Pilot Study Work Plan

Waste Oil Dump Site

NASA Wallops Flight Facility

Wallops Island, Virginia

National Aeronautics and Space Administration
Goddard Space Flight Center
Wallops Flight Facility

October 2008

CERTIFICATION

The enclosed document was prepared, and is being submitted, in accordance with the requirements of the Administrative Agreement On Consent between the United States Environmental Protection Agency and the National Aeronautics and Space Administration [U.S. EPA Docket Number RCRA-03-2004-0201TH].

I certify that the information contained in or accompanying this document is true, accurate, and complete.

I certify under penalty of law that this document and all attachments were prepared in accordance with procedures designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, or the immediate supervisor of such person(s), the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Signature: Carolyn Turner

Name: Ms. Carolyn Turner

Title: NASA Project Coordinator

PILOT STUDY
WORK PLAN

WASTE OIL DUMP SITE

NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

Submitted to:
National Aeronautics and Space Administration
Goddard Space Flight Center
Wallops Flight Facility
Code 250.W
Building F-160
Wallops Island, Virginia 23337

Submitted by:
Tetra Tech NUS, Inc.
234 Mall Boulevard Suite 260
King of Prussia, Pennsylvania 19406

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PREPARED UNDER THE DIRECTION OF:

GARTH GLENN
PROJECT MANAGER
TETRA TECH NUS, INC.
NORFOLK, VIRGINIA

APPROVED FOR SUBMISSION BY:

JOHN TREPANOWSKI, P.E.
PROGRAM MANAGER
TETRA TECH NUS, INC.
KING OF PRUSSIA, PENNSYLVANIA

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TABLE OF CONTENTS

TABLES

FIGURES

ACRONYMS

bgs	Below Ground Surface
°C	Degrees Celsius
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	Constituents of Concern
CTO	Contract Task Order
DO	Dissolved Oxygen
DPT	Direct Push Technology
EFANE	Engineering Field Activity Northeast
EPA	United States Environmental Protection Agency
FFTA	Former Fire Training Area
FOL	Field Operations Leader
ft	Feet or Foot
GSFC	Goddard Space Flight Center
HASP	Health and Safety Plan
HCl	Hydrochloric Acid
HSA	Hollow-stem Auger
HSM	Health and Safety Manager
IDW	Investigation-Derived Waste
µg/L	Micrograms per Liter
mg/L	Milligrams per Liter
ML	Mainland
ml	Milliliter
MB	Main Base
MSDS	Material Safety Data Sheet
NACA	National Advisory Committee for Aeronautics
NASA	National Aeronautics and Space Administration
NELAP	National Environmental Laboratory Accreditation Program
NTU	Nephelometric Turbidity Units
ORC®	Oxygen Releasing Compounds
ORP	Oxidation-Reduction Potential
PAH	Polynuclear Aromatic Hydrocarbons
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Control

ACRONYMS (CONTINUED)

Regenesis	Regenesis Bioremediation Products
RPM	Remedial Project Manager
Slurry	ORC® and water mixture
SOPs	Standard Operating Procedures
SVOC	Semi Volatile Organic Compound
TtNUS	Tetra Tech NUS, Inc.
USACE	United States Army Corps of Engineers
VOC	Volatile Organic Compound
WFF	Wallops Flight Facility
WOD	Waste Oil Dump Site

1.0 INTRODUCTION

This Pilot Study Work Plan has been prepared by Tetra Tech NUS, Inc. (TtNUS) for the National Aeronautics and Space Administration (NASA) under Contract Task Order (CTO) 0012 issued by the Engineering Field Activity Northeast (EFANE) of the Naval Facilities Engineering Command under the Comprehensive Long-Term Environmental Action Navy (CLEAN III) contract number N62472-03-D-0057. This work plan has been prepared to develop an application and testing methodology to evaluate enhanced bioremediation as an appropriate remedial technology for the Waste Oil Dump (WOD) Site at the NASA Goddard Space Flight Center (GSFC) Wallops Flight Facility (WFF) located in Accomack County, Virginia. The scope of this Pilot Study is limited to the documented groundwater contamination that has been previously identified at this site.

The purpose of this Pilot Study is to determine if the application of Oxygen Releasing Compound (ORC®), a proprietary formulation of phosphate intercalated magnesium peroxide manufactured by Regenesis Bioremediation Products (Regenesis), can significantly reduce semi-volatile organic compound (SVOC) and volatile organic compound (VOC) impacts in site groundwater. This work plan incorporates data presented in the Supplemental Remedial Investigation Report (TtNUS, 2004), Feasibility Study (TtNUS, 2005), and Record of Decision (TtNUS, 2008).

1.1 DOCUMENT ORGANIZATION

Section 1.0 of this report presents this introduction, a site description, the project scope, and project goals. Section 2.0 describes the proposed field operations. Section 3.0 describes the environmental sampling and analysis activities. Section 4.0 describes management aspects of the project such as management structure, reporting requirements, and quality assurance (QA) activities.

1.2 SITE OPERATIONS AND HISTORY

NASA has had a presence in the WFF area since the mid-1940s. From the 1940s until 1959, NASA's predecessor organization, the National Advisory Committee for Aeronautics (NACA), had a limited presence on Wallops Island. In 1959, shortly after its creation, NASA acquired the Main Base (MB) from the Navy. The Navy operated an aviation training field at the MB area from 1942 through 1958. NASA also acquired the Mainland (ML) area at this time and continued to expand land purchases on Wallops Island. In 1960, a causeway was constructed from the ML to Wallops Island. A detailed history of land ownership and transfers is presented in the Environmental Resources Document NASA GSFC WFF Wallops Island, Virginia, October 1999, prepared by Occu-Health, Inc. (Occu-Health, 1999). A Site Location Map is provided as Figure 1-1.

Beginning in 1942, the Navy operated a training airfield at the MB area, the Chincoteague Naval Auxiliary Air Station, until NASA occupation in 1959. The Navy constructed runways, buildings, and other support facilities throughout the MB area in 1943. The MB facility was used for naval aviation training until 1959 when operations ceased and the property was transferred to NASA. In addition to aviation training, the Navy used the facility for aviation ordnance testing to develop and test aviation ordnance and guided missiles [US Army Corps of Engineers (USACE), 2000]. NASA continues to maintain the runways constructed at the facility by the Navy and occupies many of the structures and buildings that were present at the time of the property transfer. In addition, NASA has expanded and constructed additional buildings within the MB area to support their mission and to provide support to other tenant organizations. The mission of NASA's WFF has undergone several changes since it was established in 1959, but the main focus has been and continues to be rocket research, the management of suborbital projects, suborbital and orbital tracking, aeronautical research, and space technology research.

The WOD is located at the northern end of Runway 17-35 on a peninsula-like feature adjacent to Little Mosquito Creek (see Figure 1-2). The WOD was reportedly used for the disposal of waste oils and possibly solvents from the 1940s through the 1950s. Reportedly, the site was used to dispose of excess waste oil that could not be used for fire training activities. No records are available to determine the types and quantities of materials disposed or the duration of this activity at the site. NASA conducted a removal action in the area from November 12 to December 30, 1986 that included the excavation and removal of approximately 180 cubic yards of impacted soils in four separate areas of the site.

The southern half of the site is basically flat, with little slope, and is grass covered. The central portion of the site slopes to the north and east, with slopes ranging from 1 to 3 percent. The northern, eastern, and western boundaries of the site are steeply sloped. These slopes direct surface water runoff into low-lying marshes that border an unnamed tributary to Little Mosquito Creek and Little Mosquito Creek. The northern portion of the site is vegetated by bushes, conifer saplings, and tall grasses. There are no surface water bodies within or immediately adjacent to the disposal area at the WOD.

The geology immediately underlying the study area consists of the lithologic unit called the Columbia Group. Regionally, the Columbia Group is approximately 50 feet thick and is underlain by a 20 to 40 feet thick clay and silt aquitard which isolates the Columbia from the underlying Yorktown Aquifer. The geologic materials encountered at the site consist of fine-to medium-grained quartz sand with some silt, and the lithology did not differ significantly throughout the site. A sandy clay layer was consistently encountered at depths ranging from 10 to 27 feet below ground surface (bgs), or (considering the differences in site topography) at an elevation near sea level. The thickness of this clay at the WOD is reported to be as much as 5 feet. Based on the local and regional stratigraphy, this clay is not believed to represent the upper Yorktown aquitard, which at the nearby Former Fire Training Area (FFTA) was encountered at an elevation of about 25 feet below sea level.

1.3 NATURE AND EXTENT OF CONTAMINATION

Groundwater contamination has been documented at the site during the previous assessment activities. Constituents of Concern (COCs) have been identified based on analytical data, risk drivers from the human health and ecological risk assessments, and exceedances of regulatory standards and criteria. The COCs for groundwater have been identified as benzene and arsenic. There are no COCs for soil since contaminated soil was addressed in 1986 in response to the Virginia Department of Waste Management Removal Order. Although COCs in soil are not present above Regulatory Standards, there are residual absorbed phase COCs that may act as a continuing source of groundwater contamination and therefore must be addressed.

The most recent sampling event was conducted in 2003. Results indicate the highest concentrations of benzene are found in WFF16-GW2D (8 µg/L) and WFF15-GW7 (11 µg/L) and the highest arsenic concentration is found in WFF16-GW2D (21.4 ug/L). Monitoring well locations are detailed on Figure 1-3.

1.4 OBJECTIVES AND SCOPE

The objective of the Pilot Study is to determine the number and spacing of ORC® injection points required for full-scale remediation at the WOD Site, as well as to determine the amount of ORC® to be injected into each point. The approach will be considered successful if the temporary monitoring wells and WFF15-GW7 have increases in dissolved oxygen (DO) concentrations as a result of ORC® injection. There is the potential that COC concentrations will also decrease during the Pilot Study, but due to the short timeframe, COC reduction will not be used as a measure of Pilot Study success. Arsenic will not be addressed directly by ORC®, but it is believed that the arsenic contamination is associated with the reduced environment created by the natural degradation of the organic COCs. It is anticipated that the injection of the ORC® will create an oxygen rich environment that will transfer the arsenic from soluble compounds to insoluble oxidized compounds with limited mobility.

This Pilot Study will be comprised of one injection event. During the event, an ORC® and water mixture (slurry) will be injected into three points placed in the vicinity of monitoring well WFF15-GW7. The slurry will be injected via direct push technology (DPT) equipment; the injection will take place throughout the vertical extent of contamination, from approximately 20 feet to 30 feet below ground surface (bgs). It is anticipated that the injected slurry will enhance aerobic microbial activity in groundwater containing COC concentrations above the established cleanup levels.

ORC® is a proprietary formulation of phosphate-intercalated magnesium peroxide that, when hydrated, produces a controlled release of oxygen for periods of up to 12 months on a single application. ORC® is produced by Regenesis, of San Clemente, California (Regenesis website, 2007).

As a part of the Pilot Study and prior to DPT and ORC® injection activities, one new monitoring well will be installed downgradient of the known extent of groundwater contamination. The monitoring well will be used to assess and monitor contaminant migration in the deeper portion of the shallow Columbia aquifer at the site. Seven existing wells and the new monitoring well will be sampled prior to ORC® injection to establish baseline contaminant concentrations and field parameters. The monitoring wells will also be sampled during future site monitoring events to assess contaminant migration and effectiveness of the remedial activities at the site.

2.0 FIELD OPERATIONS

2.1 FIELD OPERATIONS SUMMARY

The Pilot Study consists of the following field activities:

- Installation of one new monitoring well downgradient of the known extents of the groundwater plume (Figure 2-1). The well will be installed at an approximate depth of 25 feet bgs to ensure an adequate groundwater monitoring network in the deeper shallow Columbia aquifer (Details in Section 2.3).

- Installation of nine DPT soil borings in the area upgradient of monitoring well WFF15-GW7. Three of the DPT locations will be used to inject ORC® and the remaining six locations will be installed between the injection points and completed as temporary 1.5-inch diameter monitoring wells to monitor the radius of influence of the injections. Influence will be determined though geochemical parameter measurements in WFF15-GW7 and the six DPT monitoring locations.

- Sampling and analysis of groundwater to evaluate water quality parameters and contaminant concentrations. Sampling and analysis will include one baseline sampling event prior to injection activities that includes nearby monitoring wells and three post-injection sampling events (one day, one week, and one month following the injection event) at WFF15-GW7, the six temporary monitoring wells and a background well (WFF15-MW3R).

One new monitoring well (WFF16-GW8) will be installed at the site via hollow-stem auger (HSA) techniques. This well will be placed downgradient of the known WOD groundwater plume at the approximate location depicted on Figure 2-1.

This Pilot Study will be completed in one injection event; which includes the installation of three injection borings placed 15 feet upgradient from WFF15-GW7. The injection borings will be spaced on 15-foot centers in an upgradient radius perpendicular to the direction of groundwater flow. Six DPT monitoring locations will be installed in between the injection points and WFF15-GW7. A detailed plan view of the proposed DPT/injection point spacing is presented as Figure 2-1. The injection locations are intended to actively treat the majority of the area suspected to contain concentrations of COC above cleanup criteria and to create an oxygen-enriched barrier and an aerobic reaction zone to reduce residual SVOC and VOC concentrations in the treatment area.

Based on calculations made using Regenesis software, it is estimated that during the injection event 12.4 pounds of ORC® will be applied per foot of each borehole below the water table (a thickness of approximately 10 feet in each borehole). Therefore, a total of 372 pounds of ORC® will be required. Approximately 105 gallons of water will be required for mixing of the ORC®, approximately 3.5 gallons per foot. ORC® requirement calculations are presented in Appendix A.

To determine the effectiveness of the ORC® application in creating aerobic conditions in the subsurface for enhancement of biodegradation, the site geochemistry will be monitored for changes in water quality parameters. In addition, groundwater samples collected prior to, and following injection will be collected and analyzed to determine COC concentrations as detailed in Section 3.0.

2.2 MOBILIZATION/DEMOBILIZATION

Following approval of this work plan, TtNUS will procure the required subcontractors and begin mobilization activities. Mobilization/demobilization may include multiple events and each event will include the following as needed:

- Approval of all subcontractors by the TtNUS Health and Safety Department
- Utility clearances in the proposed boring areas.
- Mobilization of subcontractors, equipment, and materials to the site.
- Receipt of drilling and/or well permits via subcontractor.
- Conducting an approximately 1-hour long site-specific health and safety review meeting.
- Delineation of the work zones (exclusion zone, contamination reduction zone, and support zone) as required by the Health and Safety Plan (HASP) (See Appendix D).
- Arrangement of an area to perform decontamination procedures.
- Demobilization of equipment and materials from the site.
- Performance of general site clean-up and removal of trash.

