is advised whenever possible.

Prior to sampling, the drums should be staged to allow easy access. Also, any standing water or other material should be removed from the container top so that the representative nature of the sample is not compromised when the container is opened. There is also the possibility of encountering a water-reactive substance.

II. Manual Drum Opening

A. Bung Wrench

A common method for opening drums manually is using a universal bung wrench. These wrenches have fittings made to remove nearly all commonly encountered bungs. They are usually constructed of cast iron, brass, or a bronze-beryllium (a non-sparking alloy formulated to reduce the likelihood of sparks). The use of bung wrenches marked "NON SPARKING" is encouraged. However, the use of a "NON SPARKING" wrench does not completely eliminate the possibility of spark being produced. Such a wrench only prevents a spark caused by wrench-to-bung friction, but it cannot prevent sparking between the threads on the drum and the bung.

A simple tool to use, the fitting on the bung wrench matching the bung to be removed is inserted into the bung and the tool is turned counterclockwise to remove the bung. Since the contents of some drums may be under pressure (especially, when the ambient temperature is high), the bung should be turned very slowly. If any hissing is heard, the person opening the drum should back off and wait for the hissing to stop. Since drums under pressure can spray out liquids when opened, the wearing of appropriate eye and skin protection in addition to respiratory protection is critical.

B. Drum Deheader

One means by which a drum can be opened manually when a bung is not removable with a bung wrench is by using a drum deheader. This tool is constructed of forged steel with an alloy steel blade and is designed to cut the lid of a drum off or part way

[1] Taken from EPA Training Course: "Sampling for Hazardous Materials," U.S. Environmental Protection Agency, Office of Emergency and Remedial Response Support Division, March 24, 1987.

off by means of a scissors-like cutting action. A limitation of this device is that it can be attached only to closed head drums (i.e., DOT Specification 17E and 17F drums); drums with removable heads must be opened by other means.

Drums are opened with a drum deheader by first positioning the cutting edge just inside the top chime and then tightening the adjustment screw so that the deheader is held against the side of the drum. Moving the handle of the deheader up and down while sliding the deheader along the chime will enable the entire top to be rapidly cut off if so desired. If the top chime of a drum has been damaged or badly dented it may not be possible to cut the entire top off. Since there is always the possibility that a drum may be under pressure, the initial cut should be made very slowly to allow for the gradual release of any built-up pressure. A safer technique would be to employ a remote pressure release method prior to using the deheader.

C. Hand Pick or Spike

When a drum must be opened and neither a bung wrench nor a drum deheader is suitable, then it can be opened for sampling by using a hand pick, pickaxe, or spike. These tools are usually constructed of brass or a non-sparking alloy with a sharpened point that can penetrate the drum lid or head when the tool is swung. The hand picks or pickaxes that are most commonly used are commercially available, whereas the spikes are generally uniquely fabricated 4- foot long poles with a pointed end. Often the drum lid or head must be hit with a great deal of force in order to penetrate it. Because of this, the potential for splash or spraying is greater than with other opening methods and therefore this method of drum opening is not recommended, particularly when opening drums containing liquids. Some spikes used for drum opening have been modified by the addition of a circular splash plate near the penetrating end. This plate acts as a shield and reduces the amount of splash in the direction of the person using the spike. Even with this shield, good splash gear is essential.

Since drums, some of which may be under pressure, cannot be opened slowly with these tools, "sprayers" may result and appropriate safety measures must be taken. The pick or spike should be decontaminated after each drum is opened to avoid cross contamination and/or adverse chemical reaction from incompatible materials.

III. Remote Opening

A. Backhoe Spike

The most common means used to open drums remotely for sampling is the use of a metal spike attached or welded to a backhoe bucket. In addition to being very efficient, this method can greatly reduce the likelihood of personnel exposure.

Drums should be "staged," or placed in rows with adequate aisle space to allow ease in backhoe maneuvering. Once staged, the drums can be quickly opened by punching a hole in the drum head or lid with the spike.

The spike should be decontaminated after each drum is opened to prevent cross contamination. Even though some splash or spray may occur when this method is

used, the operator of the backhoe can be protected by mounting a large shatter-resistant shield in front of the operator's cage. This, combined with the normal sampling safety gear, should be sufficient to protect the operator. Additional respiratory protection can be afforded by providing the operator with an on-board airline system. The hole in the drum can be sealed with a cork.

B. Hydraulic Devices

Recently, remotely operated hydraulic devices have been fabricated to open drums remotely. One such device is discussed here. This device uses hydraulic pressure to pierce through the wall of a drum. It consists of a manually operated pump that pressurizes oil through a length of hydraulic line. A piercing device with a metal point is attached to the end of this line and is pushed into the drum by the hydraulic pressure. The piercing device can be attached so that a hole for sampling can be made in either the side or the head/lid of the drum. Some of the metal piercers are hollow or tube-like so that they can be left in place, if desired, and serve as a permanent tap or sampling port. The piercer is designed to establish a tight seal after penetrating the container.

C. Pneumatic Devices

Pneumatically-operated devices utilizing compressed air have been designed to remove drum bungs remotely. A pneumatic bung remover consists of a compressed air supply (usually SCBA cylinders) that is controlled by a heavy-duty, 2-stage regulator. A high pressure air line of desired length delivers compressed air to a pneumatic drill that is adapted to turn a bung fitting (preferably, a bronze-beryllium alloy) selected to fit the bung to be removed. An adjustable bracketing system has been designed to position and align the pneumatic drill over the bung. This bracketing system must be attached to the drum before the drill can be operated. Once the bung has been loosened, the bracketing system must be removed before the drum can be sampled. This attachment and removal procedure is time- consuming and is the major drawback of this device. This remote bung opener does not permit the slow venting of the container, and therefore appropriate precautions must be taken. It also requires the container to be upright and relatively level. Bungs that are rusted shut cannot be removed with this device.

IV. Summary

The opening of closed containers is one of the most hazardous site activities. Maximum efforts would be made to ensure the safety of the sampling team. Proper protective equipment and a general wariness of the possible dangers will minimize the risk inherent to sampling operations. Employing proper drum opening techniques and equipment will also safeguard personnel. The use of remote sampling equipment whenever feasible is highly recommended.

STANDARD OPERATING PROCEDURE 007

Disposal of Waste Fluids and Solids

I. Purpose and Scope

This SOP describes the procedures used to dispose of hazardous fluid and solid materials generated as a result of the site operations. This SOP does not provide guidance on the details of Department of Transportation regulations pertaining to the transport of hazardous wastes; the appropriate Code of Federal Regulations (49 CFR 171 through 177) should be referenced. Also, the site investigation-derived waste management plan should be consulted for additional information and should take precedence over this SOP.

II. Equipment and Materials

A. Fluids

- DOT-approved 55-gallon steel drums or Baker® Tanks
- Tools for securing drum lids
- Funnel for transferring liquid into drum
- Labels
- Paint Pens
- Marking pen for appropriate labels
- Seals for 55-gallon steel drums

B. Solids

- DOT-approved 55-gallon steel drums or rolloffs
- Tools for securing drum lids
- Paint Pens
- Plastic sheets
- Labels
- Marking pen for appropriate labels

III. Procedures and Guidelines

A. Methodology

Clean, empty drums or rolloffs or Baker® Tanks will be brought to the site by the drilling subcontractor for soil and groundwater collection and storage. The empty drums will be located at the field staging area and moved to drilling locations as required. The drums will be filled with the drilling and well installation wastes, capped, sealed, and moved to the onsite drum storage area by the drilling subcontractor. The full drums will separate types of wastes by media. The drums will

be labeled as they are filled in the field and labels indicating that the contents are pending analysis affixed.

The drum contents will be sampled to determine the disposal requirements of the drilling wastes. The drum sampling will be accomplished through the collection and submittal of composite samples, one sample per 10 drums (check with disposal facility to determine sample frequency) containing the same media. Similar compositing will be performed in each rolloff to obtain a representative sample. The compositing of the sample will be accomplished by collecting a specific volume of the material in each drum into a large sample container. When samples from each of the drums being sampled in a single compositing are collected, the sample will be submitted for TCLP, ignitability, corrosivity, and reactivity analysis. The analysis will be used to determine if drilling wastes are covered by land disposal restrictions.

If rolloffs are used, compositing and sampling of soil will comply with applicable state and federal regulations.

B. Labels

Drums and other containers used for storing wastes from drilling operations will be labeled when accumulation in the container begins. Labels will include the following minimum information:

- Container number
- Container contents
- Origin (source area including individuals wells, piezometers, and soil borings)
- Date that accumulation began
- Date that accumulation ended
- Generator Contact Information
- When laboratory results are received, drum labels will be completed or revised to indicate the hazardous waste constituents in compliance with Title 40 of the Code of Federal Regulations, Part 262, Subpart C if the results indicate hazardous waste or labeled as non-hazardous if applicable.

C. Fluids

Drilling fluids generated during soil boring and groundwater discharged during development and purging of the monitoring wells will be collected in 55-gallon, closed-top drums. When a drum is filled, the bung will be secured tightly. Fluids may also be transferred to Baker® Tanks after being temporarily contained in drums to minimize the amount of drums used.

When development and purging is completed, the water will be tested for appropriate hazardous waste constituents. Compositing and sampling of fluids will comply with applicable state and federal regulations.

D. Solids

The soil cuttings from well and boring drilling will constitute a large portion of the solids to be disposed of.

The solid waste stream also will include plastic sheeting used for decontamination pads, Tyveks, disposable sampling materials, and any other disposable material used during the field operations that appears to be contaminated. These materials will be placed in designated drums.

E. Storage and Disposal

The wastes generated at the site at individual locations will be transported to the drum storage area by the drilling services subcontractor. Drums should be stored on pallets on plastic sheeting with a short berm wall (hay bales or 2 x 4 planks or equivalent) to capture small spills.

Waste solid materials that contain hazardous constituents will be disposed of at an offsite location in a manner consistent with applicable solid waste, hazardous waste, and water quality regulations. Transport and disposal will be performed by a commercial firm under subcontract.

The liquid wastes meeting acceptable levels of discharge contamination may be disposed of through the sanitary sewer system at the site. However, prior to disposal to the sanitary sewer system, approval and contract arrangements will be made with the appropriate authorities. Wastes exceeding acceptable levels for disposal through the sanitary sewer system will be disposed of through contract with a commercial transport and disposal firm.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- Check that representative samples of the containerized materials are obtained.
- Be sure that all state and federal regulations are considered when classifying waste for disposal.

STANDARD OPERATING PROCEDURE 008

Decontamination of Personnel and Equipment

I. Purpose

To provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized ("DI") water (specifically, ASTM Type II water or lab-grade DI water)
- Potable water; must be from a municipal water supplier, otherwise an analysis must be run for appropriate volatile and semivolatile organic compounds and inorganic chemicals (e.g., Target Compound List and Target Analyte List chemicals)
- 2.5% (W/W) Liquinox® (or Alconox®) and water solution
- Concentrated (V/V) pesticide grade isopropanol (DO NOT USE ACETONE)
- Large plastic pails or tubs for Liquinox® and water, scrub brushes, squirt bottles for Liquinox® solution, methanol and water, plastic bags and sheets
- DOT approved 55-gallon drum for disposal of waste
- Personal Protective Equipment as specified by the Health and Safety Plan
- Decontamination pad and steam cleaner/high pressure cleaner for large equipment

IV. Procedures and Guidelines

A. PERSONNEL DECONTAMINATION

To be performed after completion of tasks whenever potential for contamination exists, and upon leaving the exclusion zone.

1. Wash boots in Liquinox® solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with Liquinox® solution, remove, and discard into DOT-approved 55-gallon drum.

2. Wash outer gloves in Liquinox® solution, rinse, remove, and discard into DOT-approved 55-gallon drum.

3. Remove disposable coveralls ("Tyveks") and discard into DOT-approved 55-gallon drum.

4. Remove respirator (if worn).

5. Remove inner gloves and discard.

6. At the end of the work day, shower entire body, including hair, either at the work site or at home.

7. Sanitize respirator if worn.

B. SAMPLING EQUIPMENT DECONTAMINATION—GROUNDWATER SAMPLING PUMPS

Sampling pumps are decontaminated after each use as follows.

1. Don phthalate-free gloves.

2. Spread plastic on the ground to keep equipment from touching the ground

3. Turn off pump after sampling. Remove pump from well and remove and dispose of tubing. Place pump in decontamination tube.

4. Turn pump back on and pump 1 gallon of Liquinox® solution through the sampling pump.

5. Rinse with 1 gallon of 10% isopropanol solution pumped through the pump. (DO NOT USE ACETONE).

6. Rinse with 1 gallon of tap water.

7. Rinse with 1 gallon of deionized water.

8. Keep decontaminated pump in decontamination tube or remove and wrap in aluminum foil or clean plastic sheeting.

9. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.

10. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in either DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/ project requirements.

C. SAMPLING EQUIPMENT DECONTAMINATION—OTHER EQUIPMENT

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Before entering the potentially contaminated zone, wrap soil contact points in aluminum foil (shiny side out).
3. Rinse and scrub with potable water.
4. Wash all equipment surfaces that contacted the potentially contaminated soil/water with Liquinox® solution.
5. Rinse with potable water.
6. Rinse with distilled or potable water and isopropanol solution (DO NOT USE ACETONE).
7. Air dry.
8. Rinse with deionized water.
9. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.
10. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
11. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

D. HEALTH AND SAFETY MONITORING EQUIPMENT DECONTAMINATION

1. Before use, wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with Liquinox® solution, then a towel wet with methanol solution, and finally three times with a towel wet with distilled water. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

E. SAMPLE CONTAINER DECONTAMINATION

The outsides of sample bottles or containers filled in the field may need to be decontaminated before being packed for shipment or handled by personnel without hand protection. The procedure is:

1. Wipe container with a paper towel dampened with Liquinox® solution or immerse in the solution AFTER THE CONTAINERS HAVE BEEN SEALED. Repeat the above steps using potable water.

2. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

F. HEAVY EQUIPMENT AND TOOLS

Heavy equipment such as drilling rigs, drilling rods/tools, and the backhoe will be decontaminated upon arrival at the site and between locations as follows:

1. Set up a decontamination pad in area designated by the Facility

2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of Liquinox®, methanol, and distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

STANDARD OPERATING PROCEDURE 009

Decontamination of Drilling Rigs and Equipment

I. Purpose and Scope

The purpose of this guideline is to provide methods for the decontamination of drilling rigs, downhole drilling tools, and water-level measurement equipment. Personnel decontamination procedures are not addressed in this SOP; refer to the site safety plan and SOP *Decontamination of Personnel and Equipment*. Sample bottles will not be field decontaminated; instead they will be purchased with certification of laboratory sterilization.

II. Equipment and Materials

- Portable steam cleaner and related equipment
- Potable water
- Phosphate-free detergent such as Liquinox®
- Buckets
- Brushes
- Isopropanol, pesticide grade
- Personal Protective Equipment as specified by the Health and Safety Plan
- ASTM–Type II grade water or Lab Grade DI Water
- Aluminum foil

III. Procedures and Guidelines

A. Drilling Rigs and Monitoring Well Materials

Before the onset of drilling, after each borehole, before drilling through permanent isolation casing, and before leaving the site, heavy equipment and machinery will be decontaminated by steam cleaning at a designated area. The steam-cleaning area will be designed to contain decontamination wastes and waste waters and can be an HDPE-lined, bermed pad. A pumping system will be used to convey decontaminated water from the pad to drums.

Surface casings may be steam cleaned in the field if they are exposed to contamination at the site prior to use.

B. Downhole Drilling Tools

Downhole tools will be steam cleaned before the onset of drilling, prior to drilling through permanent isolation casing, between boreholes, and prior to leaving the site. This will include, but is not limited to, rods, split spoons or similar samplers, coring equipment, augers, and casing.

Before the use of a sampling device such as a split-spoon sampler for the collection of a soil sample for physical characterization, the sampler shall be cleaned by scrubbing with a detergent solution followed by a potable water rinse.

Before the use of a sampling device such as a split-spoon sampler for the collection of a soil sample for chemical analysis, the sampler shall be decontaminated following the procedures outlined in the following subsection.

C. Field Analytical Equipment

1. Water Level Indicators

   Water level indicators that consist of a probe that comes into contact with the groundwater must be decontaminated using the following steps:

   a. Rinse with tap water
   b. Rinse with de-ionized water
   c. Solvent rinse with isopropanol
   d. Rinse with de-ionized water

2. Probes

   Probes, for example, pH or specific ion electrodes, geophysical probes, or thermometers that would come in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise. For probes that make no direct contact, for example, OVM equipment, the probe will be wiped with clean paper-towels or cloth wetted with isopropanol.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- The effectiveness of field cleaning procedures may be monitored by rinsing decontaminated equipment with organic-free water and submitting the rinse water in standard sample containers for analysis.

STANDARD OPERATING PROCEDURE 011

General Guidance for Monitoring Well Installation

I. Purpose

To provide site personnel with a review of the well installation procedures that will be performed. These procedures are to be considered general guidelines only and are in no way intended to supplement or replace the contractual specifications in the driller's subcontract.

II. Scope

Monitoring well installations are planned for shallow and/or deep unconsolidated aquifers and/or for bedrock aquifers. The SOPs *Installation of Shallow Monitoring Wells, Installation of Surface-Cased Monitoring Wells, Installation of Bedrock Monitoring Wells,* and *Installation of Monitoring Wells Using Sonic Drilling* provide more specifics.

III. Equipment and Materials

1. Drilling rig (hollow stem auger, sonic, air hammer, air rotary, or mud rotary)
2. Well-construction materials (i.e., surface casing, screens, riser, casing, caps, bottom plugs, centering guides, sand, bentonite, grout, and surface-finish materials)
3. Development equipment

IV. Procedures and Guidelines

1. Wells will be installed in accordance with standard EPA procedures. Note that USEPA Region III requires any well penetrating a confining layer to be double-cased.
2. The threaded connections will be water-tight.
3. Well screens generally will be constructed of 10-slot or 20-slot Schedule 40 PVC and will be 5 to 10 feet in length depending on saturated thickness of unconsolidated sediments. The exact slot size and length will be determined by the field team supervisor. Stainless steel may be required under certain contaminant conditions.
4. Stick-up wells will be surrounded by four concrete-filled guard posts at least 2 inches in diameter.
5. A record of the finished well construction will be compiled.

6. All soils and liquids generated during well installations will be drummed for proper disposal.

Monitoring Well Installation

- 2″ monitoring wells in unconsolidated materials will be installed in at least 6-inch-diameter boreholes to accommodate well completion materials in designated locations.
- All monitoring wells penetrating a confining layer will be surface-cased from the ground surface to approximately 5 feet into the confining layer. Exceptions to this may be allowed under certain circumstances (e.g., evidence of significant natural gaps in the confining layer).
- Monitoring wells in unconsolidated materials will be constructed of 2-inch-diameter, factory manufactured, flush-jointed, Schedule 40 PVC (or stainless steel) screen with threaded bottom plug and riser.
- Screens will be filter packed with a properly sized and graded, thoroughly washed, sound, durable, well-rounded basalt or siliceous sand. When using hollow-stem augers, the filter pack will be installed by slowly pouring the sand into the annular space while simultaneously raising the augers and using a weighted tape to sound for the sand surface. For rotary-drilled wells, the height of the sand pack also will be sounded with a weighted tape.
- The primary filter sand pack (typically Morie #00 or DSI #1 for a 10-slot screen) will extend from 1 to 2 feet below the base to 2 feet above the top of the screen; filter pack will be allowed to settle before final measurement is taken. For wells deeper than 30 feet, the filter pack will be placed using a tremie pipe and flowing water.
- A secondary filter sand pack (typically a fine sand seal) 1-foot thick may be placed above the primary sand pack.
- Annular well seals will consist of 2 feet of pelletized, chip, or granular bentonite clay placed above the filter pack. If necessary the pellets will be hydrated using potable water. For wells installed using hollow-stem augers, the bentonite will be poured into the annular space while slowly raising the augers and sounding for the top of the bentonite with a weighted tape. A high-solids bentonite slurry using powdered bentonite introduced with a side-discharging tremie pipe will be used for the bentonite seals in wells greater than 30 feet deep. For rotary-drilled wells, the height of the well seal also will be sounded with a weighted tape. High-solids slurries will have solids content of at least 20 percent.
- The top of the annular seal will be measured after the bentonite seal has been allowed to hydrate and before the grout is applied. The seal will be allowed to hydrate for at least 30 minutes before work in the well continues.
- The annular space above the bentonite seal will be filled to grade with a bentonite-cement slurry grout mixture.