Field team members will review the Pilot Study and the HASP. Mobilization includes attendance at a site-specific health and safety kick-off meeting during the initiation of on-site activities. This meeting will also include field team orientation in order to familiarize personnel with the scope of the field activities.

The Field Operations Leader (FOL) will coordinate the mobilization activities. These include responsibilities such as initiating and conducting equipment inventories to ensure equipment is available, purchasing equipment as required, staging equipment for efficient loading and transport from the TtNUS office to the site, and after field activities are completed, demobilizing the equipment.

The drilling subcontractors will furnish a truck-mounted HSA/DPT rig, support crew, all necessary tools required, personal protective equipment (PPE) for their crew, and any miscellaneous equipment and materials required to complete the described activities. The down-hole equipment, sampling tools, and the rear of the rig will be steam-cleaned prior to arrival on site. Safety shut-off equipment will be in full working condition and will be tested by the FOL prior to initiating drilling/DPT activities.

2.3 MONITORING WELL INSTALLATION

TtNUS will install one monitoring well (WFF16-GW8) downgradient of the known extent of groundwater contamination. The monitoring well will be installed at an approximate depth of 25 feet bgs at the approximate location shown on Figure 2-1. Field conditions may require slight modifications to the proposed well location and the FOL will adjust the location according to actual field conditions. The shallow monitoring well will be terminated above the Yorktown aquifer in order to monitor conditions in the deeper Columbia aquifer. Based on previous site findings contaminated groundwater was detected above a clay layer that exists at approximately 25 to 27 feet bgs within the Columbia aquifer. The monitoring well will be installed via HSA rig and constructed with 6.25 O.D. augers and 2-inch schedule 40 Polyvinyl Chloride (PVC) casing with 5 or 10 feet of 0.01-inch slotted well screen. The exact length of the well screen will be determined in the field to accommodate subsurface conditions that may impact the ability to adequately screen the water bearing zone. The monitoring well will be a stick-up well completion and protected by a steel well head cover. After installation, the monitoring well will be developed in accordance with TtNUS standard operating procedures for monitoring well installation (GH-2.8, Appendix E). Well construction records, boring logs, and well development records will be used to document well installation activities (Appendix F).

2.4 TEMPORARY MONITORING WELL INSTALLATION

TtNUS will install six temporary monitoring points between the injection points, and between WFF15-GW7 and the injection points via DPT methods. Six 1.5-inch diameter schedule 40 PVC monitoring points will be installed to an approximate depth of 30 feet bgs at the locations shown on Figure 2-1. The depth of the temporary monitoring points will be determined in the field based on the depth of the clay layer within the Columbia aquifer, as discussed above, and the depth of the water bearing zones encountered during installation. Each monitoring points will be constructed with a 10 foot 0.02-inch slotted screen from 20 feet to 30 feet bgs. The top of each monitoring point will be completed flush with the ground surface and protected by a steel well head cover. The monitoring locations will be placed 5 feet, 7.5 feet and 10 feet from the injection wells as indicated on Figure 2-1.

2.5 BASELINE GROUNDWATER SAMPLING

Prior to the Pilot Study injection activities, a baseline groundwater monitoring event will be performed. The newly installed monitoring well (WFF16-GW8), WFF15-MW3R, WFF15-GW7, WFF15-GW1, WFF15-

GW2, WFF16-GW2S, WFF16-GW2D, WFF16-GW5, and each of the six temporary monitoring points will be monitored for field parameters and a groundwater sample will be collected from each well. The samples will be analyzed for VOCs, SVOCs, and total and dissolved arsenic. Samples collected from WFF15-GW7, WFF15-MW3R, and the six temporary wells will be analyzed for quick turnaround (7 day) analysis. All other samples will be analyzed on a standard turnaround basis. More details on groundwater level measurements, sampling, and laboratory analysis are presented in Section 3.0.

2.6 INJECTION POINT INSTALLATION

The three injection points will be installed via DPT to a depth of 30 feet bgs on 15-feet centers in an upgradient radius perpendicular to groundwater flow direction, as depicted on Figure 2-1. Groundwater contamination is assumed to extend to a depth of approximately 30 feet bgs, based on the construction of WFF15-GW7.

2.7 ORC® MIXING AND INJECTION

The ORC® powder will be shipped to the site from the Regenesis manufacturing facility in Inwood, New York. For each injection boring, 35 gallons of water will be mixed with 124 pounds of ORC® using a standard environmental slurry mixer or grout pump. The slurry will be injected from the bottom of the borehole to one foot above the water table through the DPT rig's pump or a slurry/grout pump. Mixing and injection will be performed in general accordance with the Regenesis instructions in Appendix B. As with any chemical compound, proper health and safety procedures must be followed when handling ORC®. Material Safety Data Sheets (MSDS) for the ORC® is provided in Appendix C.

2.8 POST-INJECTION GROUNDWATER SAMPLING

Following ORC® injection, several rounds of groundwater monitoring and a final sampling event will be conducted at WFF15-GW7, WFF15-MW3R, and the six temporary monitoring points. The monitoring events will occur approximately one day, one week and one month following injection. The six temporary DPT monitoring locations, and monitoring wells WFF15-GW7 and WFF15-MW3R will be field tested for geochemical parameters during all three events and samples will be collected from WFF15-GW7 and WFF15-MW3R for laboratory analysis during the final event. The samples will be analyzed for VOCs, SVOCs, and arsenic on a fourteen-day turnaround basis. More details on groundwater level measurements, sampling, and laboratory analysis are presented in Section 3.0.

2.9 DECONTAMINATION

The field team's PPE will be disposed as required. These items, such as Tyvek™ suits, disposable latex gloves, and paper towels will be disposed of using procedures required by the HASP. Personnel will also perform decontamination procedures as required by the HASP. The equipment involved in field sampling activities will be decontaminated prior to and upon completion of drilling and sampling activities. This equipment includes drilling rigs, down-hole tools, augers, and all non-dedicated sampling equipment.

<u>Major Equipment</u>

All down-hole HSA/DPT equipment and sampling tools will be decontaminated by the subcontractor prior to beginning work. HSA/DPT equipment will be decontaminated at the completion of the installation/injection program (due to the nature of this study and previous delineation of impacted groundwater, the DPT equipment will not be decontaminated between injection points). The decontamination procedures will consist of high pressure wash with laboratory-grade detergent solution and clean water rinse.

<u>Sampling Equipment</u>

Sampling equipment used for collecting the groundwater samples will be disposable equipment. Therefore, no decontamination of this equipment will be required. Field analytical equipment such as water level probes, and water quality meters will be first wiped down with laboratory-grade detergent solution, then rinsed with a isopropanol and distilled water mix, and then with a final rinse of distilled water.

2.10 INVESTIGATION-DERIVED WASTE (IDW) MANAGEMENT

All IDW accumulated during HSA/DPT installation, well purging and sampling, and decontamination proceedings will be collected, containerized, and stored in Department of Transportation (17C)/UN (1A2)-approved, 55-gallon drums. The drums will be labeled and temporarily stored in the NASA hazardous material consolidation area pending receipt of analytical results.

Upon receipt of the analytical results (approximately 35 days after completion of sampling), TtNUS will provide the results to NASA, who will be responsible for off site disposal. NASA personnel will sign all manifests and bills of lading for transportation off site. TtNUS will coordinate with NASA personnel for completion of this activity.

3.0 ENVIRONMENTAL SAMPLING

As stated in Section 2.0, one pre-injection (baseline) and three post-injection groundwater sampling events (one day, one week and one month) will be conducted at the site. This section describes those sampling events.

3.1 SAMPLE ANALYSIS SUMMARY

Both field and laboratory analytical data will be collected to evaluate the overall effectiveness of the injection and to provide baseline data for full remedy implementation. The baseline monitoring and sampling round will consist of collecting water level measurements and groundwater samples from monitoring wells WFF16-GW8, WFF15-MW3R, WFF15-GW7, WFF15-GW1, WFF15-GW2, WFF16-GW2S, WFF16-GW2D, WFF16-GW5, and each of the six temporary monitoring points for field parameters and laboratory analysis. Additionally, field analysis will be conducted for geotechnical parameters at WFF15-GW7, WFF15-MW3R (for background comparison purposes) and the six temporary wells approximately one day, one week and one month after the injection event. Groundwater samples for laboratory analysis will also be collected from WFF15-GW7, WFF15-MW3R, and each of the six temporary monitoring points during the final monitoring event. Sections 3.1.1 and 3.1.2 and Tables 3-1 and 3-2, presented below, provide details regarding the laboratory and field analytical programs.

3.1.1 Laboratory Sample Analysis Summary

A Navy and National Environmental Laboratory Accreditation Program (NELAP) certified laboratory will be subcontracted by TtNUS to perform the chemical analyses for the environmental samples collected during the Pilot Study. The laboratory analytical methods, bottle requirements, and preservation requirements are presented in Table 3-1 below.

TABLE 3-1
LABORATORY GROUNDWATER ANALYSES

Parameter	Cleanup Goal (1) (µg/L)	Detection Limit (µg/L)	Analytical Method	Bottle/Preservation Requirements	Holding Time
Benzene Total Xylenes (2) 1,2,4-trimethylbenzene (2) Tetrachloroethene (2)	5 NA NA NA	1 1 1 1	EPA SW846 8260B	3 - 40ml vials; hydrochloric acid (HCl) pH< 2; cool to 4°C	14 days
Naphthalene (2) 4-methylphenol (2)	NA NA	5 5	EPA SW846 8270C	Two 1-Liter amber jar; cool to 4°C	7 days to extraction, 40 days after extraction
arsenic	10	3	EPA SW846 3005	One 1-Liter HDPE bottle; HNO3 to pH<2	6 months (Hg – 28 days)

Notes:

1 United States Environmental Protection Agency Drinking Water MCL (USEPA, 2003b)

2 Not a COC but the ROD stipulates that this compound is to be included in long-term monitoring

Analytical results for samples collected during the baseline monitoring event from monitoring wells WFF16-GW8, WFF15-GW1, WFF15-GW2, WFF16-GW2S, WFF16-GW2D, and WFF16-GW5 will be reported on a 21-day standard turn-around basis. Analytical results for samples collected from monitoring wells WFF15-GW7and WFF15-MW3R and the six temporary monitoring wells will be reported on a 7-day turn-around basis. A final set of groundwater samples will be collected from monitoring wells WFF15-GW7and WFF15-MW3R approximately one month after the Pilot Study injection and the results will be reported on a 14-day turn-around basis.

3.1.2 Field Analysis Summary

Field geochemical analyses will be performed during all groundwater monitoring events (baseline, one day, one week and one month). The field parameters, analytical methods and holding times are presented in Table 3-2, below.

TABLE 3-2
FIELD ANALYSES

Parameter	Analytical Method	Holding Time	Analyze
Dissolved oxygen	CHEMetrics K-7501/7512 and Horiba U-22	Analyze immediately	Field
Carbon dioxide	CHEMetrics K-1910/1920/1925	Analyze immediately	Field
Alkalinity	CHEMetrics K-9810/9815/9820	Analyze immediately	Field
Ferrous iron	HACH IR-18C	Analyze immediately	Field
Hydrogen sulfide	HACH HS-C	Analyze immediately	Field
Temperature	Horiba U-22	Analyze immediately	Field
pH	Horiba U-22	Analyze immediately	Field
Conductivity	Horiba U-22	Analyze immediately	Field
Turbidity	LaMotte Turbidimeter	Analyze immediately	Field
Oxidation Reduction Potential (ORP)	Horiba U-22	Analyze immediately	Field

3.2 GROUNDWATER SAMPLING PROCEDURES

Groundwater samples will be obtained from groundwater monitoring wells during the baseline sampling and three events of post-injection sampling. Samples will be collected for the above laboratory groundwater analyses and reference field analytical tests. Groundwater sampling will be conducted in general accordance with TtNUS SOP SA-1-1 (Appendix E).

A round of groundwater level measurements will be obtained during each sampling event from the designated WOD monitoring wells. The synoptic measurements will be taken within a 2-hour period of consistent weather conditions to minimize atmospheric/precipitation effects on groundwater levels. Measurements will be taken with an electronic water level indicator or interface probe using the marked location on the top of the well casing as the reference point. Groundwater level measurements will be recorded to the nearest 0.01-ft on the appropriate field log as presented in Appendix F. This information will be used to confirm groundwater flow direction.

The wells will be purged with a peristaltic pump using low flow quiescent purging techniques per TtNUS SOP SA-1-1. The field data will be recorded on the data collection sheets provided in Appendix F. Depending on the groundwater parameters, two to five well volumes may be purged. If wells are purged dry with less than three well volumes removed, the water level in the well will be allowed to recover enough to collect the field readings listed in Table 3-2 prior to collecting a water sample. If the well does not purge dry using the low flow purging technique, groundwater characteristics will be taken at no less than 2 minute intervals, depending on the flow rate. Sampling may be conducted once three consecutive readings, taken at 5 to 10 minute intervals, are within the following limits:

- pH ±0.2 standard units
- Specific conductance ±10%
- Temperature ±10%
- Turbidity less than 10 NTUs
- Dissolved oxygen ±10%

If the above conditions have still not been met after the well has been purged for 4 hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters on the Data Collection and Log Forms provided in Appendix F.

Teflon® and surgical-grade silicon tubing will be used for sample collection. Groundwater samples will be collected according to the methods outlined in TtNUS SOP SA-1-1. Samples requiring preservation will be collected in pre-preserved bottles provided by the laboratory.

Pertinent sampling data will be recorded using the appropriate sample log sheet (Appendix F) and field logbook.

3.3 SAMPLE HANDLING

Sample handling, including the field-related considerations concerning sample identification, packaging, and shipping, will be addressed throughout this section.

3.3.1 Sampling Identification System

Each sample collected will be assigned a unique sample tracking number. The sample tracking number will consist of a four-segment, alphanumeric code that identifies the site, sample location, and sample round. Pertinent information regarding sample identification will be recorded in the field logbooks.

The appropriate alphanumeric sample identification code is explained as follows:

(Site Location) - (Site) - (Sample Number) – (Sample round)

Site Location: WFF (Wallops Flight Facility)

Site: WOD (Waste Oil Dump)

Sample Number: Groundwater sample = well identifier.

Sample Round: For groundwater samples = designated sample round number (e.g. 1, 2, 3, 4)

For example, a groundwater sample collected from monitoring well WFF15-GW7 during the baseline sampling before the ORC® Pilot Study will be designated as WFF-WOD-15-GW7-1.

3.3.2 Sample Packaging and Shipping

The FOL will be responsible for completion of the following forms:

- Sample labels
- Chain-of-custody forms
- Appropriate labels applied to shipping coolers
- Chain-of-custody seals
- Federal Express air bills

All samples will be packaged and shipped in accordance with TtNUS SOPs.