- The grout mixture consists of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 6 pounds of bentonite added per bag of cement to reduce shrinkage.
- The grout mix will be carefully applied to avoid disturbing the bentonite seal; the method of grout placement must force grout from the top of the bentonite seal to ground surface.
- After allowing the grout to settle and set up overnight, additional grout will be added to maintain grade.
- A protective steel casing equipped with keyed alike locking caps will be grouted in place for each new well; the casing will extend at least 2 feet above grade and 3 feet below grade, and will be painted a bright color.

Well Development

- New monitoring wells will be developed after the well has been completely installed and the grout has hardened (at least 24 hours)
- The well will be developed by surging and pumping.
- Equipment placed in the well will be decontaminated before use.
- If information is available, begin developing in the least-contaminated well first.
- Development will include surging the well by either abruptly stopping flow and allowing water in the well column to fall back into the well or through the use of a surge block that is slightly smaller in diameter than the well casing inner diameter.
- Pipes and pumps must not be fitted with foot valves or other devices that might inhibit the return flow of water to the well.
- Surging should continue throughout the development process.
- The air-lift method may be used to pump materials out of the well. The air compressor will be fitted with filters to remove all oil and the air lift hose used will be made of inert materials.
- Well development will continue until the water produced is free of turbidity, sand, and silt. A Horiba-U22 meter, YSI meter with separate Hanna turbidity meter, or equivalent should be used to determine when the turbidity is low and parameters have stabilized.
- Development water will be considered hazardous and placed in sealed 55-gallon U.S. DOT approved steel drums. CH2M HILL will label and date the drums as pending analysis, and transport the drums to a designated site for storage.

V. Attachments

None.

VI. Key Check and Items

- Ensure that all equipment is properly decontaminated as needed.
- Only new, sealed materials (e.g., screens, risers, and sand) will be used in constructing the well.
- Care shall be taken when making downhole measurements to ensure that proper heights of sand, seal, and grout are achieved.

STANDARD OPERATING PROCEDURE 010

Water-Level Measurements

I. Purpose and Scope

The purpose of this procedure is to provide a guideline for the measurement of the depth to groundwater in piezometers and monitoring wells, even where a second phase of floating liquid (e.g., gasoline) is encountered, and on staff gages in surface-water bodies. This SOP includes guidelines for discrete measurements of static water levels and does not cover the use of continuously recording loggers (see SOP *Use of Data Loggers and Pressure Transducers)*.

II. Equipment and Materials

- Electronic water-level meter (Solinst® or equivalent) with a minimum 100-foot tape; the tape should have graduations in increments of 0.01 feet or less
- Interface probe (Solinst® Model 122 Interface Meter or equivalent)

III. Procedures and Guidelines

Verify that the unit is turned on and functioning properly. Slowly lower the probe on its cable into the piezometer or well until the probe just contacts the water surface; the unit will respond with a tone or light signal. Note the depth from a reference point indicated on the piezometer or well riser. Typically this is the top of the PVC casing. If no reference is clearly visible, measure the depth to water from the northern edge of the PVC casing. If access to the top of the PVC casing is difficult, sight across the top of the locking casing adjacent to the measuring point, recording the position of the cable when the probe is at the water surface.

Measure the distance from this point to the closest interval marker on the tape, and record the water level reading in the logbook. Water levels will be measured to the nearest 0.01-foot. Also when specified in the project plans, measure and record the depth of the piezometer or well. The depth of the piezometer or well may be measured using the water-level probe with the instrument turned off.

Free product light or dense nonaqueous phase liquid may be present in the piezometer or well. If the presence of free product is suspected, the thickness of the product should be determined using appropriate equipment (e.g., Solinst® Model 122 Interface Meter). The depth to water also is determined with this equipment and the water-level meter should not be used in the piezometer or well as long as product is present. Typically, a constant sound is emitted from the device when free product is encountered and an alternating on/off beep sound is emitted when water is encountered.

The apparent elevation of the water level in the well or piezometer is determined by measuring both the apparent depth to water and the thickness of free product. The corrected water-level elevation is calculated by the following equation:

$WL_c = Wl_a + (\text{Free-product thickness} \times 0.80)$

Where WL_c = Corrected water-level elevation

Wl_a = Apparent water-level elevation

0.80 = Typical value for the density of petroleum hydrocarbon products.

If free product is detected on the surface of the water in the piezometer or well, the value of sampling should be reconsidered because of the potential for contaminating the sampling equipment.

Staff gages may be installed in some surface-water bodies. These facilities typically are constructed by attaching a calibrated, marked staff gage to a wood or metal post, driving the post into the bottom of the surface-water body, and surveying the elevation of the top of the post to a resolution or 0.01-foot. The elevation of the water in the surface-water body then can be determined by reading off the distance the water level is from the top of the post. A shield or other protection may be needed to calm the fluctuations in water level if the gage is installed at a location exposed to wind or wave.

IV. Attachments

None.

V. Key Checks

- Before each use, verify that the battery is charged by pressing the test button on the water-level meter.
- Verify that the unit is operating correctly by testing the probe in distilled or de-ionized water. Leave the unit turned off when not in use.

STANDARD OPERATING PROCEDURE 012

Installation of Shallow Monitoring Wells

I. Purpose and Scope

The purpose of this guideline is to describe methods for drilling and installation of shallow monitoring wells and piezometers in unconsolidated or poorly consolidated materials using hollow stem augers, air rotary, or mud rotary. Installing monitoring wells in unconsolidated materials using sonic drilling is discussed in SOP *Installation of Monitoring Wells Using Sonic Drilling*. Methods for drilling and installing bedrock monitoring wells and deep, surface-cased wells in unconsolidated materials are presented in SOPs *Installation of Bedrock Monitoring Wells* and *Installation of Surface-Cased Monitoring Wells,* respectively.

II. Equipment and Materials

Drilling

- Drilling rig (hollow stem auger, air rotary or mud rotary) and associated tools and equipment

Well Riser/Screen and Associated Materials

- Polyvinyl chloride (PVC), Schedule 40, minimum 2-inch ID, flush-threaded riser; alternatively, stainless-steel riser
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted screen; alternatively, stainless-steel screen
- PVC bottom cap, threaded to match the well screen; alternatively, stainless steel
- PVC or stainless-steel centering guides (if used)
- Above-grade well completion: PVC well cap, threaded or push-on type, vented
- Flush-mount well completion: PVC well cap, locking, leak-proof seal
- Stainless steel to be used as appropriate

Sand

- Clean silica sand, provided in factory-sealed bags, well-rounded, containing no organic material, anhydrite, gypsum, mica, or calcareous material; primary (coarse – e.g., Morie #1) filter pack, and secondary (fine sand seal) filter pack. Grain size determined based on sediments observed during drilling.

Bentonite

- Pure, additive-free bentonite pellets or chips
- Pure, additive-free powdered bentonite
- Coated bentonite pellets; coating must biodegrade within 7 days

- Cement-Bentonite Grout: proportion of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 6 pounds of bentonite added per bag of cement to reduce shrinkage.

Protective Casing

- Above-grade well completion: 6-inch minimum ID black iron steel pipe with locking cover, diameter at least 2 inches greater than the well casing, painted with epoxy paint for rust protection; heavy duty lock; protective posts if appropriate
- Flush-mount well completion: Morrison 9-inch or 12-inch 519 manhole cover, or equivalent; rubber seal to prevent leakage; locking cover inside of road box

Well Development

- Surge block
- Well-development pump and associated equipment
- Calibrated meters to ensure pH, temperature, specific conductance, ORP, and dissolved oxygen of development water
- Containers (e.g., DOT-approved 55-gallon drums) for water produced from well.

III. Procedures and Guidelines

A. Drilling Method

Typically, continuous-flight hollow-stem augers with a minimum 4.25-inch inside diameter (ID) will be used to drill shallow monitoring well boreholes for 2-inch diameter monitoring wells. Alternatively, air or mud rotary may be used.

The bit of the auger is placed at the ground surface and then turned with the drilling rig. To collect split spoon samples, the auger is advanced to the top of the sampling depth, and the split-spoon sample is collected from below the auger head. The split spoon is advanced through repeated blows from a 140- or 300-pound hammer dropped from a height of 30 inches. Thin-walled tube samplers are advanced by pressing down on the rods with the weight of the drilling rig. Split-spoon samples may be collected at selected intervals for chemical analysis and/or lithologic classification. Soil sampling procedures are detailed in SOPs *Soil Boring Sampling – Split Spoons* and *Soil Sampling*.

The use of water to assist in hollow-stem auger drilling for monitoring well installation will be avoided, unless required for such conditions as running sands.

Hollow-stem augers, drilling bits, rods, split-spoon samplers, and other downhole drilling tools will be properly decontaminated prior to the initiation of drilling activities and between each borehole location. Split-spoon samplers and other downhole soil sampling equipment will also be

properly decontaminated before and after each use. SOP *Decontamination of Drill Rigs and Equipment* details proper decontamination procedures.

Drill cuttings and decontamination fluids generated during well drilling activities will be contained according to the procedures detailed in the SOP *Disposal of Waste Fluids and Solids* and the Investigation Derived Waste Management Plan (IDWMP).

Air or mud rotary drilling may be used instead of hollow-stem augers. The use of added mud should be kept to a minimum.

B. Monitoring-Well Installation

Shallow monitoring wells will be constructed inside the hollow-stem augers, once the borehole has been advanced to the desired depth, or in the mudded borehole once the drilling rods have been withdrawn. If the borehole has been drilled to a depth greater than that at which the well is to be set, the borehole will be backfilled with bentonite pellets or chips or a bentonite-cement slurry to a depth approximately 1 foot below the intended well depth. Approximately 1 foot of clean sand will be placed on top of the bentonite to return the borehole to the proper depth for well installation.

The appropriate lengths of well screen, nominally 10 feet (with bottom cap), and casing will be joined watertight and lowered inside the augers to the bottom of the borehole. Centering guides, if used, will be placed at the bottom of the screen and above the interval in which the bentonite seal is placed.

Selection of the filter pack and well screen intervals for the shallow monitoring wells shall be made in the field.

A primary sand pack consisting of clean Morie No. 00 (or DSI No.1) silica sand for 10-slot screen and Morie No. 01 (or DSI No.2) for 20-slot screen silica sand will be placed around the well screen. The sand will be placed into the borehole at a uniform rate, in a manner that will allow even placement of the sand pack. The augers will be raised gradually during sand pack installation to avoid caving of the borehole wall; at no time will the augers be raised higher than the top of the sand pack during installation. During placement of the sand, the position of the top of the sand will be continuously sounded. The primary sand pack will be extended from the bottom of the borehole to a minimum height of 2 feet above the top of the well screen. A secondary, finer-grained (fine sand seal), sand pack will be installed for a minimum of 1 foot above the coarse sand pack. Heights of the coarse and fine sand packs and bentonite seal may be modified in the field to account for a shallow water table and a small saturated thickness of the surficial aquifer.

A bentonite seal at least 2 feet thick will be placed above the sand pack. The seal will be placed into the borehole in a manner that will prevent bridging. The position of the top of the bentonite seal will be verified using a weighted tape measure. If all or a portion of the bentonite seal is above the water table,

clean water will be added to hydrate the bentonite. A hydration period of at least 30 minutes will be required following installation of the bentonite seal.

Above the bentonite seal, an annular seal of cement-bentonite grout will be placed. The cement-bentonite grout will be installed continuously in one operation from the bottom of the space to be grouted to the ground surface through a tremie pipe. The tremie pipe must be plugged at the bottom and have small openings along the sides of the bottom 1-foot length of pipe. This will allow the grout to diffuse laterally into the borehole and not disturb the bentonite pellet seal.

C. Well Completion

For monitoring wells that will be completed above-grade, a locking steel protective casing set in a concrete pad will be installed. The steel protective casing will extend at least 3 feet into the ground and 2 feet above ground but should not penetrate the bentonite seal. The concrete pad will be square, approximately 2 feet per side (unless otherwise specified in the project plans), and poured into wooden forms. The concrete will be sloped away from the protective casing.

Guard posts may be installed in high-traffic areas for additional protection. Four steel guard posts will be installed around the protective casing Guard posts would be concrete-filled, at least 2 inches in diameter, and would extend at least 2 feet into the ground and 3 feet above the ground. The protective casing and guard posts will be painted with an epoxy paint to prevent rust.

For monitoring wells with flush-mount completions, Morrison 9-inch or 12-inch 519 manhole cover or equivalent, with a rubber-sealed cover and drain will be installed. The top of the manhole cover will be positioned approximately 1 inch above grade. A square concrete pad, approximately 2 feet per side (unless otherwise specified in the project plans), will be installed as a concrete collar surrounding the road box cover, and will slope uniformly downward to the adjacent grade. The road box and installation thereof will be of sufficient strength to withstand normal vehicular traffic.

Concrete pads installed at all wells will be a minimum of 6 inches below grade. The concrete pad will be 12 inches thick at the center and taper to 6-inch thick at the edge. The surface of the pad should slope away from the protective casing to prevent water from pooling around the casing. Protective casing, guard posts, and flush mounts will be installed into this concrete.

Each well will be properly labeled on the exterior of the locking cap or protective casing with a metal stamp indicating the permanent well number.

D. Well Development

Well development will be accomplished using a combination of surging throughout the well screen and pumping, until the physical and chemical parameters of the discharge water that are measured in the field have

stabilized and the turbidity of the discharge water is substantially reduced. Fine-grained materials in the surficial aquifer at the site may not allow low turbidity results to be achieved.

The surging apparatus will include a surge block. Well development will begin by surging the well screen, starting at the bottom of the screen and proceeding upwards, throughout the screened zone. Following surging, the well will be pumped to remove the fine materials that have been drawn into the well. During pumping, measurements of pH, temperature, and specific conductance will be recorded.

Development will continue by alternately surging and pumping until the discharge water is free from sand and silt, the turbidity is substantially reduced, and the pH, temperature, and specific conductance have stabilized at regional background levels, based on historical data. Development will continue for a minimum of 30 minutes and until the water removed from the well is as clear of turbidity as practicable.

Well development equipment will be decontaminated prior to initial use and after the development of each well. Decontamination procedures are detailed in SOP *Decontamination of Personnel and Equipment*. Water generated during well development will be contained and managed as detailed in the SOP *Disposal of Waste Fluids and Solids* and the Investigation Derived Waste Management Plan.

IV. Attachments

Schematic diagram of shallow monitoring-well construction (MWSingleDiag.xls)

STANDARD OPERATING PROCEDURE 013

Logging of Soil Borings

I. Purpose and Scope

This SOP provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil-sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations.

II. Equipment and Materials

- Indelible pens
- Tape measure or ruler
- Field logbook
- Spatula
- HCL, 10 percent solution
- Squirt bottle with water
- Rock- or soil-color chart (e.g., Munsell)
- Grain-size chart
- Hand lens
- Unified Soil Classification System (USCS) index charts and tables to help with soil classification (attached)

III. Procedures and Guidelines

This section covers several aspects of soil characterization: instructions for completing the CH2M HILL soil boring log Form D1586 (attached), field classification of soil, and standard penetration test procedures.

A. Instructions for Completing Soil Boring Logs

Soil boring logs will be completed in the field log books or on separate soil boring log sheets. Information collected will be consistent with that required for Form D1586 (attached), a standard CH2M HILL form (attached), or an equivalent form that supplies the same information.

The information collected in the field to perform the soil characterization is described below.

Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Samples also should be checked to see that information is correctly recorded on both jar lids and labels and on the log sheets.

B. Heading Information

Boring/Well Number. Enter the boring/well number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each boring.

Location. If station, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as "approximate" or "estimated" as appropriate.

Elevation. Elevation will be determined at the conclusion of field activities through a survey.

Drilling Contractor. Enter the name of the drilling company and the city and state where the company is based.

Drilling Method and Equipment. Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger). Information on the drilling equipment (e.g., CME 55, Mobile B61) also is noted.

Water Level and Date. Enter the depth below ground surface to the apparent water level in the borehole. The information should be recorded as a comment. If free water is not encountered during drilling or cannot be detected because of the drilling method, this information should be noted. Record date and time of day (for tides, river stage) of each water level measurement.

Date of Start and Finish. Enter the dates the boring was begun and completed. Time of day should be added if several borings are performed on the same day.

Logger. Enter the first and last name.

C. Technical Data

Depth Below Surface. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. Note the depth at the top and bottom of the sample interval.

Sample Type and Number. Enter the sample type and number. SS-1 = split spoon, first sample. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.

Sample Recovery. Enter the length to the nearest 0.1-foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement. Record soil recovery in feet.

Standard Penetration Test Results. In this column, enter the number of blows required for each 6 inches of sampler penetration and the "N" value, which is the sum of the blows in the middle two 6-inch penetration intervals. A typical standard penetration test involving successive blow counts of 2, 3, 4, and 5 is recorded as 2-3-4-5 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of less than 6 inches with a blow count of 50. A

partial penetration of 50 blows for 4 inches is recorded as 50/4 inches. Penetration by the weight of the slide hammer only is recorded as "WOH."

Samples should be collected using a 140-pound hammer and 2-inch diameter split spoons. Samples may be collected using direct push sampling equipment. However, blow counts will not be available. A pocket penetrometer may be used instead to determine relative soil density of fine grained materials (silts and clays).

Sample also may be collected using a 300-pound hammer or 3-inch-diameter split-spoon samples at the site. However, use of either of these sample collection devices invalidates standard penetration test results and should be noted in the comments section of the log. The 300-pound hammer should only be used for collection of 3-inch-diameter split-spoon samples. Blow counts should be recorded for collection of samples using either a 3-inch split-spoon, or a 300-pound hammer. An "N" value need not be calculated.

Soil Description. The soil classification should follow the format described in the "Field Classification of Soil" subsection below.

Comments. Include all pertinent observations (changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). In addition, note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders, and loss of drilling fluid). Such information should be attributed to the driller and recorded in this column.

Specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of rod chatter
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Health and safety monitoring data
- Drilling interval through a boulder

D. Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488, Visual-Manual Procedure for Description and Identification of Soils (attached).

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests. It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D 2488). In addition, some elements of a complete soil

description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

1. Soil name (synonymous with ASTM D 2488 Group Name) with appropriate modifiers. Soil name should be in all capitals in the log, for example "POORLY-GRADED SAND."

2. Group symbol, in parentheses, for example, "(SP)."

3. Color, using Munsell color designation

4. Moisture content

5. Relative density or consistency

6. Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D 2488.

E. Soil Name

The basic name of a soil should be the ASTM D 2488 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).

- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as "Interlayered Sand and Silt," should be used. In addition, the relative proportion of each soil type should be indicated (see Table 1 for example).

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488.

F. Group Symbol

The appropriate group symbol from ASTM D 2488 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

G. Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

H. Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed on Table 2.

I. Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586 [attached]). If the presence of large gravel, disturbance of the sample, or non-standard sample collection makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values. Relationships for determining relative density or consistency of soil samples are given in Tables 3 and 4.

J. Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product.

K. Equipment and Calibration

Before starting the testing, the equipment should be inspected for compliance with the requirements of ASTM D 1586. The split-barrel sampler should measure 2-inch or 3-inch O.D., and should have a split tube at least 18 inches long. The minimum size sampler rod allowed is "A" rod (1-5/8-inch O.D.). A stiffer rod, such as an "N" rod (2-5/8-inch O.D.), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound or 300-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

IV. Attachments

Soil Boring Log (Sample Soil Boring Log.xls)

CH2M HILL Form D1586 and a completed example (Soil_Log_Examp.pdf)

ASTM D 2488 *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)* (ASTM D2488.pdf)

ASTM 1586 *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils* (ASTM D1586.pdf)

Tables 1 through 4 (Tables 1-4.pdf)

V. Key Checks and Preventive Maintenance

- Check entries to the soil-boring log and field logbook in the field; because the samples will be disposed of at the end of fieldwork, confirmation and corrections cannot be made later.
- Check that sample numbers and intervals are properly specified.
- Check that drilling and sampling equipment is decontaminated using the procedures defined in SOP *Decontamination of Drilling Rigs and Equipment*.