3.4 SAMPLE CUSTODY

Custody of samples must be maintained and documented at all times. Chain-of-custody begins with the collection of the samples in the field. TtNUS SOP SA-6.3 (Appendix E) provides a description of the chain-of-custody procedures to be followed.

3.5 QUALITY CONTROL (QC) SAMPLES

In addition to regular calibration of field equipment and appropriate documentation, minimal QC samples will be collected during the Pilot Study sampling activities since dedicated and/or disposable equipment is to be used for sampling. A trip blank will be included with all VOC samples. In addition, a field equipment blank will also be included. No other QC samples are proposed and duplicate samples will not be collected.

3.6 EQUIPMENT CALIBRATION

Several monitoring instruments may be used during field activities including the following:

- Photoionization or flame ionization detector
- Horiba U-22 water quality meter/probe
- Electronic water-level meter

Calibration will be documented on an equipment calibration log (Appendix D). During calibration, an appropriate maintenance check will be performed on each piece of equipment. If damaged or defective parts are identified during the maintenance check and it is determined that the damage could have an impact on the instrument's performance, the instrument will be removed from service until the defective parts are repaired or replaced.

3.7 EQUIPMENT MAINTENANCE

Measuring equipment used in environmental monitoring or analysis and test equipment used for calibration and maintenance shall be maintained by established procedures.

TtNUS maintains an inventory of sampling and measurement equipment. In the event that failed equipment cannot be repaired, replacement equipment will be shipped to the site by overnight carrier to minimize downtime.

3.8 RECORD KEEPING

In addition to chain-of-custody records, certain standard forms will be completed for sample description and documentation. These shall include sample log sheets, daily record of subsurface investigation reports, and logbooks. Field documentation and example field log forms are provided in Appendix D.

A bound/weatherproof site logbook shall be maintained by the FOL. All information related to sampling or field activities will be recorded in the site logbook. This information will include, but is not limited to, sampling time, weather conditions, unusual events, field measurements, descriptions of photographs, etc.

3.9 DATA VALIDATION

The field and laboratory analytical results generated during the Pilot Study will be used to refine the conceptual remedial design. No risk assessment or remedy selection decisions will be made based on the analytical results. Therefore, the analytical results will not undergo data validation. The laboratory will be required to provide full analytical data packages to support data validation should it be required at a later date and for other data applications.

4.0 PROJECT MANAGEMENT

The management and technical aspects of this project are the ultimate responsibility of TtNUS. Each contractor assigned to individual tasks has the responsibility to fulfill the objectives of that task and to ensure the quality of the data generated by the task. At the direction of NASA, TtNUS has overall responsibility for the activities to be performed at the WOD Site.

4.1 PROJECT ORGANIZATION

The various quality assurance and management responsibilities of key TtNUS project personnel are defined in the following paragraphs.

Project Manager - The Project Manager is responsible for project performance, budget, and schedule, and for ensuring the availability of necessary personnel, equipment, subcontractors, and services. He/she will direct the development of the field program, evaluation of findings, determination of conclusions and recommendations, and preparation of technical reports. The TtNUS Project Manager is Mr. Garth Glenn.

FOL - The FOL is responsible for providing on-site supervision of day-to-day activities on the project. The FOL serves as the primary on-site contact with the client and subcontractors. In addition, the FOL is responsible for all field QA/QC and safety-related issues as defined in the HASP. The FOL for this project will be designated later by the Project Manager.

Health and Safety Manager (HSM) - The Program HSM will review and internally approve the HASP tailored to the specific needs of the investigation. In consultation with the Project Manager/FOL, the HSM will ensure that an adequate level of personal protection exists for anticipated potential hazards for all field personnel. As the HSM does not report to either the Program or Project Manager, his/her actions are not dictated by Program or project constraints (such as budget and schedule) other than the assurance of appropriate safeguards while conducting investigation activities. The TtNUS HSM is Mr. Matthew Soltis, Certified Industrial Hygienist.

QA Manager/Sampling Coordinators - The Project Manager/FOL will coordinate the schedule of field sampling activities with the schedule and capacity requirements of the selected analytical laboratory. All sampling will be coordinated to assure that environmental sampling is conducted in a manner that complies with all QA/QC requirements and is in compliance with holding time and analytical procedure requirements. All Program-wide, QA issues are the responsibility of the QA Manager. The TtNUS QA Manager for NASA activities will be designated later by the Project Manager.

Project Laboratory – The project laboratory will be identified prior to the field sampling event and will be selected from the list of Navy and NELAP certified laboratories approved under the Administrative Agreement on Consent between EPA and NASA [USEPA Docket Number RCRA-03-2004-0201TH].

4.2 PROJECT RESPONSIBILITIES

Throughout the field activities, NASA personnel, as described below, will provide various support functions:

- Locate and mark underground utilities and issue digging or other required permits prior to the commencement of digging or drilling operations.
- Take custody of all drill cuttings, well development fluids, decontamination fluids, or drill cuttings.
- Secure staging areas for decontamination operations and for storing equipment and supplies. It is anticipated that access can be gained to the WOD Site.
- Supply electricity and potable water for equipment cleaning, slurry mixing, etc.

4.3 CONTINGENCY PLAN

In the event of problems that may be encountered during the injection activities, the TtNUS Project Manager will notify the NASA Project Manager and the NASA WFF Point of Contact. The TtNUS Project Manager will determine a course of action so as to minimize impacts to the project schedule and/or budget. Contingency plans will be approved through the NASA Project Manager and the NASA WFF Point of Contact before being enacted.

4.4 REPORTING

During performance of the Pilot Study, TtNUS will prepare the following report:

Pilot Study Evaluation Report

Upon completion of the DPT well installation, baseline sampling, enhancement injection, and three post-injection sampling events, TtNUS will prepare the Pilot Study Evaluation Report, which will include the following:

- A summary the DPT well installation,
- The ORC® installation procedures and other data collected as part of the pilot-scale field activities,
- The groundwater sampling procedures and sample results for each event, and
- The groundwater flow conditions.

In addition, the report will present conclusions and recommendations for full remedial action implementation at the site. Dissolved oxygen levels will be the primary indicator used to determine proposed injection point spacing. Other Pilot Study findings, including field and laboratory analytical results and groundwater level measurements will be used to design full scale implementation. The Pilot Study Evaluation Report will be prepared and presented as an appendix to a Remedial Action Work Plan. The Work Plan will be submitted in draft and final form to NASA and EPA for review and approval and DEQ for review.

REFERENCES

TtNUS, 2004. Supplemental Remedial Investigation Report. NASA Wallops Flight Facility, Wallops Island, Virginia. December.

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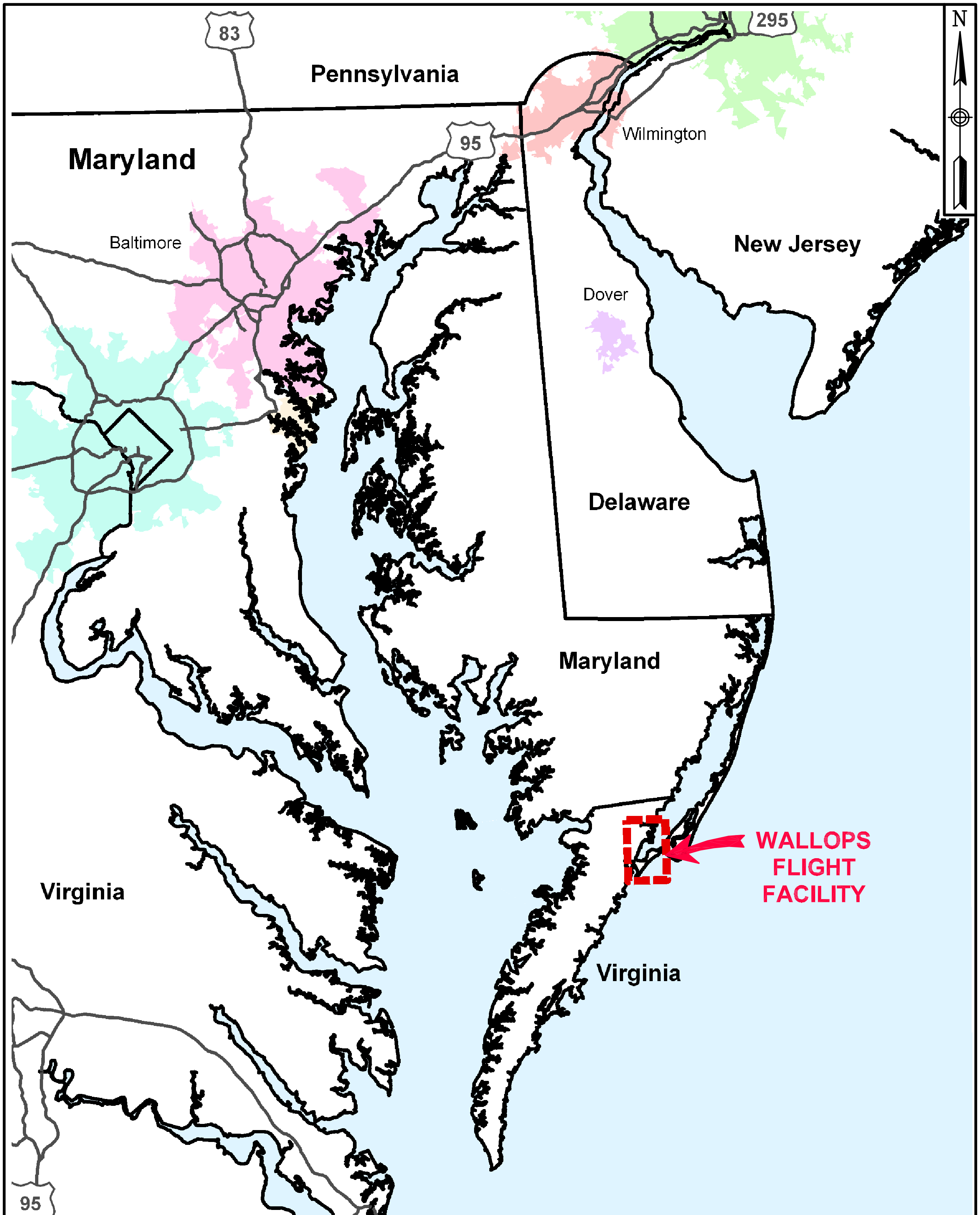
Occu-Health. 1999. Environmental Resources Document, NASA Goddard Space Flight Center, Wallops Flight Facility, Wallops Island, Virginia. October.

USACE, 2000. United States Army Corps of Engineers Wallops Flight Facility Main Base – GIS Based Historical Photographic Analysis. November.

Regenesis, 2007. Regenesis Bioremediation Products website, **www.regenesis.com**, 2007.

FIGURES

112GN1612\0311\1612BM01.DWG 03/19/08 MKB

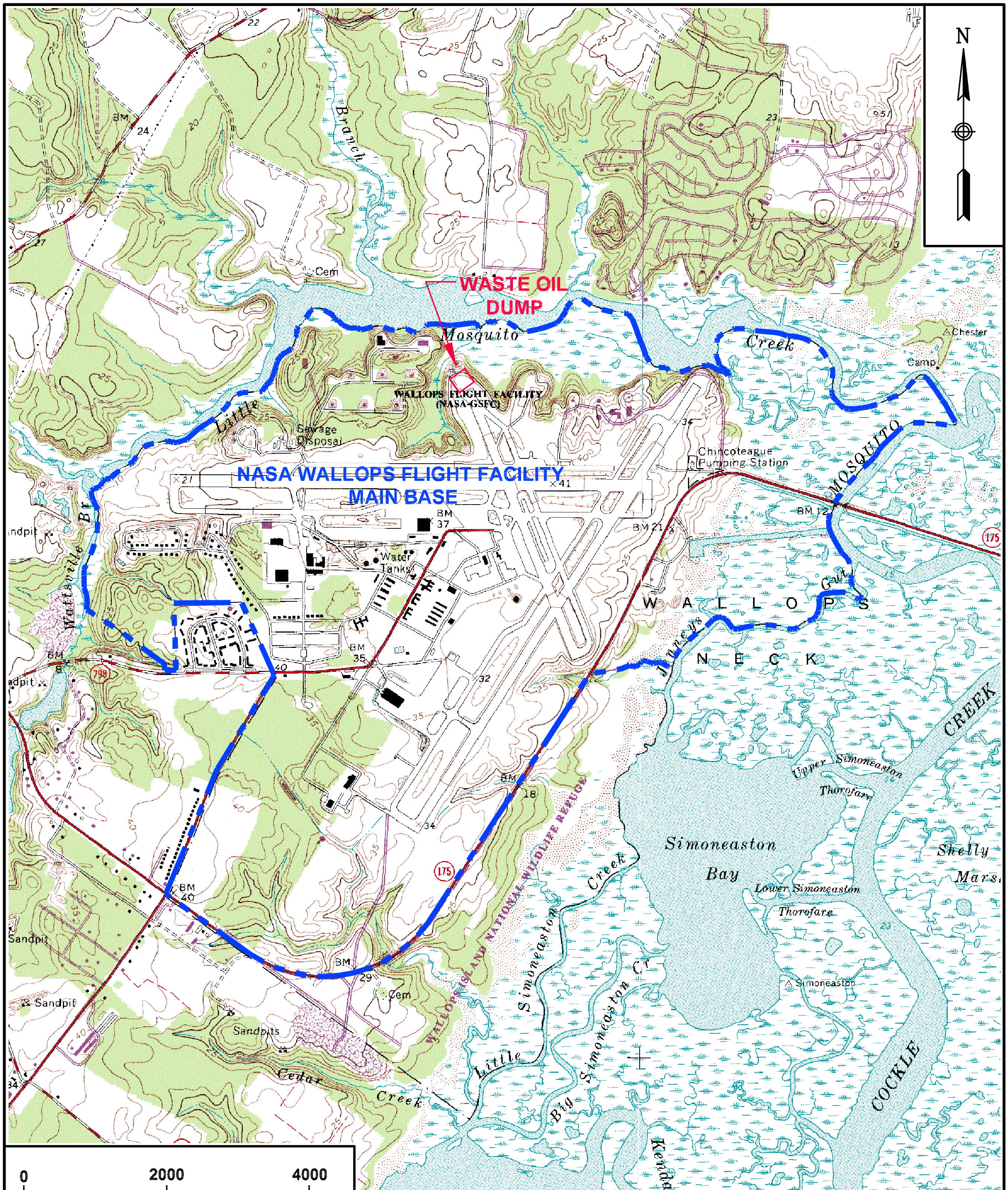


TETRA TECH NUS, INC.

SITE LOCATION MAP
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

SCALE AS NOTED	
FILE 1612BM01.DWG	
REV 0	DATE 03/19/08
FIGURE NUMBER FIGURE 1–1	

112GN1612/0311/1612BM02.DWG 03/19/08 MKB



0 2000 4000

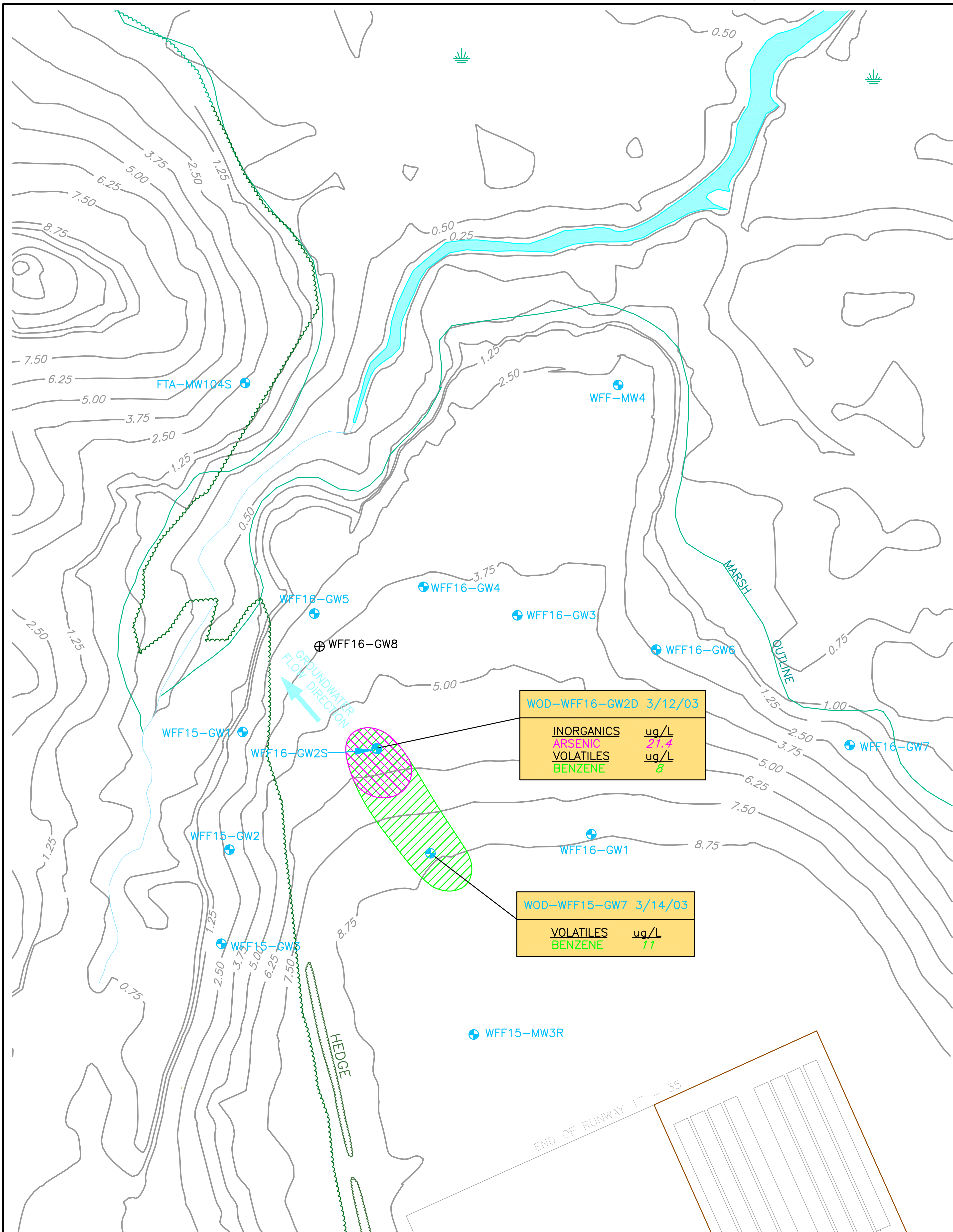
SCALE IN FEET

SOURCE: U.S.G.S. 7.5' QUADRANGLE MAPS, WALLOPS ISLAND, VA. (37075-G4), AND BLOXOM, VA. (37075-G5).

TETRA TECH NUS, INC.

STUDY AREA LOCATION MAP
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

SCALE	AS NOTED
FILE:	112G00086BM02
REV	DATE 03/19/08
FIGURE NUMBER	FIGURE 1-2



LEGEND

- APPROXIMATE EXTENT OF BRUSHLINE/WETLAND
- MONITORING WELL
- MONITORING WELL
- GROUNDWATER EXCEEDING BENZENE PRG (5 ug/L)
- GROUNDWATER EXCEEDING ARSENIC PRG (10 ug/L)

NOTE: ELEVATION CONTOURS ARE METRIC.

80' = 24.384m

0 80 160

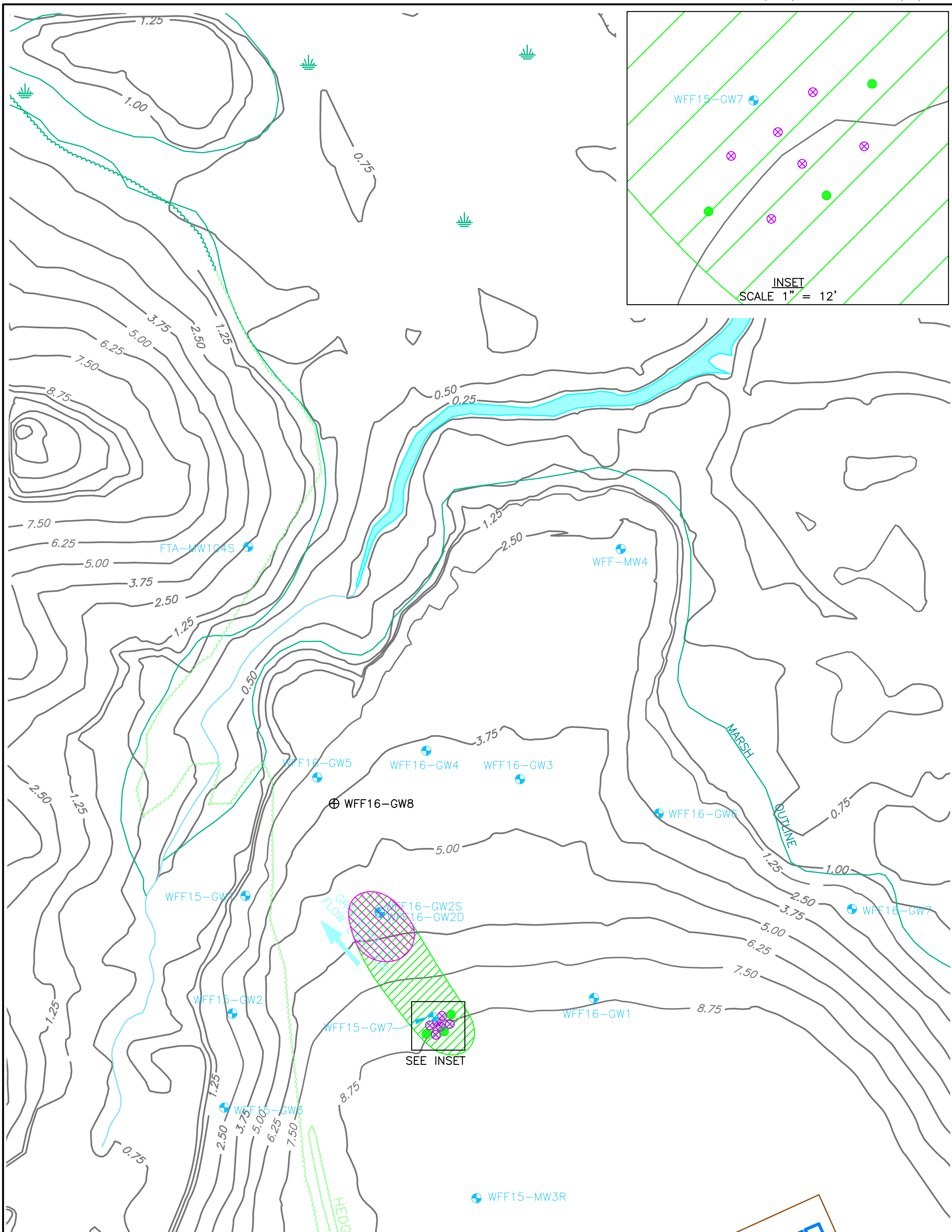
SCALE IN FEET

TETRA TECH NUS, INC.

WASTE OIL DUMP
SITE MAP
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

FILE	SCALE
112G00086GM33-1	AS NOTED

FIGURE NUMBER	REV	DATE
FIGURE 1-3	0	07/20/08



LEGEND

— · — APPROXIMATE EXTENT OF BRUSHLINE/WETLAND

MONITORING WELL

PROPOSED MONITORING WELL

PROPOSED TEMPORARY MONITORING POINT

PROPOSED INJECTION POINT

GROUNDWATER EXCEEDING BENZENE PRG (5 ug/L)

GROUNDWATER EXCEEDING ARSENIC PRG (10 ug/L)

NOTE: ELEVATION CONTOURS ARE METRIC.

0 80 160

SCALE IN FEET

TETRA TECH NUS, INC.

WASTE OIL DUMP
PROPOSED MONITORING WELL/DPT/
INJECTION WELL LOCATIONS
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

FILE	SCALE
112G00086GM32	AS NOTED

FIGURE NUMBER	REV	DATE
FIGURE 2–1	0	10/29/08

APPENDIX A

ORC® CALCULATIONS

ORC Design Software for Grid Applications Using Slurry Injection

US Version 3.1

Regenesis Technical Support: USA (949) 366-8000, www.regenesis.com

Site Name: Waste Oil Dump Area
Location: NASA Wallops Flight Facility
Consultant: J.P. Kumar/TtNUS

Site Conceptual Model/Extent of Plume Requiring Remediation

Width of plume (intersecting gw flow direction)	52	ft			
Length of plume (parallel to gw flow direction)	162	ft	=	8,424	sq. ft.
Depth to contaminated zone	20	ft			
Thickness of contaminated saturated zone	10	ft			
Nominal aquifer soil (gravel, sand, silty sand, silt, clay)	sand				
Total porosity	0.25		Eff. porosity	0.05	
Hydraulic conductivity	25	ft/day	=	8.8E-03	cm/sec
Hydraulic gradient	0.005	ft/ft			
Seepage velocity	912.5	ft/yr	=	2.500	ft/day
Treatment Zone Pore Volume	21,060	ft^3	=	157,550	gallons

Dissolved Phase Oxygen Demand:

Individual species that represent oxygen demand:	Contaminant Conc (mg/L)	Contaminant Mass (lb)	Stoich. (wt/wt) O_2/contam.	ORC (lb) (10% O_2)
benzene	0.01	0.0	3.1	0
toluene	0.12	0.2	3.1	5
ethylbenzene	0.07	0.1	3.2	3
xylenes	0.54	0.7	3.2	23
MTBE	0.00	0.0	2.7	0
dichloroethene	0.00	0.0	0.7	0
vinyl chloride	0.00	0.0	1.3	0
4-methylphenol	0.04	0.1	4.0	2
naphthalene	0.13	0.2	6.0	10
reduced metals: Fe (+2) and Mn(+2)	20.00	26.3	0.10	26
Measures of total oxygen demand				
Total Petroleum Hydrocarbons	0.00	0.0	3.1	0
Biological Oxygen Demand (BOD)	0.00	0.0	1	0
Chemical Oxygen Demand (COD)	0.00	0.0	1	0

Estimates for Sorbed Phase Oxygen Demand:

Soil bulk density	1.76	g/cm^3	=	110	lb/cf
Fraction of organic carbon: foc	0.001	range: 0 to 0.01			

(Estimated using Soil Conc=foc*Koc*Cgw)
(Adjust Koc as nec. to provide realistic est.)

Individual species that represent oxygen demand:	Koc (L/kg)	Contaminant Conc (mg/kg)	Contaminant Mass (lb)	Stoich. O_2/contam.	ORC (lb) (10% O_2)
benzene	800	0.01	0.1	3.1	2
toluene	2800	0.34	3.1	3.1	96
ethylbenzene	6500	0.46	4.2	3.2	135
xylenes	4900	2.65	24.5	3.2	784
MTBE	0	0.00	0.0	2.7	0
dichloroethene	0	0.00	0.0	0.7	0
vinyl chloride	0.0	0.00	0.0	1.3	0
4-methylphenol	0.0	0.00	0.0	4.0	0
naphthalene	0.0	0.00	0.0	6.0	0
Measures of total oxygen demand					
Total Petroleum Hydrocarbons	0	0.00	0.0	3.1	0
Biological Oxygen Demand (BOD):	Use a multiple of dissolved phase -> 1.00		0.0	1	0
Chemical Oxygen Demand (COD):	Use a multiple of dissolved phase -> 1.00		0.0	1	0

Summary of Estimated ORC Requirements	ORC for Dissolved Phase (lbs)	ORC for Sorbed Phase (lbs)	Add Dem Factor (1 to 10x)	ORC Total w/ Add Dem Factor	ORC Cost at $ 10.00
Individual Species: Total BTEX, MTBE	70	1,017	5	5,434	$ 54,336 <-
Total Petroleum Hydrocarbons	-	-	2	-	$ -
Biological Oxygen Demand (BOD)	-	-	2	-	$ -
Chemical Oxygen Demand (COD)	-	-	1	-	$ -

Select above measure (button) to specify required ORC quantity (in 30 lb increments) ------> 5,460 **pounds ORC**

Delivery Design for ORC Slurry

Spacing within rows (ft)	15.0	feet
# points per row	4	points/row
Spacing between rows (ft)	15.0	ft
# of rows	11	rows
Advective travel time bet. rows (days)	6	days
Number of points in grid	44	points
Required ORC per foot	12.4	lbs/foot
Total ORC	**5,460**	lbs of ORC

Slurry Mixing Volume for Injections

Pounds per location	124
Buckets per location	4.1
Design solids content (20-40% by wt. for injections)	30%
Volume of water required per hole (gal)	35
Total water for mixing all holes (gal)	1528
Simple ORC Backfilling: min hole dia. for 67% slurry	5.8
Feasibility for slurry injection in sand: ok up to 15 lb/ft	(ok)
Feasibility for slurry injection in silt: ok up to 10 lb/ft	(call Regenesis)
Feasibility for slurry injection in clay: ok up to 5 lb/ft	(call Regenesis)

Project Summary			
ORC bulk material for slurry injection (lbs)			5,460
Number of 30 lb ORC buckets			182.0
ORC bulk material cost		$	9.00
Cost for bulk ORC material		$	49,140
Shipping and Tax Estimates in US Dollars			
Sales Tax	rate: 0%	$	-
Total Matl. Cost		$	49,140
Shipping (call for amount)		$	-
Total Regenesis Material Cost		**$**	**49,140**

ORC Slurry Injection Cost Est. (responsibility of customer to contract work)		
Footage for each inj. point = uncontaminated + HRC inj. interval (ft)		30
Total length for direct push for project (ft)		1,320
Estimated daily installation rate (ft per day: 400 for push, 150 for drilling)		400
Estimated points per day (15 to 30 is possible for direct push)		13.3
Required number of days		4
Mob/demob cost for injection subcontractor	$	1,000
Daily rate for inj. Sub. ($1-2K for push $3-4K for drill rig)	$	1,500
Total injection subcontrator cost for application	$	7,000
Total Install Cost (not including consultant, lab, etc.)	**$**	**56,140**

Other Project Cost Estimates		
Design	$	-
Permitting and reporting	$	-
Construction management	$	-
Groundwater monitoring and rpts	$	-
Other	$	-
Other	$	-
Other	$	-
Other	$	-
Total Project Cost	**$**	**56,140**

APPENDIX B

ORC® MIXING & INJECTING INSTRUCTIONS

(As retrieved from Regenesis' Website.)