Table 1
EXAMPLE SOIL DESCRIPTIONS

POORLY GRADED SAND (SP), light brown, moist, loose, fine sand size

FAT CLAY (CH), dark gray, moist, stiff

SILT (ML), light greenish gray, wet, very loose, some mica, lacustrine

WELL-GRADED SAND WITH GRAVEL (SM), reddish brown, moist, dense, subangular gravel to 0.6 inches max

POORLY GRADED SAND WITH SILT (SP-SM), white, wet, medium dense

ORGANIC SOIL WITH SAND (OH), dark brown to black, wet, firm to stiff but spongy undisturbed, becomes soft and sticky when remolded, many fine roots, trace of mica

SILTY GRAVEL WITH SAND (GM), brownish red, moist, very dense, subrounded gravel to 1.2 inches max

INTERLAYERED SILT (60 percent) AND CLAY (40 percent): SILT WITH SAND (ML), medium greenish gray, nonplastic, sudden reaction to shaking, layers mostly 1.5 to 8.3 inches thick; LEAN CLAY (CL), dark gray, firm and brittle undisturbed, becomes very soft and sticky when remolded, layers 0.2 to 1.2 inches thick

SILTY SAND WITH GRAVEL (SM), light yellowish brown, moist, medium dense, weak gravel to 1.0 inches max, very few small particles of coal, fill

SANDY ELASTIC SILT (MH), very light gray to white, wet, stiff, weak calcareous cementation

LEAN CLAY WITH SAND (CL/MH), dark brownish gray, moist, stiff

WELL-GRADED GRAVEL WITH SILT (GW-GM), brown, moist, very dense, rounded gravel to 1.0 inches max

Table 2
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 3
RELATIVE DENSITY OF COARSE-GRAINED SOIL
(Developed from Sowers, 1979)

Blows/Ft	Relative Density	Field Test
0-4	Very loose	Easily penetrated with ½-in. steel rod pushed by hand
5-10	Loose	Easily penetrated with ½-in. steel rod pushed by hand
11-30	Medium	Easily penetrated with ½-in. steel rod driven with 5-lb hammer
31-50	Dense	Penetrated a foot with ½-in. steel rod driven with 5-lb hammer
>50	Very dense	Penetrated only a few inches with ½-in. steel rod driven with 5-lb hammer

Table 4
CONSISTENCY OF FINE-GRAINED SOIL
(Developed from Sowers, 1979)

Blows/Ft	Consistency	Pocket Penetrometer (TSF)	Torvane (TSF)	Field Test
<2	Very soft	<0.25	<0.12	Easily penetrated several inches by fist
2-4	Soft	0.25-0.50	0.12-0.25	Easily penetrated several inches by thumb
5-8	Firm	0.50-1.0	0.25-0.5	Can be penetrated several inches by thumb with moderate effort
9-15	Stiff	1.0-2.0	0.5-1.0	Readily indented by thumb, but penetrated only with great effort
16-30	Very stiff	2.0-4.0	1.0-2.0	Readily indented by thumbnail
>30	Hard	>4.0	>2.0	Indented with difficulty by thumbnail

Designation: D 1586 – 08

Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 1586; 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 test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative disturbed soil sample for identification purposes, and measure the resistance of the soil to penetration of the sampler. Another method (Test Method D 3550) to drive a split-barrel sampler to obtain a representative soil sample is available but the hammer energy is not standardized.

1.2 Practice D 6066 gives a guide to determining the normalized penetration resistance of sands for energy adjustments of N-value to a constant energy level for evaluating liquefaction potential.

1.3 Test results and identification information are used to estimate subsurface conditions for foundation design.

1.4 Penetration resistance testing is typically performed at 5-foot depth intervals or when a significant change of materials is observed during drilling, unless otherwise specified.

1.5 This test method is limited to use in nonlithified soils and soils whose maximum particle size is approximately less than one-half of the sampler diameter.

1.6 This test method involves use of rotary drilling equipment (Guide D 5783, Practice D 6151). Other drilling and sampling procedures (Guide D 6286, Guide D 6169) are available and may be more appropriate. Considerations for hand driving or shallow sampling without boreholes are not addressed. Subsurface investigations should be recorded in accordance with Practice D 5434. Samples should be preserved and transported in accordance with Practice D 4220 using Group B. Soil samples should be identified by group name and symbol in accordance with Practice D 2488.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026, unless superseded by this test method.

1.8 The values stated in inch-pound units are to be regarded as standard, except as noted below. The values given in parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.8.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.9 Penetration resistance measurements often will involve safety planning, administration, and documentation. This test method does not purport to address all aspects of exploration and site safety. *This standard does not purport to address all of the safety concerns, 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.* Performance of the test usually involves use of a drill rig; therefore, safety requirements as outlined in applicable safety standards (for example, OSHA regulations,[2] NDA Drilling Safety Guide,[3] drilling safety manuals, and other applicable state and local regulations) must be observed.

2. Referenced Documents

2.1 *ASTM Standards:* [4]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D 2488 Practice for Description and Identification of Soils

[1] This method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved Feb. 1, 2008. Published March 2008. Originally approved in 1958. Last previous edition approved in 1999 as D 1586 – 99.

[2] Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, http://www.osha.gov.

[3] Available from the National Drilling Association, 3511 Center Rd., Suite 8, Brunswick, OH 44212, http://www.nda4u.com.

[4] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

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(Visual-Manual Procedure)
D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils
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
D 4220 Practices for Preserving and Transporting Soil Samples
D 4633 Test Method for Energy Measurement for Dynamic Penetrometers
D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
D 6026 Practice for Using Significant Digits in Geotechnical Data
D 6066 Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential
D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations
D 6286 Guide for Selection of Drilling Methods for Environmental Site Characterization
D 6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

3. Terminology

3.1 *Definitions:* Definitions of terms included in Terminology D 653 specific to this practice are:

3.1.1 *cathead, n*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.2 *drill rods, n*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.3 *N-value, n*—the blow count representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows (*N*) required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.4 *Standard Penetration Test (SPT), n*—a test process in the bottom of the borehole where a split-barrel sampler having an inside diameter of either 1-1/2-in. (38.1 mm) or 1-3/8-in. (34.9 mm) (see Note 2) is driven a given distance of 1.0 ft (0.30 m) after a seating interval of 0.5 ft (0.15 m) using a hammer weighing approximately 140-lbf (623-N) falling 30 ± 1.0 in. (0.76 m ± 0.030 m) for each hammer blow.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anvil, n*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2.2 *drive weight assembly, n*—an assembly that consists of the hammer, anvil, hammer fall guide system, drill rod attachment system, and any hammer drop system hoisting attachments.

3.2.3 *hammer, n*—that portion of the drive-weight assembly consisting of the 140 ± 2 lbf (623 ± 9 N) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.2.4 *hammer drop system, n*—that portion of the drive-weight assembly by which the operator or automatic system accomplishes the lifting and dropping of the hammer to produce the blow.

3.2.5 *hammer fall guide, n*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.2.6 *number of rope turns, n*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.2.7 *sampling rods, n*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

4. Significance and Use

4.1 This test method provides a disturbed soil sample for moisture content determination, for identification and classification (Practices D 2487 and D 2488) purposes, and for laboratory tests appropriate for soil obtained from a sampler that will produce large shear strain disturbance in the sample such as Test Methods D 854, D 2216, and D 6913. Soil deposits containing gravels, cobbles, or boulders typically result in penetration refusal and damage to the equipment.

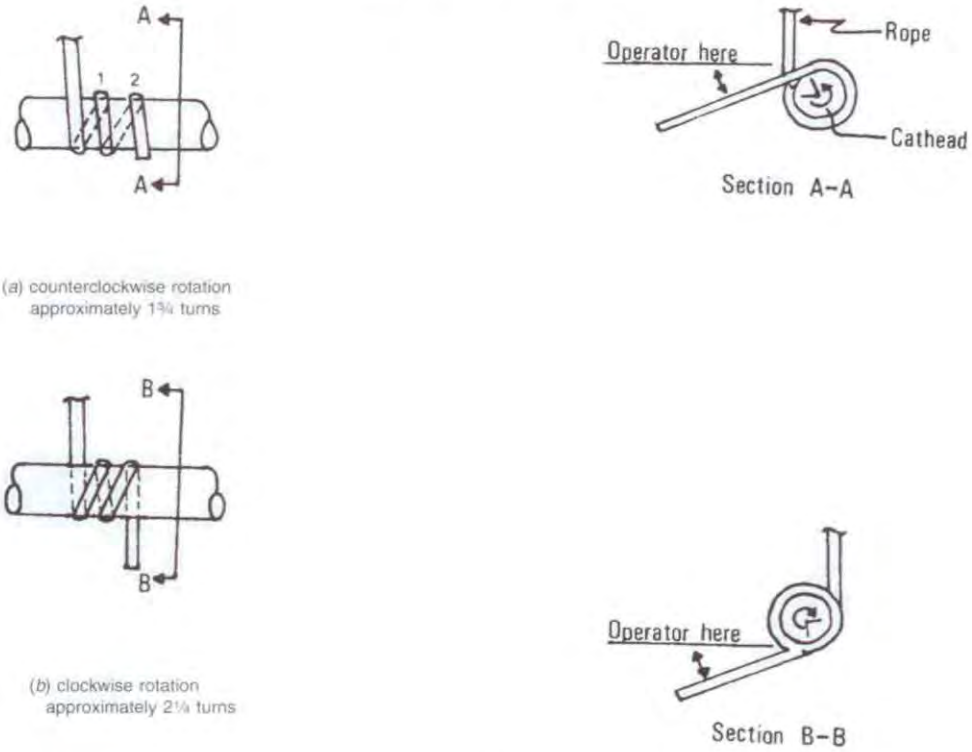
4.2 This test method provides a disturbed soil sample for moisture content determination and laboratory identification. Sample quality is generally not suitable for advanced laboratory testing for engineering properties. The process of driving the sampler will cause disturbance of the soil and change the engineering properties. Use of the thin wall tube sampler (Practice D 1587) may result in less disturbance in soft soils. Coring techniques may result in less disturbance than SPT sampling for harder soils, but it is not always the case, that is, some cemented soils may become loosened by water action during coring; see Practice D 6151, and Guide D 6169.

4.3 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate blow count, or *N*-value, and the engineering behavior of earthworks and foundations are available. For evaluating the liquefaction potential of sands during an earthquake event, the *N*-value should be normalized to a standard overburden stress level. Practice D 6066 provides methods to obtain a record of normalized resistance of sands to the penetration of a standard sampler driven by a standard energy. The penetration resistance is adjusted to drill rod energy ratio of 60 % by using a hammer system with either an estimated energy delivery or directly measuring drill rod stress wave energy using Test Method D 4633.