REGENESIS

Oxygen Release Compound (ORC®) Installation Instructions

(Slurry Mixing)

1. OPEN 5 GALLON BUCKET, AND REMOVE PRE-MEASURED BAG OF ORC.
2. MEASURE AND POUR WATER INTO THE 5-GALLON BUCKET ACCORDING TO THE FOLLOWING DESIRED CONSISTENCY:

65% Solids Slurry	Mix .63 gallons of water per 10 pounds of ORC powder.	
	Example:	Mix 20 pounds of ORC with 1.26 gallons of water.
		Mix 30 pounds of ORC with 1.89 gallons of water.

60% Solids Slurry	Mix .79 gallons of water per 10 pounds of ORC powder.	
	Example:	Mix 20 pounds of ORC with 1.58 gallons of water.
		Mix 30 pounds of ORC with 2.37 gallons of water.

50% Solids Slurry	Mix 1.19 gallons of water per 10 pounds of ORC powder.	
	Example:	Mix 20 pounds of ORC with 2.38 gallons of water.
		Mix 30 pounds of ORC with 3.57 gallons of water.

25% Solids Slurry	Mix 3.57 gallons of water per 10 pounds of ORC powder.	
	Example:	Mix 10 pounds of ORC with 3.57gallons of water.

3. ADD THE APPROPRIATE ORC QUANTITY TO THE WATER. Check weight of each bucket (see label). The 5 gallon shipping bucket weighs 2 pounds. An additional 4 pounds of ORC would require one additional quart of water, at the 65% solids level.
4. USE AN APPROPRIATE MIXING DEVICE TO THOROUGHLY MIX ORC AND WATER. A hand held drill with a "jiffy mixer" or a stucco mixer on it may be used in conjunction with a small paddle to scrape the bottom and sides of the container. Standard environmental slurry mixers may also be used, following the equipment instructions for operation. For small quantities a usable slurry can be mixed by hand, if care is taken to blend all lumps into the mixture thoroughly.

<u>CAUTION</u>: ORC MAY SETTLE OUT OF SLURRY IF LEFT STANDING. ALSO, ORC EVENTUALLY HARDENS INTO A CEMENT-LIKE COMPOUND, AND CANNOT BE RE-MIXED AFTER THAT HAS HAPPENED. THEREFORE:

Mix immediately before using. <u>Do not let stand</u> more than 30 minutes, and re-mix immediately before use, to be sure the mixture has not settled out. If a mechanical slurry mixer attached to a pump is being used, the material may be cycled back through the mixer to maintain slurry suspension and consistency.

5. CHECK SLURRY CONSISTENCY FOR POURABILITY. ADD WATER IF NECESSARY (IN 1 CUP INCREMENTS) TO ACHIEVE THE CORRECT CONSISTENCY.

For direct assistance or answers to any questions you may have regarding these instructions, contact Regenesis Technical Services at 949-366-8000.

REGENESIS, 2002
www.regenesis.com

APPENDIX C

ORC® MSDS Sheets

(As retrieved from Regenesis' Website.)

Oxygen Release Compound (ORC®)
MATERIAL SAFETY DATA SHEET (MSDS)

Last Revised: **October 18, 2005**

Section 1 - Material Identification

Supplier:

REGENESIS

1011 Calle Sombra
San Clemente, CA 92673
Phone: **949.366.8000**
Fax: **949.366.8090**
E-mail: **info@regenesis.com**

Chemical Description:	**A mixture of Magnesium Peroxide (MgO_2), Magnesium Oxide (MgO), and Magnesium Hydroxide [$Mg(OH)_2$]**
Chemical Family:	**Inorganic Chemical**
Trade Name:	**Oxygen Release Compound (ORC®)**
Product Use:	**Used to remediate contaminated soil and groundwater (environmental applications)**

Section 2 – Chemical Identification

CAS#	**Chemical**
14452-57-4	**Magnesium Peroxide (MgO_2)**
1309-48-4	**Magnesium Oxide (MgO)**
1309-42-8	**Magnesium Hydroxide [$Mg(OH)_2$]**
7758-11-4	**Dipotassium Phosphate (HK_2O_4P)**
7778-77-0	**Monopotassium Phosphate (H_2KO_4P)**
Assay:	**25-35% Magnesium Peroxide (MgO_2)**

Section 3 - Physical Data

Melting Point:	**Not Determined (ND)**
Boiling Point:	**ND**
Flash Point:	**Not Applicable (NA)**
Self-Ignition Temperature:	**NA**
Thermal Decomposition:	**Spontaneous Combustion possible at ≈ 150°C**
Density:	**0.6 – 0.8 g/cc**
Solubility:	**Reacts with Water**
pH:	**Approximately 10 in saturated solution**
Appearance:	**White Powder**
Odor:	**None**
Vapor Pressure:	**None**
Hazardous Decomposition Products:	**Not Known**
Hazardous Reactions:	**Hazardous Polymerization will not occur**
Further Information:	**Non-combustible, but will support combustion**

Section 4 – Reactivity Data

Stability:	**Product is stable unless heated above 150 °C. Magnesium Peroxide reacts with water to slowly release oxygen. Reaction by product is Magnesium Hydroxide**
Conditions to Avoid:	**Heat above 150 °C. Open Flames.**
Incompatibility:	**Strong Acids. Strong Chemical Agents.**
Hazardous Polymerization:	**None known.**

Section 5 - Regulations

Permissible Exposure Limits in Air	**Not Established. Should be treated as a nuisance dust.**

Section 6 – Protective Measures, Storage and Handling

Technical Protective Measures

Storage:	**Keep in tightly closed container. Keep away from combustible material.**
Handling:	**Use only in well ventilated areas.**

Personal Protective Equipment (PPE)

Respiratory Protection:	**Recommended (HEPA Filters)**
Hand Protection:	**Wear suitable gloves.**
Eye Protection:	**Use chemical safety goggles.**
Other:	**NA**
Industrial Hygiene:	**Avoid contact with skin and eyes**
Protection Against Fire & Explosion:	**NA**
Disposal:	**Dispose via sanitary landfill per state/local authority**
Further Information:	**Not flammable, but may intensify a fire**
After Spillage/Leakage/Gas Leakage:	**Collect in suitable containers. Wash remainder with copious quantities of water.**
Extinguishing Media:	**NA**
Suitable:	**Carbon Dioxide, dry chemicals, foam**
Further Information:	**Self contained breathing apparatus or approved gas mask should be worn due to small particle size. Use extinguishing media appropriate for surrounding fire.**
First Aid:	**After contact with skin, wash immediately with plenty of water and soap. In case of contact with eyes, rinse immediately with plenty of water and seek medical attention.**

Section 7 – Information on Toxicology

Toxicity Data:	**Not Available**

Section 8 – Information on Ecology

Water Pollution Hazard Raging (WGK):	**0**

Section 9 – Further Information

After the reaction of magnesium peroxide with water to form oxygen, the resulting material, magnesium hydroxide, is mildly basic. The amounts of magnesium oxide (magnesia) and magnesium hydroxide in the initial product have an effect similar to lime, but with lower alkalinity.

The information contained in this document is the best available to the supplier at the time of writing, but is provided without warranty of any kind. Some possible hazards have been determined by analogy to similar classes of material. The items in this document are subject to change and clarification as more information become available.

APPENDIX D

HEALTH AND SAFETY PLAN

WOD Site

Health and Safety Plan

For

Former Fire Training Area
and
Waste Oil Dump Site 16
NASA Wallops Flight Facility
Wallops Island, Virginia

National Aeronautics and Space Administration
Goddard Space Flight Center
Wallops Flight Facility

May 2008

HEALTH AND SAFETY PLAN

FOR

FORMER FIRE TRAINING AREA
AND
WASTE OIL DUMP SITE 16
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY CONTRACT

Submitted to:
National Aeronautics and Space Administration
Goddard Space Flight Center
Wallops Flight Facility
Building F-160, Code 250.W
Wallops Island, Virginia 23337

Submitted by:
Tetra Tech NUS, Inc.
234 Mall Boulevard, Suite 260
King of Prussia, Pennsylvania 19406

CONTRACT NO. N62472-03-D-0057
CONTRACT TASK ORDER 0012

MAY 2008

PREPARED UNDER THE SUPERVISION OF:

GARTH GLENN
PROJECT MANAGER
TETRA TECH NUS, INC.
NORFOLK, VIRGINIA

APPROVED FOR SUBMITTAL BY:

MATTHEW SOLTIS, CIH, CSP.
CLEAN HEALTH & SAFETY MANAGER
TETRA TECH NUS, INC.
PITTSBURGH, PENNSYLVANIA

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

TABLE **PAGE**

LIST OF FIGURES

FIGURE **PAGE**

1.0 INTRODUCTION

The objective of this Health and Safety Plan (HASP) is to provide the safety and health requirements, restrictions, practices and procedures for Tetra Tech NUS, Inc. (TtNUS) personnel participating in soil boring via Direct Push Technology (DPT), groundwater sampling and (ORC) Oxygen Release Compound injection at the Former Fire Training Area at NASA Wallops Flight Facility (WWF) Wallops Island, Virginia.

This HASP is to be used in conjunction with the Tetra Tech NUS Health and Safety Guidance Manual. The Guidance Manual provides detailed information pertaining to hazard recognition and control, and TtNUS standard operating procedures. This HASP and the contents of the Guidance Manual were developed to comply with the requirements stipulated in 29 CFR 1910.120 (OSHA's Hazardous Waste Operations and Emergency Response Standard). Both documents must be present at the site to satisfy these requirements.

This HASP has been written to support proposed tasks and techniques associated with the scope of work as presented in Section 4.0. It has been developed using the latest available information regarding known or suspected chemical contaminants and potential physical hazards associated with the proposed work at the site. Should the proposed work site conditions and/or suspected hazards change, or if new information becomes available, this document will be modified. Changes to the HASP will be made with the approval of the TtNUS Site Safety Officer (SSO) and the TtNUS Health and Safety Manager (HSM). Requests for modifications to the HASP will be directed to the SSO who will determine whether to make the changes. The SSO will notify the Project Manager (PM), who will notify the affected personnel of changes.

1.1 AUTHORITY

This work is authorized under the Comprehensive Long - Term Environmental Action Navy (CLEAN) contract, administered through the U.S. Navy Southeast, Naval Facilities Engineering Command, as defined under Contract No. N62467-04-D-0055; Contract Task Order Number 012.

1.2 KEY PROJECT PERSONNEL AND ORGANIZATION

This section defines responsibilities for site safety and health for TtNUS employees conducting the DPT soil boring, groundwater sampling and ORC Injection and other supporting field activities under this field effort. All personnel assigned to participate in the field work have the primary responsibility for performing all of their work tasks in a manner that is consistent with the TtNUS Health and Safety Policy, the health and safety training that they have received, the contents of this HASP, and in an overall manner that protects their personal safety and health and that of their co-workers. The following persons are the primary point of contact and have the primary responsibility for observing and implementing this HASP and for overall on-site health and safety.

- The TtNUS PM is responsible for the overall direction and implementation of health and safety for this work.

- The TtNUS Field Operations Leader (FOL) is responsible for implementation of this HASP. The FOL manages field activities, executes the Work Plan, and enforces safety procedures as applicable to the Work Plan. Specifically, the FOL will:

  - Verify training and medical status of on-site personnel in relation to site activities.
  - Assist and represent TtNUS with emergency services (if needed)
  - Provide elements site-specific training for on site personnel.

- The TtNUS Site Safety Officer (SSO) or his/her representative supports the FOL concerning the aspects of health and safety including, but not limited to:

  - Coordinating health and safety activities
  - Selecting, applying, inspecting, and maintaining personal protective equipment
  - Establishing work zones and control points
  - Implementing air monitoring procedures
  - Implementing hazard communication, respiratory protection, and other associated safety and health programs
  - Coordinating emergency services
  - Providing elements of site-specific training

- Compliance with these requirements is monitored by the Project Health and Safety Officer (PHSO) and is coordinated through the HSM.

1.3 SITE INFORMATION AND PERSONNEL ASSIGNMENTS

Site Name: NASA Wallops Flight Facility **Address:** Wallops Island, Virginia

Remedial Project Manager: Carolyn Turner **Phone Number:** 747-824-1720

Site Contact: T.J. Meyer **Phone Number:** 747-824-1987

Site Address: Wallops Island, Virginia 23337

Purpose of Site Visit: Pilot study to determine if the application of Oxygen Releasing compounds can reduce SVOC's and VOC's

Proposed Start-up Date: .May 2008 till completion

Project Team:

TtNUS Personnel:	Discipline/Tasks Assigned:
Garth Glenn,	Project Manager (PM)
TBD	Field Operations Leader
Matthew M. Soltis, CIH, CSP	Health and Safety Manager (HSM)
Clyde J. Snyder	Project Health and Safety Officer (PHSO)
TBD	Site Safety Officer

Prepared by: Clyde J. Snyder

2.0 EMERGENCY ACTION PLAN

2.1 INTRODUCTION

This section has been developed as part of a planning effort to direct and guide field personnel in the event of an emergency. In the event of an emergency, the field team will primarily evacuate and assemble to an area unaffected by the emergency and notify the appropriate local emergency response personnel/agencies. TtNUS personnel are not authorized to participate in any emergency response activities. Workers who are ill or who have suffered a non-serious injury may be transported by site personnel to nearby medical facilities, provided that such transport does not aggravate or further endanger the welfare of the injured/ill person. The emergency response agencies listed in this plan are capable of providing the most effective response, and as such, will be designated as the primary responders. These agencies are located within a reasonable distance from the area of site operations, which ensures adequate emergency response time. The Navy RPM will be notified if outside response agencies are contacted.

TtNUS personnel may participate in minor event response and emergency prevention activities such as:

- Initial fire-fighting support and prevention
- Initial spill control and containment measures and prevention
- Removal of personnel from emergency situations
- Provision of initial medical support for injury/illness requiring only first-aid level support
- Provision of site control and security measures as necessary

2.2 EMERGENCY PLANNING

Through the initial hazard/risk assessment effort, emergencies resulting from chemical, physical, or fire hazards are the types of emergencies which could be encountered during site activities. To minimize or eliminate the potential for these emergency situations, pre-emergency planning activities will include the following (which are the responsibility of the SSO and/or the FOL):

- Coordinating with the Municipal Emergency Response personnel to ensure that TtNUS emergency action activities are compatible with existing emergency response procedures.

- Establishing and maintaining information at the project staging area (support zone) for easy access in the event of an emergency. This information will include the following:

  - Chemical Inventory (of chemicals used onsite), with Material Safety Data Sheets.

- Onsite personnel medical records (Medical Data Sheets).
- A log book identifying personnel onsite each day.
- Hospital route maps with directions (these should also be placed in each site vehicle).
- Emergency Notification - phone numbers.

The TtNUS FOL will be responsible for the following tasks:

- Identifying a chain of command for emergency action.
- Educating site workers to the hazards and control measures associated with planned activities at the site, and providing early recognition and prevention, where possible.
- Periodically performing practice drills to ensure site workers are familiar with incidental response measures.
- Providing the necessary equipment to safely accomplish identified tasks.

2.3 EMERGENCY RECOGNITION AND PREVENTION

2.3.1 Recognition

Emergency situations that may be encountered during site activities will generally be recognized by visual observation. Visual observation will also play a role in detecting potential exposure events to some chemical hazards. To adequately recognize chemical exposures, site personnel must have a clear knowledge of signs and symptoms of exposure associated with the principle site contaminants of concern as presented in this HASP. Tasks to be performed at the site, potential hazards associated with those tasks and the recommended control methods are discussed in detail in Sections 5.0 and 6.0. Additionally, early recognition of hazards will be supported by daily site surveys to eliminate any situation predisposed to an emergency. The FOL and/or the SSO will be responsible for performing surveys of work areas prior to initiating site operations and periodically while operations are being conducted. Survey findings are documented by the FOL and/or the SSO in the Site Health and Safety logbook; however, site personnel will be responsible for reporting hazardous situations. Where potential hazards exist, TtNUS will initiate control measures to prevent adverse effects to human health and the environment.

The above actions will provide early recognition for potential emergency situations, and allow TtNUS to instigate necessary control measures. However, if the FOL and the SSO determine that control measures are not sufficient to eliminate the hazard; TtNUS will withdraw from the site and notify the appropriate response agencies listed in Table 2-1.

2.3.2 Prevention

TtNUS and subcontractor personnel will minimize the potential for emergencies by following the Health and Safety Guidance Manual and ensuring compliance with the HASP and applicable OSHA regulations. Daily site surveys of work areas, prior to the commencement of that day’s activities, by the FOL and/or the SSO will also assist in prevention of illness/injuries when hazards are recognized early and control measures initiated.

2.4 EVACUATION ROUTES, PROCEDURES, AND PLACES OF REFUGE

An evacuation will be initiated whenever recommended hazard controls are insufficient to protect the health, safety or welfare of site workers. Specific examples of conditions that may initiate an evacuation include, but are not limited to the following: severe weather conditions; fire or explosion; monitoring instrumentation readings which indicate levels of contamination are greater than instituted action levels; and evidence of personnel overexposure to potential site contaminants.

In the event of an emergency requiring evacuation, personnel will immediately stop activities and report to the designated safe place of refuge unless doing so would pose additional risks. When evacuation to the primary place of refuge is not possible, personnel will proceed to a designated alternate location and remain until further notification from the TtNUS FOL. Safe places of refuge will be identified prior to the commencement of site activities by the SSO and will be conveyed to personnel as part of the pre-activities training session. This information will be reiterated during daily safety meetings. Whenever possible, the safe place of refuge will also serve as the telephone communications point for that area. During an evacuation, personnel will remain at the refuge location until directed otherwise by the TtNUS FOL or the on-site Incident Commander of the Emergency Response Team. The FOL or the SSO will perform a head count at this location to account for and to confirm the location of site personnel. Emergency response personnel will be immediately notified of any unaccounted personnel. The SSO will document the names of personnel onsite (on a daily basis) in the site Health and Safety Logbook. This information will be utilized to perform the head count in the event of an emergency.

Evacuation procedures will be discussed during the pre-activities training session, prior to the initiation of project tasks. Evacuation routes from the site and safe places of refuge are dependent upon the location at which work is being performed and the circumstances under which an evacuation is required. Additionally, site location and meteorological conditions (i.e., wind speed and direction) may dictate evacuation routes. As a result, assembly points will be selected and communicated to the workers relative to the site location where work is being performed. Evacuation should always take place in an upwind direction from the site.

2.5 EMERGENCY CONTACTS

Prior to initiating field activities, personnel will be thoroughly briefed on the emergency procedures to be followed in the event of an accident. Table 2-1 provides a list of emergency contacts and their associated telephone numbers. This table must be posted where it is readily available to site personnel. Facility maps should also be posted showing potential evacuation routes and designated meeting areas.

As soon as possible, Navy contact will be informed of any incident or accident that requires medical attention.

Any pertinent information regarding allergies to medications or other special conditions will be provided to medical services personnel. This information is listed on Medical Data Sheets filed onsite (See Attachment I). If an exposure to hazardous materials has occurred, provide hazard information from Table 6-1 to medical service personnel.

TABLE 2-1
EMERGENCY CONTACTS

WALLOPS FLIGHT FACILITY WALLOPS ISLAND, VIRGINIA

AGENCY	TELEPHONE
EMERGENCY (WFF Land Line) - Fire, Security, Emergency Medical Services	911
Site Emergency From a Cell Phone	**(757) 824-1333**
Peninsula Regional Medical Center	(410) 546-6400
Chemtrec	(800) 424-9300
National Response Center	(800) 424-8802
Virginia Utility One Call (Miss Utility of Virginia)	(800) 552-7001
Virginia Poison Control	(800) 222-1222
NASA Point of Contact, Carolyn Turner	(757) 824-1720
Base Safety Office:	
Alyson Cornell	(757) 824-1884
Terry Potterton	(757) 824-1498
Marvin Bunting	(757) 824-2030
Project Manager, Garth Glenn	(610) 491-9688
Project Health and Safety Officer, Clyde Snyder	412-921-8904
CLEAN Health and Safety Manager, Matthew M. Soltis, CIH, CSP	(412) 921-8912

2.6 EMERGENCY ROUTE TO HOSPITAL

ROUTE TO MEDICAL CENTER

TtNUS will notify WFF Emergency Services of any serious illness or injury. However workers who are ill or who have suffered a non-serious injury may be transported to the Peninsula Regional Medical Center provided the transport can be completed in a safe manner for the injured or ill person.

Peninsula Regional Medical Center
100 East Carroll Street
Salisbury, MD 21801-5493
410-546-6400

Take Virginia Route 175 for 10.5 miles.

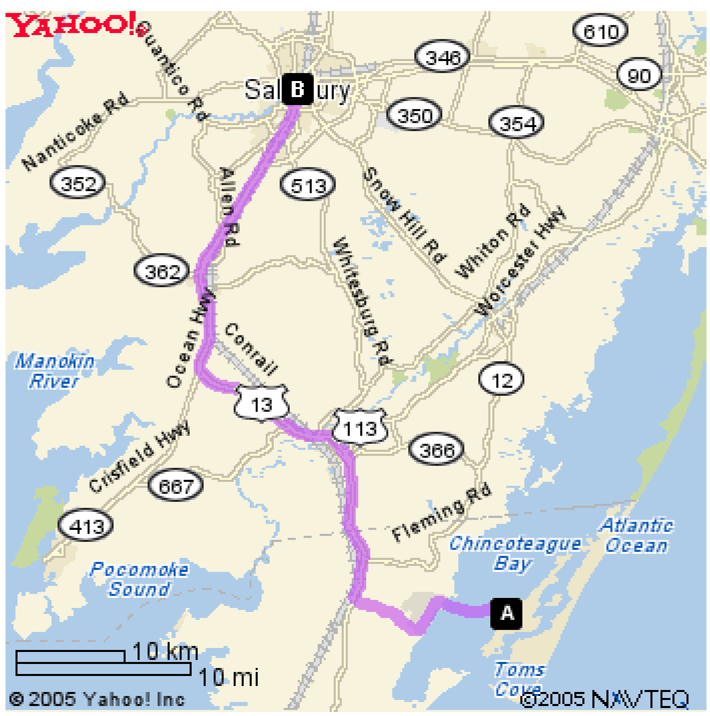
Turn right on US 13 North.

Continue straight into Maryland approximately 31 miles.

Take the ramp onto US 13 Business North toward Salisbury/Fruitland and go 5 miles.

At Carroll St turn left and the facility will be on the left.

FIGURE 2-1
ROUTE TO MEDICAL CENTER



2.7 EMERGENCY ALERTING AND ACTION/RESPONSE PROCEDURES

TtNUS personnel will be working in close proximity to each other at NASA Wallops Island and other work sites associated with the ORC Pilot Study. As a result, hand signals, voice commands, and line of site communication will be sufficient to alert site personnel of an emergency.

If an emergency warranting evacuation occurs, the following procedures are to be initiated:

- Initiate the evacuation via hand signals, voice commands, or line of site communication
- Report to the designated refuge point where the FOL will account for all personnel
- Once non-essential personnel are evacuated, appropriate response procedures will be enacted to control the situation.
- Describe to the FOL (FOL will serve as the Incident Coordinator) pertinent incident details.

In the event that site personnel cannot mitigate the hazardous situation, the FOL and SSO will enact emergency notification procedures to secure additional assistance in the following manner:

Dial 911 and call other pertinent emergency contacts listed in Table 2-1 and report the incident. Give the emergency operator the location of the emergency, the type of emergency, the number of injured, and a brief description of the incident. Stay on the phone and follow the instructions given by the operator. The operator will then notify and dispatch the proper emergency response agencies.

2.8 PPE AND EMERGENCY EQUIPMENT

A first-aid kit, eye wash units (or bottles of disposable eyewash solution) and fire extinguishers (strategically placed) will be maintained onsite and shall be immediately available for use in the event of an emergency. This equipment will be located in the field office as well as in each site vehicle. At least one first aid kit supplied with equipment to protect against bloodborne pathogens will also be available on site. Personnel identified within the field crew with bloodborne pathogen and first-aid training will be the only personnel permitted to offer first-aid assistance.

2.9 DECONTAMINATION PROCEDURES / EMERGENCY MEDICAL TREATMENT

During any site evacuation, decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. Decontamination will not be performed if the incident warrants immediate evacuation. However, it is unlikely that an evacuation would occur which would require workers to evacuate the site without first performing the necessary decontamination procedures.

TtNUS personnel will perform rescue operations from emergency situations and may provide initial medical support for injury/illnesses requiring only "Basic First-Aid" level support, and only within the limits of training obtained by site personnel. Basic First-Aid is considered treatment that can be rendered by a trained first aid provider at the injury location and not requiring follow-up treatment or examination by a physician (for example; minor cuts, bruises, stings, scrapes, and burns). Not included as Basic First-Aid are second or third degree burns, cuts, lacerations requiring stitches or butterfly bandaging, heat exhaustion, severe poisonous plant or insect bite reactions. Personnel providing medical assistance are required to be trained in First-Aid and in the requirements of OSHA's Bloodborne Pathogen Standard (29 CFR 1910.1030). Medical attention above First-Aid level support will require assistance from the designated emergency response agencies. Attachment II provides the procedure to follow when reporting an injury/illness, and the form to be used for this purpose. **If the emergency involves personnel exposures to chemicals, follow the steps provided in Figure 2-2.**

2.10 INJURY/ILLNESS REPORTING

If any TtNUS personnel are injured or develop an illness as a result of working on site, the TtNUS “Incident Report Form” (Attachment II) must be followed. Filling out this form is necessary for documenting of the information obtained at the time of the incident. In addition any onsite injury must also be reported to NASA via the Mishap Report Form contained in Attachment II.

Any pertinent information regarding allergies to medications or other special conditions will be provided to medical services personnel. This information is listed on Medical Data Sheets filed onsite. If an exposure to hazardous materials has occurred, provide information on the chemical, physical, and toxicological properties of the subject chemical(s) to medical service personnel.

FIGURE 2-2

POTENTIAL EXPOSURE PROTOCOL

The purpose of this protocol is to provide guidance for the medical management of injury situations.

In the event of a personnel injury or accident:

- Rescue, when necessary, employing proper equipment and methods.
- Give attention to emergency health problems -- breathing, cardiac function, bleeding, and shock.
- Transfer the victim to the medical facility designated in this HASP by suitable and appropriate conveyance (i.e. ambulance for serious events)
- Obtain as much exposure history as possible (a Potential Exposure report is attached).
- If the injured person is a Tetra Tech NUS employee, call the medical facility and advise them that the patient(s) is/are being sent and that they can anticipate a call from the WorkCare physician. WorkCare will contact the medical facility and request specific testing which may be appropriate. WorkCare physicians will monitor the care of the victim. Site officers and personnel should not attempt to get this information, as this activity leads to confusion and misunderstanding.
    - Call WorkCare at 1-800-455-6155 and enter Extension 109, being prepared to provide:
        - Any known information about the nature of the injury.
        - As much of the exposure history as was feasible to determine in the time allowed.
        - Name and phone number of the medical facility to which the victim(s) has/have been taken.
        - Name(s) of the involved Tetra Tech NUS, Inc. employee(s).
        - Name and phone number of an informed site officer who will be responsible for further investigations.
        - Fax appropriate information to WorkCare at (714) 456-2154.
- Contact Corporate Health and Safety Department (Matt Soltis) and Human Resources Department (Marilyn Duffy) at 1-800-245-2730.

As data is gathered and the scenario becomes more clearly defined, this information should be forwarded to WorkCare.

WorkCare will compile the results of data and provide a summary report of the incident. A copy of this report will be placed in each victim's medical file in addition to being distributed to appropriately designated company officials.

Each involved worker will receive a letter describing the incident but deleting any personal or individual comments. A personalized letter describing the individual findings/results will accompany this generalized summary. A copy of the personal letter will be filed in the continuing medical file maintained by WorkCare.