NOTE 1—The reliability of data and interpretations generated by this practice is dependent on the competence of the personnel performing it

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(*a*) counterclockwise rotation approximately 1¾ turns

(*b*) clockwise rotation approximately 2¼ turns

FIG. 1 Definitions of the Number of Rope Turns and the Angle for (*a*) Counterclockwise Rotation and (*b*) Clockwise Rotation of the Cathead

and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 generally are considered capable of competent testing. Users of this practice are cautioned that compliance with Practice D 3740 does not assure reliable testing. Reliable testing depends on several factors and Practice D 3740 provides a means of evaluating some of these factors. Practice D 3740 was developed for agencies engaged in the testing, inspection, or both, of soils and rock. As such, it is not totally applicable to agencies performing this practice. Users of this test method should recognize that the framework of Practice D 3740 is appropriate for evaluating the quality of an agency performing this test method. Currently, there is no known qualifying national authority that inspects agencies that perform this test method.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitable borehole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions:

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

5.1.2 *Roller-Cone Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the borehole. The inside diameter of the hollow-stem augers shall be less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm).

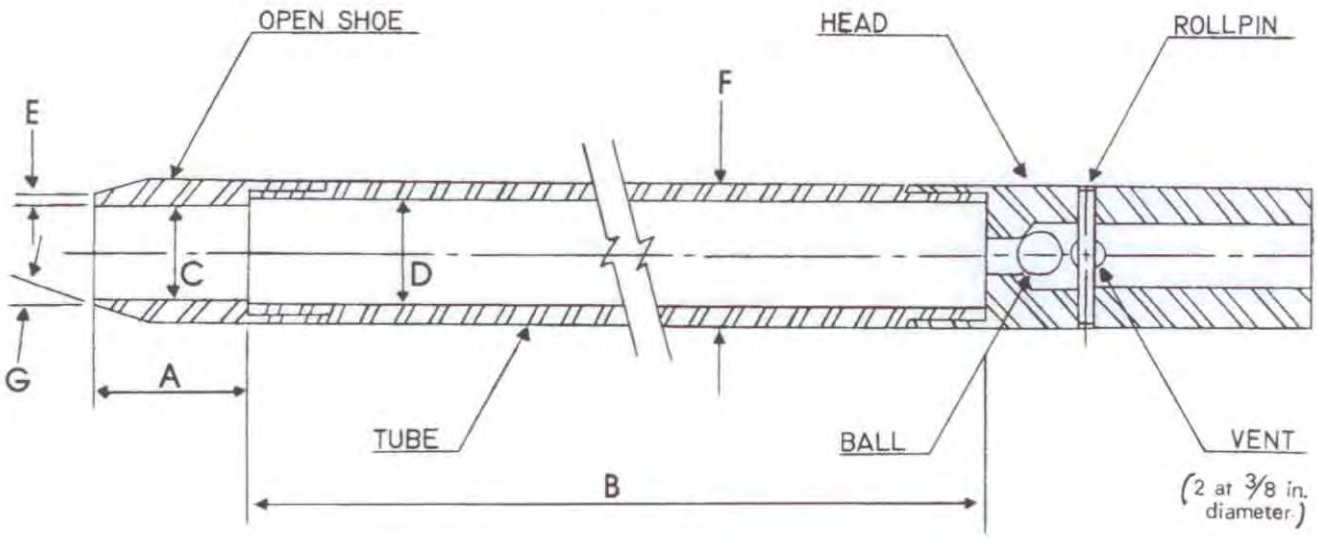
5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm) in diameter may be used if the soil on the side of the borehole does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod that has an outside diameter of 1-5/8 in. (41.3 mm) and an inside diameter of 1-1/8 in. (28.5 mm).

5.3 *Split-Barrel Sampler*—The standard sampler dimensions are shown in Fig. 2. The sampler has an outside diameter of 2.00 in. (50.8 mm). The inside diameter of the of the split-barrel (dimension D in Fig. 2) can be either 1½-in. (38.1

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A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)
G = 16.0° to 23.0°

FIG. 2 Split-Barrel Sampler

mm) or 1⅜-in. (34.9 mm) (see Note 2). A 16-gauge liner can be used inside the 1½-in. (38.1 mm) split barrel sampler. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The penetrating end of the drive shoe may be slightly rounded. The split-barrel sampler must be equipped with a ball check and vent. Metal or plastic baskets may be used to retain soil samples.

NOTE 2—Both theory and available test data suggest that *N*-values may differ as much as 10 to 30 % between a constant inside diameter sampler and upset wall sampler. If it is necessary to correct for the upset wall sampler refer to Practice D 6066. In North America, it is now common practice to use an upset wall sampler with an inside diameter of 1½ in. At one time, liners were used but practice evolved to use the upset wall sampler without liners. Use of an upset wall sampler allows for use of retainers if needed, reduces inside friction, and improves recovery. Many other countries still use a constant ID split-barrel sampler, which was the original standard and still acceptable within this standard.

5.4 *Drive-Weight Assembly:*

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lbf (623 ± 9 N) and shall be a rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting an unimpeded fall shall be used. Fig. 3 shows a schematic of such hammers. Hammers used with the cathead and rope method shall have an unimpeded over lift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged as shown in Fig. 3. The total mass of the hammer assembly bearing on the drill rods should not be more than 250 ± 10 lbm (113 ± 5 kg).

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic or automatic hammer drop systems, as shown in Fig. 4 may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The borehole shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata. Record the depth of drilling to the nearest 0.1 ft (0.030 m).

6.2 Any drilling procedure that provides a suitably clean and stable borehole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures has proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable boreholes. The process of jetting through an open tube sampler and

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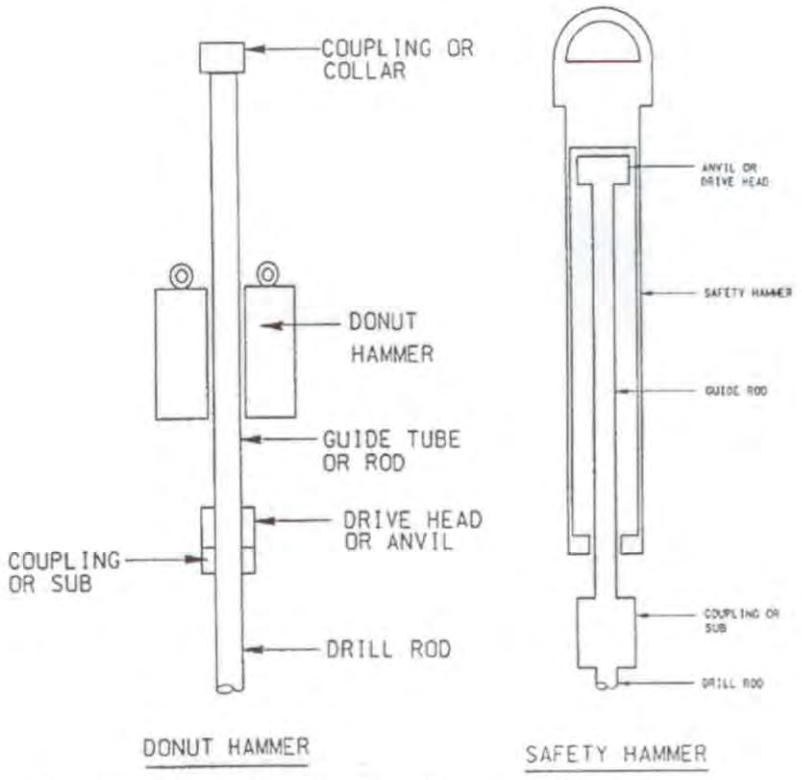


FIG. 3 Schematic Drawing of the Donut Hammer and Safety Hammer

then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the borehole below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a borehole with bottom discharge bits is not permissible. It is not permissible to advance the borehole for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the borehole or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the borehole has been advanced to the desired sampling elevation and excessive cuttings have been removed, record the cleanout depth to the nearest 0.1 ft (0.030 m), and prepare for the test with the following sequence of operations:

7.1.1 Attach either split-barrel sampler Type A or B to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the borehole. Record the sampling start depth to the nearest 0.1 ft (0.030 m). Compare the sampling start depth to the cleanout depth in 7.1. If excessive cuttings are encountered at the bottom of the borehole, remove the sampler and sampling rods from the borehole and remove the cuttings.

7.1.4 Mark the drill rods in three successive 0.5-foot (0.15 m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 0.5-foot (0.15 m) increment.

7.2 Drive the sampler with blows from the 140-lbf (623-N) hammer and count the number of blows applied in each 0.5-foot (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 0.5-foot (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 1.5 ft. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.2.5 If the sampler sinks under the weight of the hammer, weight of rods, or both, record the length of travel to the nearest 0.1 ft (0.030 m), and drive the sampler through the remainder of the test interval. If the sampler sinks the complete interval, stop the penetration, remove the sampler and sampling rods from the borehole, and advance the borehole through the very soft or very loose materials to the next desired sampling elevation. Record the *N*-value as either weight of hammer, weight of rods, or both.

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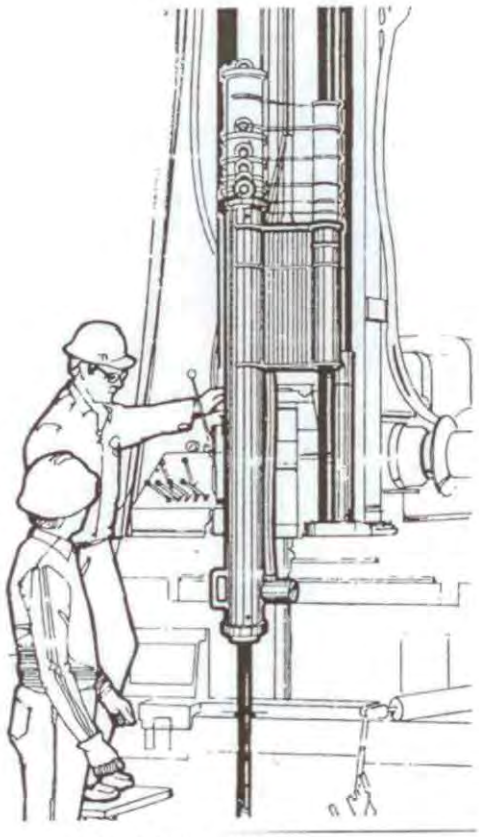


FIG. 4 Automatic Trip Hammer

7.3 Record the number of blows (*N*) required to advance the sampler each 0.5-foot (0.15 m) of penetration or fraction thereof. The first 0.5-foot (0.15 m) is considered to be a seating drive. The sum of the number of blows required for the second and third 0.5-foot (0.15 m) of penetration is termed the "standard penetration resistance," or the "*N*-value." If the sampler is driven less than 1.5 ft (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 0.5-foot (0.15 m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 0.1 ft (0.030 m) in addition to the number of blows. If the sampler advances below the bottom of the borehole under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lbf (623-N) hammer shall be accomplished using either of the following two methods. Energy delivered to the drill rod by either method can be measured according to procedures in Test Method D 4633.