FIGURE 2-2 (continued)
WORKCARE

POTENTIAL EXPOSURE REPORT

Name: ______________________ Date of Exposure: ______________

Social Security No.: ______________ Age: ________ Sex: ________

Client Contact: ______________________ Phone No.: ______________

Company Name: ______________________

I. Exposing Agent
Name of Product or Chemicals (if known):______________________
____
Characteristics (if the name is not known)
Solid Liquid Gas Fume Mist Vapor

II. Dose Determinants
What was individual doing?______________________
How long did individual work in area before signs/symptoms developed? ______________
Was protective gear being used? If yes, what was the PPE? ______________
Was their skin contact? ______________________
Was the exposing agent inhaled?______________________
Were other persons exposed? If yes, did they experience symptoms? ______________

III. Signs and Symptoms (check off appropriate symptoms)

Immediately With Exposure:

Burning of eyes, nose, or throat
Tearing
Headache
Cough
Shortness of Breath
Chest Tightness / Pressure
Nausea / Vomiting
Dizziness
Weakness

Delayed Symptoms:

Weakness
Nausea / Vomiting
Shortness of Breath
Cough
Loss of Appetite
Abdominal Pain
Headache
Numbness / Tingling

IV. Present Status of Symptoms (check off appropriate symptoms)
Burning of eyes, nose, or throat
Tearing
Headache
Cough
Shortness of Breath
Chest Tightness / Pressure
Cyanosis
Nausea / Vomiting
Dizziness
Weakness
Loss of Appetite
Abdominal Pain
Numbness / Tingling

Have symptoms: (please check off appropriate response and give duration of symptoms)
Improved: ________ Worsened: _______ Remained Unchanged: _______

V. Treatment of Symptoms (check off appropriate response)
None: ___________ Self-Medicated: _______ Physician Treated: _______

3.0 SITE BACKGROUND

3.1 SITE HISTORY AND CURRENT OPERATIONS

The (WFF) is located in Accomack County, on the Eastern Shore of the Commonwealth of Virginia. The facility is comprised of three separate areas, the Main Base (MB), the Mainland (ML), and Wallops Island (WI). These three areas are in close proximity to each other and total approximately 5,000 acres of landmass and 1,000 acres of marshland. The most heavily developed area is the MB (about 1900 acres) which includes administrative and technical offices, tracking and data acquisition components, the range control center, rocket motor storage and processing facilities, research and development facilities, airfield and control tower, aircraft hangar and maintenance facilities, and Navy administration and housing areas.

3.2 INVESTIGATION AREAS

The Former Fire Training Area (FFTA) and the Waste Oil Dump (WOD) (Site 16) are both located within the MB area.

3.2.1 <u>FFTA</u>

Environmental investigations at the FFTA began in 1986 after a Virginia inspection noted the presence of possible petroleum products in the fire training area. NASA responded to this finding by conducting a soil excavation and disposal in that same year. From 1990 through 1992 additional investigations including soil gas surveys and soil and groundwater sampling were conducted at the FFTA. Based on the finding that a potential for groundwater contamination and exposure existed, NASA initiated Remedial Investigation (RI) activities in 1993. RI activities included the completion of soil gas surveys, soil boring and sampling programs, monitoring well installation and groundwater sampling, and surface soil sampling. Based on the findings of the RI an FS was completed in 1997. Additional groundwater sampling and further human health risk assessment evaluations were completed between 1997 and 2000.

The FFTA is located adjacent to an abandoned runway and was used for fire fighting training exercises from 1965 to 1987. Fuels, waste solvents, and other combustibles were released into an open tank or below grade pit and ignited as part of the exercises. The open tank and pit were removed by NASA and a soil excavation and disposal operation was completed in 1986. The area is an open grass field surround by areas of higher elevation. No samples were collected at the time of the removal. However, subsequent to the removal investigations conducted from 1988 through 2000 have included the performance of soil gas surveys, magnetometer surveys, surface and subsurface soil sampling, soil boring, monitoring well installation, and groundwater sampling. The analytical data from these investigations has been evaluated and presented in a series of reports including preliminary assessments, site investigations, remedial investigations, human and ecological risk assessments, and feasibility studies.

3.2.2 Waste Oil Dump Site (WOD) (Site 16)

The WOD Site 16 history is similar to that of the FFTA. NASA conducted a soils removal action at WOD Site 16 in 1986 shortly after an area of petroleum impacted soils were noted during a Virginia site inspection. In 1988 a preliminary assessment of the area was conducted. As a follow-up to the preliminary assessment, a site inspection, including soil, groundwater and sediment sampling and a soil gas survey was conducted in 1989. Based on the results of the soil gas study additional surveys and sampling were conducted in 1990. Based on these investigations it was concluded that no further action was necessary at Site 16. During the performance of a RI at an adjacent Former Used Defense Site (FUD) (Site 15) groundwater contamination was discovered and thought to be originating from the Site 16 area. Upon further investigation a previously unknown area of surface disposal was discovered at Site 16. In response to this finding a full RI was initiated at WOD Site 16 in 1998 and completed in 2000.

WOD Site 16 is located at the end of an active runway and is an unimproved open plot of land that extends out in a peninsula-like manner into marshland adjacent to Little Mosquito Creek. WOD Site 16 was the site of waste oil and solvent disposal for an unknown period of time from the mid-1940’s to the mid-1950’s. The exact quantity and nature of material disposed at WOD Site 16 is not documented. In 1986 an inspection of the area identified what appeared to be waste petroleum residues in the area. At that time NASA conducted an extensive excavation and off-site disposal operation that removed 180 cubic yards of petroleum impacted soils. No sampling was conducted at that time. Subsequent investigations in the area conducted from 1988 through 2000 have included the performance of soil gas surveys, magnetometer surveys, surface and subsurface soil sampling, soil boring, monitoring well installation, and groundwater sampling. The analytical data from these investigations has been evaluated and presented in a series of reports including preliminary assessments, site investigations, remedial investigations, human and ecological risk assessments, and feasibility studies.

4.0 SCOPE OF WORK

This section of the HASP addresses proposed site activities for the Pilot Study:

- Mobilization and Demobilization

- Installation of DPT soil borings in the area up gradient of monitoring wells MW-61I and 15GW-7. Three DPT locations will be used to inject ORC® and the six remaining locations will be installed between the injection points and completed as temporary 1.5-inch diameter monitoring wells to monitor the radius of influence of the injections. Influence will be determined though geochemical parameter measurements in MW-61I and 15GW-7 and the DPT monitoring locations.

- The injection and monitoring points will be surveyed by a surveyor licensed in the Commonwealth of Virginia.

- Sampling and analysis of groundwater at MW-61I and 15GW-7, the temporary monitoring points and a background monitoring wells to evaluate water quality parameters and contaminant concentrations, including one baseline sampling event prior to injection activities and three post-injection sampling events (one day, one week and one month following the injection event).

- Decontamination of DPT, ORC and sampling equipment.

- IDW Waste Management

No other activities are anticipated to be necessary. If it becomes apparent that additional or modified tasks must be performed beyond those listed above, the work is not to proceed until the FOL or SSO notifies the Project Manager and the HSM, so that any appropriate modifications to this HASP can first be developed and communicated to the intended task participants.

5.0 IDENTIFYING AND COMMUNICATING TASK-SPECIFIC HAZARDS AND GENERAL SAFE WORK PRACTICES

The purpose of this section is to identify the anticipated hazards and appropriate hazard prevention/hazard control measures that are to be observed for each planned task or operation. These topics have been summarized for each planned task through the use of task-specific Safe Work Permits (SWPs), which are to be reviewed in the field by the SSO with all task participants prior to initiating any task. Additionally, potential hazard and hazard control matters that are relevant but are not necessarily task-specific are addressed it the following portions of this section.

Section 6.0 presents additional information on hazard anticipation, recognition, and control relevant to the planned field activities.

5.1 GENERAL SAFE WORK PRACTICES

In addition to the task-specific work practices and restrictions identified in the SWPs attached to this HASP, the following general safe work practices are to be followed when conducting work on-site.

- Eating, drinking, chewing gum or tobacco, taking medication, or smoking in contaminated or potentially contaminated areas or where the possibility for the transfer of contamination exists is prohibited.

- Wash hands and face thoroughly upon leaving a contaminated or suspected contaminated area. If a source of potable water is not available at the work site that can be used for hands-washing, the use of waterless hands cleaning products will be used, followed by actual hands-washing as soon as practicable upon exiting the site.

- Avoid contact with potentially contaminated substances including puddles, pools, mud, or other such areas. Avoid, kneeling on the ground or leaning or sitting on equipment. Keep monitoring equipment away from potentially contaminated surfaces.

- Plan and mark entrance, exit, and emergency evacuation routes.

- Rehearse unfamiliar operations prior to implementation.

- Buddies should maintain visual contact with each other and with other on-site team members by remaining in close proximity to assist each other in case of emergency.

- Establish appropriate safety zones including support, contamination reduction, and exclusion zones.

- Minimize the number of personnel and equipment in contaminated areas (such as the exclusion zone). Non-essential vehicles and equipment should remain within the support zone.

- Establish appropriate decontamination procedures for leaving the site.

- Immediately report all injuries, illnesses, and unsafe conditions, practices, and equipment to the SSO.

- Observe co-workers for signs of toxic exposure and heat or cold stress.

- Inform co-workers of potential symptoms of illness, such as headaches, dizziness, nausea, or blurred vision.

5.2 DPT/DRILLING SAFE WORK PRACTICES

The following safe work practices are to be followed when working in or around drill rig/DPT operations.

- Identify underground utilities and buried structures before drilling. Use the Utility Locating and Excavation Clearance SOP provided in Section 7 of the Health and Safety Guidance Manual.

- Drill/DPT rigs will be inspected by the SSO or designee, prior to the acceptance of the equipment at the site and prior to the use of the equipment.

- Any repairs or deficiencies identified during the inspection will be corrected prior to use.

- The inspection will be documented using the Equipment Inspection Checklist provided in Attachment III.

- Equipment Inspections will be conducted once each shift (either 5 or 10 day) or following repairs.

- Equipment and staging lay down areas will be established keep the work area clear of clutter and slips, trips, and fall hazards.

- The drill operator shall verbally alert employees and visually ensure employees are clear from dangerous parts of equipment before starting or engaging equipment.

- One person shall be responsible for emergency shut-off switch operation during drilling operation, such that the machinery can be shutdown quickly if another person is in danger. The identity of this person will be made known to personnel in the drilling area.
- Secure frayed or loose clothing, hair, and jewelry when working with operating equipment.
- Minimize contact to the extent possible with contaminated tooling and environmental media.
- Support functions (sampling and screening stations) will be maintained a minimum distance from the drill/DPT rig of the height of the mast plus five feet to remove these activities from within physical hazard boundaries.
- Only qualified operators and knowledgeable ground crew personnel will participate in the operation of the drill/DPT rig.
- Only personnel absolutely essential to the work activity will be allowed in the exclusion zone. Site visitors will be escorted.
- Equipment that comes into direct contact with potentially contaminated media will undergo a complete decontamination prior to moving to the next location, exiting the site, or prior to down time for maintenance.
- Whenever possible, motorized equipment will be fueled prior to the commencement of the day's activities.
- During fueling operations on site, equipment will be shutdown and bonded to the fuel provider to prevent the potential accumulation of static charges.
- When not in use drill/DPT rigs will be shutdown, emergency brakes set, and wheels chocked where hilly terrain is present.

Areas subjected to subsurface investigative methods will be restored to equal or better condition than original to the extent practical to remove contamination brought to the surface and to remove physical hazards. In situations where these hazards cannot be removed these areas will be barricaded to minimize the impact on field crews working in the area.

6.0 HAZARD ASSESSMENT AND CONTROLS

This section provides reference information regarding the chemical and physical hazards which may be associated with activities that are to be conducted as part of the scope of work.

6.1 CHEMICAL HAZARDS

Previous analytical data determined the presence of various volatile organic compounds (VOCs). Based on an evaluation of these data, and historical information about the site, the primary contaminants of concern (COC) at this site are Benzene and Vinyl Chloride. Other VOCs have been detected, but an evaluation of the data indicate that will not likely be encountered at concentrations that would represent a reasonable exposure concern.

Properties and Exposure Signs/Symptoms

TABLE 6-1

COMPARISON OF WORST-CASE PCE AIR CONCENTRATIONS WITH CURRENT OCCUPATIONAL EXPOSURE LIMITS

Contaminant of Concern	Highest Concentration Previously Detected in Water	Worst-Case Air Concentration That Could Be Encountered	Current OSHA PEL And ACGIH TLV
Benzene	28 ug/l	1.94	OSHA: 1 PPM TWA 1 PPM STEL ACGIH: 0.5 PPM TWA_8 2.5 PPM STEL
Vinyl Chloride	6 ug/l	2.67	OSHA: 1 PPM TWA_8 5 PPM STEL ACGIH: 1 PPM TWA_8 NA STEL

Table Notes:

TWA_8: Average air concentration over an 8-hour work period that is not to be exceeded

OSHA STEL: Concentration in air that is not to be exceed for more than 5 minutes in any 3 hour period

ACGIH STEL: Concentration in air that is not be exceeded for more than 15 minutes more than 4 times per day

Benzene

Benzene is a highly flammable liquid the odor of benzene can be detected in water at 2 ppm. Brief exposure (5 to 10 minutes) to very high benzene air concentrations (10,000 to 20,000 ppm) can result in death. Lower levels (700 to 3,000 ppm) can cause drowsiness, dizziness, tachycardia, headaches, tremors, confusion and unconsciousness. Exposure to high air concentrations (3,000 ppm or higher) may cause acute poisoning, characterized by the narcotic action of benzene on the CNS. The planned work area is outdoors, with ample natural ventilation that will reduce any airborne through dilution and dispersion,

Vinyl Chloride

Vinyl chloride is a flammable gas that depresses the central nervous system, and inhaling its vapors produces symptoms similar to alcohol intoxication. The nervous system is the primary target of vinyl chloride exposure. Signs and symptoms following ingestion include weakness; ataxia; inebriation; headache; fatigue; numbness; tingling and pallor or cyanosis of the extremities; nausea; abdominal pain; GI bleeding; visual disturbances; cardiac dysrhythmias; narcosis and death. Vinyl chloride is a severe irritant of the eyes, skin, and mucous membranes.

As a result of the data previously identified at this site, it is very unlikely that workers participating in this activity will encounter any airborne concentrations of benzene or vinyl chloride that would represent an occupational exposure concern. To monitor this route, real-time direct reading monitoring instruments will be used (as described in section 7.0).