7.4.1 *Method A*—By using a trip, automatic, or semi-automatic hammer drop system that lifts the 140-lbf (623-N) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 0.030 m) with limited unimpedence. Drop heights adjustments for automatic and trip hammers should be checked daily and at first indication of variations in performance. Operation of automatic hammers shall be in strict accordance with operations manuals.

7.4.2 *Method B*—By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM.

7.4.2.3 The operator should generally use either 1-3/4 or 2-1/4 rope turns on the cathead, depending upon whether or not the rope comes off the top (1-3/4 turns for counterclockwise rotation) or the bottom (2-1/4 turns for clockwise rotation) of the cathead during the performance of the penetration test, as shown in Fig. 1. It is generally known and accepted that 2-3/4 or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be stiff, relatively dry, clean, and should be replaced when it becomes excessively frayed, oily, limp, or burned.

7.4.2.4 For each hammer blow, a 30 ± 1.0 in. (0.76 m ± 0.030 m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

NOTE 4—If the hammer drop height is something other than 30 ± 1.0 in. (0.76 m ± 0.030 m), then record the new drop height. For soils other than sands, there is no known data or research that relates to adjusting the *N*-value obtained from different drop heights. Test method D 4633 provides information on making energy measurement for variable drop

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heights and Practice D 6066 provides information on adjustment of *N*-value to a constant energy level (60 % of theoretical, N60). Practice D 6066 allows the hammer drop height to be adjusted to provide 60 % energy.

7.5 Bring the sampler to the surface and open. Record the percent recovery to the nearest 1 % or the length of sample recovered to the nearest 0.01 ft (5 mm). Classify the soil samples recovered as to, in accordance with Practice D 2488, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 0.5-foot (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel. Samples should be preserved and transported in accordance with Practice D 4220 using Group B.

8. Data Sheet(s)/Form(s)

8.1 Data obtained in each borehole shall be recorded in accordance with the Subsurface Logging Guide D 5434 as required by the exploration program. An example of a sample data sheet is included in Appendix X1.

8.2 Drilling information shall be recorded in the field and shall include the following:

8.2.1 Name and location of job,

8.2.2 Names of crew,

8.2.3 Type and make of drilling machine,

8.2.4 Weather conditions,

8.2.5 Date and time of start and finish of borehole,

8.2.6 Boring number and location (station and coordinates, if available and applicable),

8.2.7 Surface elevation, if available,

8.2.8 Method of advancing and cleaning the borehole,

8.2.9 Method of keeping borehole open,

8.2.10 Depth of water surface to the nearest 0.1 ft (0.030 m) and drilling depth to the nearest 0.1 ft (0.030 m) at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.2.11 Location of strata changes, to the nearest 0.5 ft (15 cm),

8.2.12 Size of casing, depth of cased portion of borehole to the nearest 0.1 ft (0.030 m),

8.2.13 Equipment and Method A or B of driving sampler,

8.2.14 Sampler length and inside diameter of barrel, and if a sample basket retainer is used,

8.2.15 Size, type, and section length of the sampling rods, and

8.2.16 Remarks.

8.3 Data obtained for each sample shall be recorded in the field and shall include the following:

8.3.1 Top of sample depth to the nearest 0.1 ft (0.030 m) and, if utilized, the sample number,

8.3.2 Description of soil,

8.3.3 Strata changes within sample,

8.3.4 Sampler penetration and recovery lengths to the nearest 0.1 ft (0.030 m), and

8.3.5 Number of blows per 0.5 foot (0.015 m) or partial increment.

9. Precision and Bias

9.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

9.1.1 The Subcommittee 18.02 is seeking additional data from the users of this test method that might be used to make a limited statement on precision. Present knowledge indicates the following:

9.1.1.1 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent boreholes in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.1.1.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; soil; split-barrel sampling; standard penetration test

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APPENDIX

(Nonmandatory Information)

X1. Example Data Sheet

X1.1 See Fig. 5.

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DRILLERS BORING LOG

Project _____ Project No _____ Boring No _____

Location _____ Sheet _____ of _____

Date Started _____ Date Completed _____

Drill Crew:

Boring Location
Station _____ Offset _____

Elevation

Strata Depth		Soil Description and Remarks	Sample	No.	Depth		Recovery	N-Values		
From	To		Type		From	To		6"	6"	6"

Drill Rig Type _____

Method Of Drilling:

Auger _____ Size _____

Wash _____ Water _____ Mud _____

Hammer Type

Auto _____ Manual _____

Spill-Spoon Type

Length _____ Liner Used _____

Boring Size _____ Bit Used _____

Casing Size _____ Length _____

Weather _____

Non-Drilling Time (Hrs.)

Boring Layout _____ Moving _____

Hauling Water _____ Standby _____

Water Level @ _____ Date _____ Time _____

@ _____ Date _____ Time _____

@ _____ Date _____ Time _____

Cave-in Depth

@ _____ Date _____ Time _____

FIG. 5 Example Data Sheet

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SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D 1586 – 99) that may impact the use of this standard. (Approved February 1, 2008.)

(1) There have been numerous changes to this standard to list them separately. From the most recent main ballot process, additional changes were requested and incorporated into this newest revision. Stated below is a highlight of some of the changes.
(2) Scope was completely revised.
(3) Referenced Documents updated to include new standards.
(4) Terminology: added section on Definitions.
(5) Significance and Use: clarified use of the SPT test.
(6) Apparatus: general editorial changes.
(7) Sampling and Testing Procedure: general editorial changes.
(8) Data Sheets/Forms: general editorial changes.
(9) Precision and Bias: added Sections 9.1.1.1 and 9.1.1.2.

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

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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.**

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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).

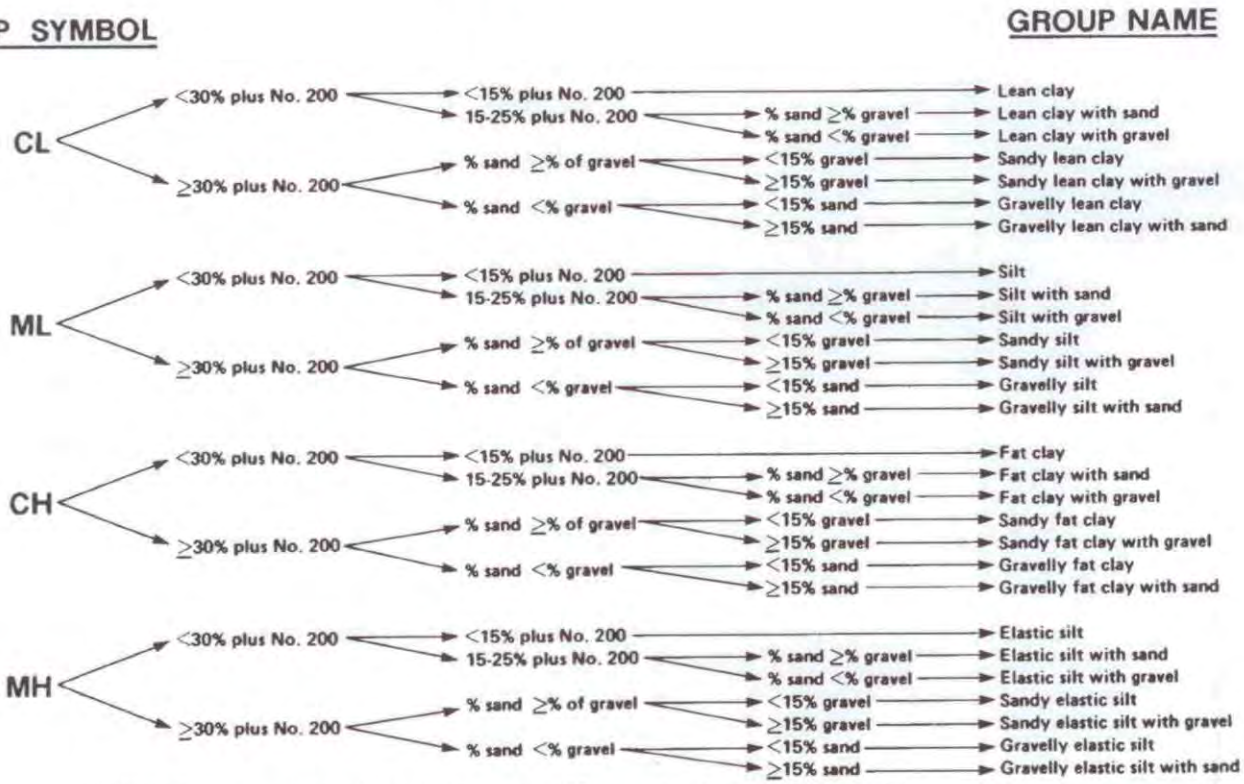
6.2.2 *Small Hand Lens.*

7. Reagents

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

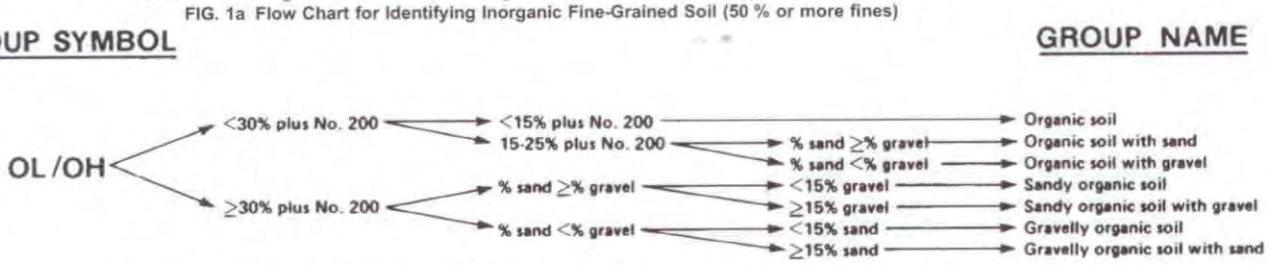
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NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

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.

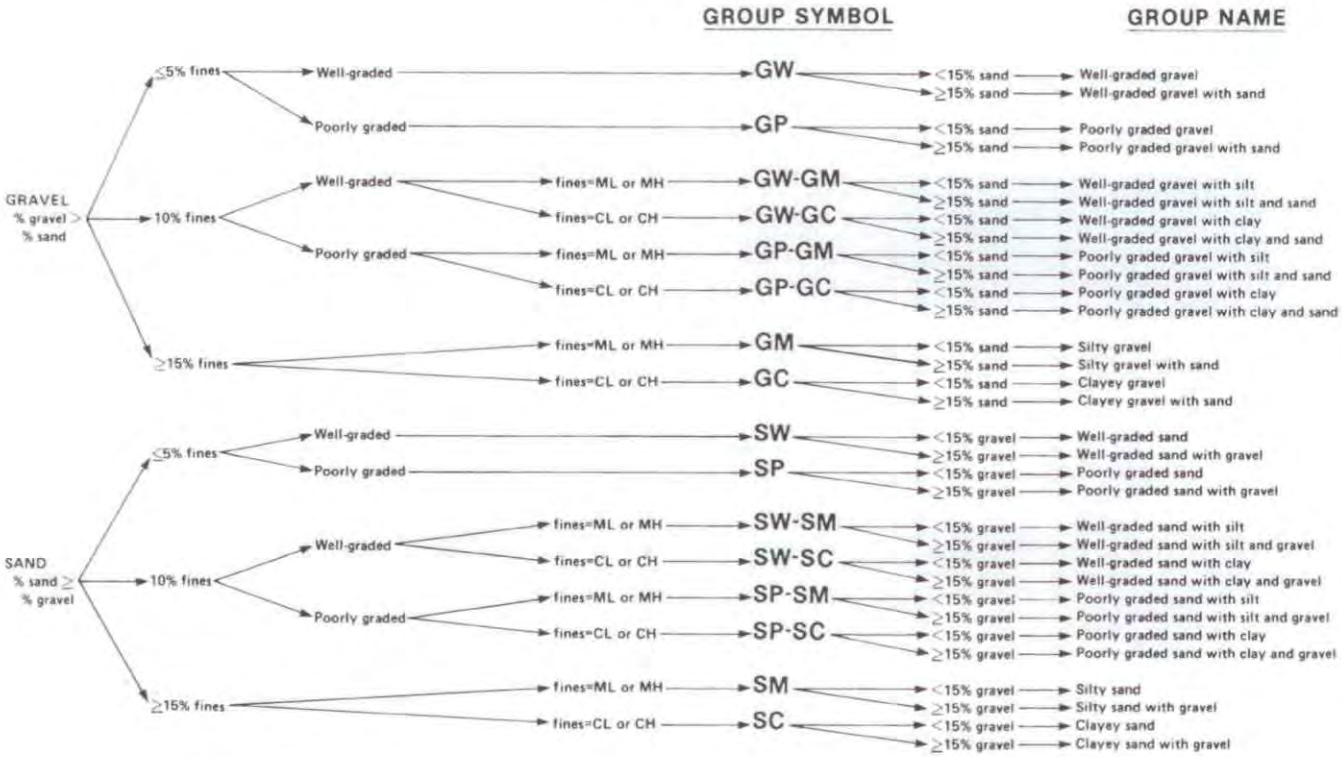
NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline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

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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 preceeding 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.

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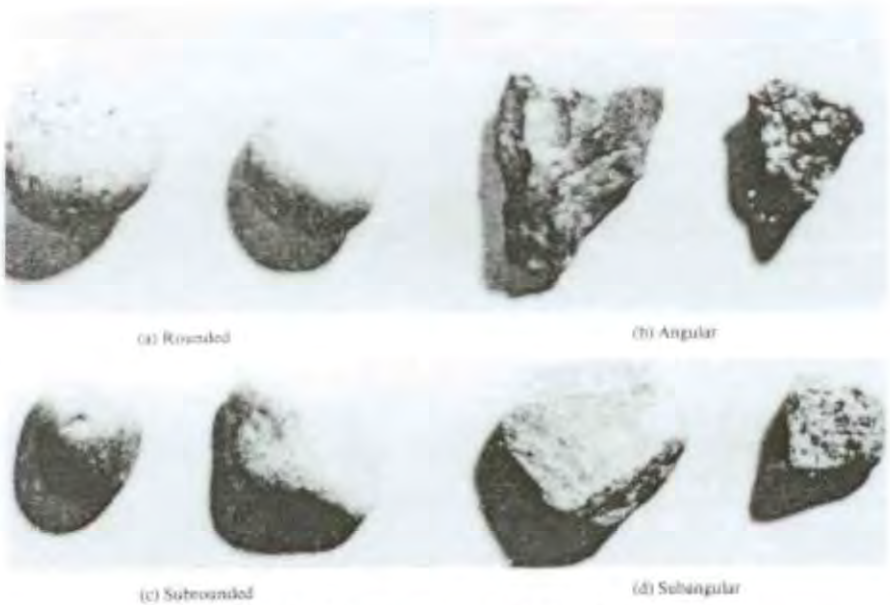


FIG. 3 Typical Angularity of Bulky Grains

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, 1½ in. (will pass a 1½-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.

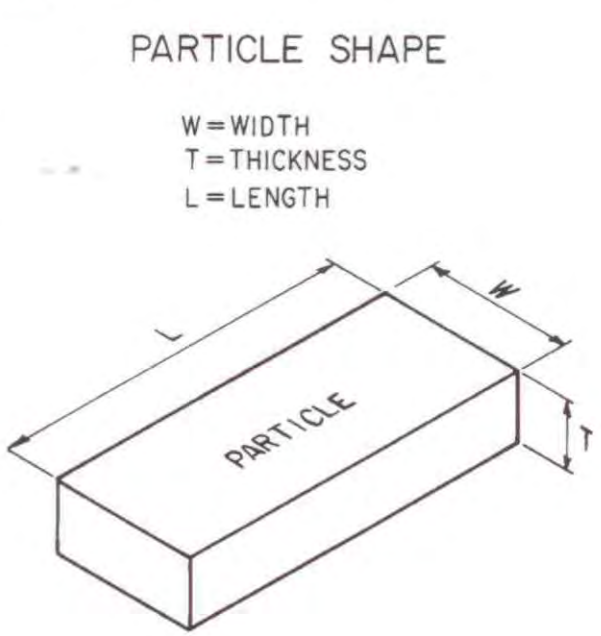


FIG. 4 Criteria for Particle Shape

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

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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

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,

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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

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

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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.

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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,

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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:

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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.

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CH2MHILL

PROJECT NUMBER	BORING NUMBER

SOIL BORING LOG

PROJECT : LOCATION :

ELEVATION : DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

ATD WATER LEVEL : START : END : LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N')	COPR Strata	SOIL DESCRIPTION	USCS	COMMENTS
						SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.		DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS PID Readings: Breathing Zone: Above Hole:

CH2M HILL

PROJECT NUMBER	BORING NUMBER SHEET OF

SOIL BORING LOG

PROJECT _____ LOCATION _____

ELEVATION _____ DRILLING CONTRACTOR _____

DRILLING METHOD AND EQUIPMENT _____

WATER LEVELS _____ START _____ FINISH _____ LOGGER _____

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION

Figure 1
SOIL BORING LOG,
FORM D1586

REV 11/89 | QRM D1586

CH2M HILL

PROJECT NUMBER	BORING NUMBER	SHEET	OF
DEN 22371.G5	BL-3	1	3

SOIL BORING LOG

PROJECT Howard Ave. Landslide LOCATION Howard & 24th Ave, Centennial, CO

ELEVATION 5136 Feet DRILLING CONTRACTOR Kendall Explorations, Ashcan, Colorado

DRILLING METHOD AND EQUIPMENT 4"-inch H.S. Augers, Mobil B-61 rotary drilling

WATER LEVELS 3.2 Feet, 8/5/89 START August 4, 1989 FINISH August 8, 1989 LOGGER J.A. Michner

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Surface material consist of 4 inches AC underlain by 6 inches of 3/4 inch minus base rock	Start Drilling @ 3:00
	2.5					
	4.0	1-S	1.5	2-3-4 (7)	POORLY-GRADED SAND WITH SILT, (SP-SM), fine, light brown, wet, loose	Driller notes water at 4 feet
	5.0					Driller notes very soft drilling 4ft. dark grey, wet silty cuttings.
5	6.5	2-S	0.9	WOH/12"-1	ORGANIC SILT, (OL), very dark, gray to black, wet, very soft; strong H_2S odor, many fine roots up to about 1/4 inch	
	8.0					
	10.0	3-ST	1.3	——	ORGANIC SILT, similar to 2-S, except includes fewer roots (by volume)	
10	11.5	4-S	1.3	2-2-2 (4)	SILT, (ML), very dark gray to black, wet, soft	water level @ 3.2 feet on 8/5/89 @ 0730
	15.0					Driller notes rough drilling action and chatter @ 13 ft
15	15.5	5-S	0.5	60/6"	SILTY GRAVEL, (GM), rounded gravel up to about 1 inch maximum observed size, wet, very dense	
	20.0					Driller notes smoother, firm drilling @ 19 ft
20	21.0	6-S	1.0	12-50/6"	LEAN CLAY WITH SAND, (CL), medium to light green, moist, very stiff	some angular rock chips @ bot. tip of 6-S, poss boulders or rock
	23.0					Driller notes very hard, slow grinding, smooth drilling action from 21 to 23 ft, possibly bedrock
	23.1	7-S	0	50/1"	NO RECOVERY	
					END SOIL BORING @ 23.1 FEET SEE ROCK CORE LOG FOR CONTINUATION OF BL-3	

Figure 2
EXAMPLE OF COMPLETED LOG FORM