Ingestion and Skin Contact: Potential exposure concerns to benzene and Vinyl chloride may also occur through ingesting or coming into direct skin contact with contaminated soils. The likelihood of worker exposure concerns through these two routes are also considered very unlikely, provided that workers follow good personal hygiene and standard good sample collection/sample handling practices, and wear appropriate PPE as specified in this HASP. Examples onsite practices that are to be observed that will protect workers from exposure via ingestion or skin contact include the following:

- No hand-to-mouth activities on site (eating, drinking, smoking, etc.)
- Washing hands upon leaving the work area and prior to performing any hand to mouth activities
- Wearing surgeon's-style gloves whenever handling potentially-contaminated media, including soils, hand tools, and sample containers.

ORC®

ORC® will be injected into specified soil borings using a pump and tremie method. This method introduces the ORC® from the bottom of the boring in a retracting up-ward fashion. The material to be injected is a registered material and the MSDS is provided in Appendix VII.

Health effects associated with overexposure to magnesium products are as indicated below.

6.1.1.1 Chemical Hazards of ORC® include:

- Magnesium oxide fume – Metal fume fever –Flu-like symptoms

- Magnesium particles or alloys which enter through perforations in the skin have been recorded to produce a severe local reaction (evolution of gas and severe irritation locally) resulting in necrosis or killing of the cells within the impacted area (See chemical gas gangrene for more information). These injuries are very slow to heal.

- It is estimated based on the physical properties and ingredients (magnesium oxide, magnesium peroxide, and magnesium hydroxide) evaluated that this material will be irritating to the eyes and skin and upper respiratory tract as well as other exposed mucous membranes.

- The material as indicated in the MSDS has a pH of 10 in solution. If swallowed, this material is slow to be absorbed, however, will result in vomiting and diarrhea.

The health effects reported above are considered acute responses to overexposure. Based on limited use and application chronic responses are not addressed. It is imperative to control the dust when dispensing this product.

6.1.1.2 Physical Hazards of ORC® include:

- Incompatibilities with acids, certain bases and interhalogen compounds(i.e., maleic anhydride, sodium hydroxide, bromine pentafluoride, chlorine trifluoride). The result will be violent reaction and potentially ignition. This material should be maintained and used away from potential ignition sources because of the potential violent reaction (i.e., oxidizer + any fuel source/combustible material = fire and/or explosion) given suitable conditions (i.e., closed container; insufficient media to absorb the heat of reaction). This material will intensify a fire.

- This material (25-35% Magnesium peroxide) will react with water to release oxygen. The magnesium oxide component will react with water to create magnesium hydroxide, both of which will slowly release oxygen to the water. To control the release of oxygen and the reaction, it is recommended that this material, when mixing, is added slowly to the prescribed amount of water. Upon completing the mixture and the injection, flush the container and pump with copious amounts of water.

Specified control measures have been provided in the Safe Work Permit for this task (See Attachment IV).

Table 6-1 provides information on the most common and significant site contaminants that may be present at Wallops Island. Included is information on the toxicological, chemical, and physical properties of these substances.

6.2 PHYSICAL HAZARDS

The following is a list of physical hazards that may be encountered at the site or may be present during the performance of site activities.

- Injury due to overexertion from operating the hand auger
- Slip, trips, and falls
- Contact with underground (electric lines, gas lines, water lines, etc.)
- Strain/muscle pulls from heavy lifting
- Heat Stress
- Pinch/compression points
- Natural hazards (snakes, ticks, poisonous plants, etc.)
- Vehicular and equipment traffic
- Inclement weather
- Noise

These hazards are discussed further below, and are presented relative to each task in the task-specific Safe Work Permits.

6.2.1 Slips, Trips, and Falls

During various site activities there is a potential for slip, trip, and fall hazards associated with wet, steep, or unstable work surfaces. To minimize hazards of this nature, personnel required to work in and along areas prone to these types of hazards will be required to exercise caution, and use appropriate precautions (restrict access, guardrails, life lines and/or safety harnesses) and other means suitable for the task at hand. Site activities will be performed using the buddy system.

6.2.2 Contact with Underground Utilities

Underground utilities such as pressurized lines, water lines, telephone lines, buried utility lines, and high voltage power lines are known to be present throughout the facility. Clearance of underground utilities for each boring injection location will be coordinated with the NASA WFF Facility Management Branch and a dig permit will be issued by the facility before any intrusive activities. The dig permit request will be completed by the PM or FOL a copy of the dig permit must be present at the site before any intrusive activities begin. The TtNUS Utility Locating and Excavation Clearance SOP found in Section 7.0 of the Health and Safety Guidance Manual and must also be completed to verify site clearance.

6.2.3 Strain/Muscle Pulls from Heavy Lifting

During execution of planned activities there is some potential for strains, sprains, and/or muscle pulls due to the physical demands and nature of this site work. To avoid injury during lifting tasks personnel are to lift with the force of the load carried by their legs and not their backs. When lifting or handling heavy material or equipment use an appropriate number of personnel. Keep the work area free from ground clutter to avoid unnecessary twisting or sudden movements while handling loads.

6.2.4 Heat Stress

Because of the geographical location of the planned work, the likely seasonal weather conditions that will exist during the planned schedule, and the physical exertion that can be anticipated with some of the planned tasks, it will be necessary for the field team to be aware of the signs and symptoms and the measures appropriate to prevent heat stress. This is addressed in detail in section 4.0 of the TtNUS Health and Safety Guidance Manual, which the SSO is responsible for reviewing and implementing as appropriate on this project.

In general, early signs of heat-related disorders include heat rash, cramps, heavy sweating which may be followed by the complete shutdown of a person's ability to sweat, pale/clammy skin, headaches, dizziness, incoordination, and other maladies. To prevent heat stress disorders, the following preventive measures are to be implemented by the SSO:

- When possible, schedule the most physically-demanding tasks so that they are performed during cooler periods of the day such as early morning or late afternoon

- Educate the field staff in heat stress signs and symptoms so that they can monitor themselves and their co-workers

- Schedule frequent breaks during the hottest parts of the day (such as a few minutes each hour). Breaks should be in shaded areas, and in a location where workers can remove PPE, wash their hands, and drink fluids

- Drinking fluids should be cool and non-caffeinated. Sports-drinks with electrolytes are acceptable provided that they do not contain alcohol. Water is also acceptable.

For more information on heat stress recognition and prevention, consult section 4.0 of the TtNUS Health and Safety Guidance Manual.

6.2.5 Pinch/Compression Points

Handling of tools, machinery, and other equipment on site may expose personnel to pinch/compression point hazards during normal work activities. Where applicable, equipment will have intact and functional guarding to prevent personnel contact with hazards. Personnel will exercise caution when working around pinch/compression points, using additional tools or devices (e.g., pinch bars) to assist in completing activities.

6.2.6 Natural Hazards

Natural hazards such as poisonous plants, bites from poisonous or disease carrying animals or insects (e.g., snakes, ticks, mosquitoes) are often prevalent at sites that are being investigated as part of hazardous waste site operations. Given the geographic location and the environment (marshes and lakes), alligators are also assumed to be potentially present at the NASA Wallops Island facility. To minimize the potential for site personnel to encounter these hazards, nesting areas in and about work areas will be avoided to the greatest extent possible. Work areas will be inspected to look for any evidence that dangerous animals may be present. Based on the planned location for the work covered by this HASP, encountering alligators is not a likely probability.

During warm months (spring through early fall), tick-borne Lyme Disease may pose a potential health hazard. The longer a disease carrying tick remains attached to the body, the greater the potential for contracting the disease. Wearing long sleeved shirts and long pants (tucked into boots and taped) will prevent initial tick attachment, while performing frequent body checks will help prevent long term attachment. Site first aid kits should be equipped with medical forceps and rubbing alcohol to assist in tick removal. For information regarding tick removal procedures and symptoms of exposure, consult Section 4.0 of the Health and Safety Guidance Manual.

Contact with poisonous plants and bites or stings from poisonous insects are other potential natural hazards. Long sleeved shirts and long pants (tucked into boots), and avoiding potential nesting areas, will minimize the potential for exposure. Additionally, insect repellents may be used by site personnel. Personnel who are allergic to stinging insects (such as bees, wasps and hornets) must be particularly careful since severe illness and death may result from allergic reactions. As with any medical condition or allergy, information regarding the condition must be listed on the Medical Data Sheet (see Attachment I of this HASP), and the FOL or SSO notified.

6.2.7 Inclement Weather

Project tasks under this Scope of Work will be performed outdoors. As a result, inclement weather may be encountered. In the event that adverse weather (electrical storms, tornadoes, etc.) conditions arise, the FOL and/or the SSO will be responsible for temporarily suspending or terminating activities until hazardous conditions no longer exist.

7.0 AIR MONITORING

None of the contaminants are expected to be present in significant concentrations to present an inhalation hazard during planned site activities. As a precautionary measure to assure that such exposures are avoided and documented, a direct reading instrument will be used to monitor worker exposures to chemical hazards present at the site. For this project, based on the properties of the primary contaminants of concern (i.e., Benzene and vinyl chloride), a Photoionization Detector (PID) may be used to monitor the air.

7.1 INSTRUMENTS AND USE

Instruments will be used primarily to monitor source points and worker breathing zone areas, while observing instrument action levels. The SSO shall obtain and document the daily background (BG) reading at an upwind, unaffected area and observe for readings above that BG level. The SSO shall monitor source areas (e.g., auger bore hole locations and above collected soil samples) for the presence of any reading above the daily-established BG level. If elevated readings are observed, the SSO shall monitor the workers breathing zone (BZ) areas with the PID

7.1.1 Action Level

Based on the contaminant of concern, Benzene and vinyl chloride, workers must limit exposure to a maximum of 10 ppm in the BZ for no more than 15 minutes total in an 8 hour work day (e.g., 1 exposure for 15 minutes, 2 exposures for 7.5 minutes or 3 exposures for 5 minutes). If sustained readings above 10 ppm are measured, the following process will be followed:

- The SSO shall stop work and retreat upwind to a safe, unaffected area, where they will remain until further directed by the SSO.

- The SSO shall allow at least 5 minutes to pass so that the work area can ventilate, and will then re-approach the work area while continuously monitoring the BZ areas.

- Only when BG levels are regained in BZ areas will work be permitted to resume.

- If BG levels are not regained, the SSO will contact the HSM for additional direction.

<u>Instrument Action Levels</u>: The use of a PID will be acceptable, provided that the following action levels are observed:

- PID Action Level: 10 ppm above BG in BZ areas.

7.2 INSTRUMENT MAINTENANCE AND CALIBRATION

Hazard monitoring instruments will be maintained and pre-field calibrated by the equipment provider (i.e., rental agency used). Operational checks and field calibration will be performed on site instruments each day prior to their use. Field calibration will be performed on instruments according to manufacturer's recommendations. These operational checks and calibration efforts will be performed in a manner that complies with the employees health and safety training, the manufacturer's recommendations, and with the applicable manufacturer standard operating procedure (which the SSO must assure are included with the instrument upon its receipt onsite). Field calibration efforts must be documented. Figure 7-1 is provided for documenting these calibration efforts. This information may instead be recorded in a field operations logbook, provided that the information specified in Figure 7-1 is recorded. This required information includes the following:

- Date calibration was performed
- Individual calibrating the instrument
- Instrument name, model, and serial number
- Any relevant instrument settings and resultant readings (before and after) calibration
- Identification of the calibration standard (lot no., source concentration, supplier)
- Any relevant comments or remarks

7.3 DOCUMENTING INSTRUMENT READINGS

The SSO is responsible for ensuring that air monitoring instruments are used in accordance with the specifications of this HASP and with manufacturer's specifications/recommendations. In addition, the SSO is also responsible for ensuring that all instrument use is documented. This requirement can be satisfied either by recording instrument readings on pre-printed sampling log sheets or in a field log book. **This includes the requirement for documenting instrument readings that indicate no elevated readings above noted daily background levels (i.e., no-exposure readings)**. At a minimum, the SSO must document the following information for each use of an air monitoring device:

- Date, time, and duration of the reading
- Site location where the reading was obtained

- Instrument used (e.g., PID, etc.)
- Personnel present at the area where the reading was noted
- Other conditions that are considered relevant to the SSO (such as weather conditions, possible instrument interferences, etc.)

FIGURE 7-1

DOCUMENTATION OF FIELD CALIBRATION

SITE NAME: ____ **PROJECT NO.:**______________

Date of Calibration	Instrument Name and Model	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot Number)	Remarks/ Comments
				Pre-Calibration	Post-Calibration	Pre-Calibration	Post-Calibration		

8.0 TRAINING/MEDICAL SURVEILLANCE REQUIREMENTS

8.1 INTRODUCTORY/REFRESHER/SUPERVISORY TRAINING

This section is included to specify health and safety training and medical surveillance requirements for TtNUS personnel participating in on site activities. TtNUS personnel must complete 40 hours of introductory hazardous waste site training prior to performing work at the NASA Wallops Island. TtNUS personnel who have had introductory training more than 12 months prior to site work must have completed 8 hours of refresher training within the past 12 months before being cleared for site work. In addition, 8-hour supervisory training in accordance with 29 CFR 1910.120(e)(4) will be required for site supervisory personnel.

Documentation of TtNUS introductory, supervisory, and refresher training as well as site-specific training will be maintained at the site. Copies of certificates or other official documentation will be used to fulfill this requirement.

8.2 SITE-SPECIFIC TRAINING

TtNUS SSO will provide site-specific training to TtNUS employees who will perform work on this project. Figure 8-1 will be used to document the provision and content of the project-specific and associated training. Site personnel will be required to sign this form prior to commencement of site activities. This training documentation will be employed to identify personnel who through record review and attendance of the site-specific training are cleared for participation in site activities. This document shall be maintained at the site to identify and maintain an active list of trained and cleared site personnel.

The TtNUS SSO will also conduct a pre-activities training session prior to initiating site work. This will consist of a brief meeting at the beginning of each day to discuss operations planned for that day, and a review of the appropriate Safe Work Permits with the planned task participants. A short meeting may also be held at the end of the day to discuss the operations completed and any problems encountered.

8.3 MEDICAL SURVEILLANCE

TtNUS personnel participating in project field activities will have had a physical examination meeting the requirements of TtNUS's medical surveillance program. Documentation for medical clearances will be maintained in the TtNUS Pittsburgh office and made available, as necessary, and will be documented using Figure 8-1 for every employee participating in onsite work activities at this site.

Each field team member, including visitors, entering the exclusion zone(s) shall be required to complete and submit a copy of the Medical Data Sheet (see Attachment I of this HASP). This shall be provided to the SSO, prior to participating in site activities. The purpose of this document is to provide site personnel and emergency responders with additional information that may be necessary in order to administer medical attention.

8.4 SITE VISITORS

All site visitors to the site must be 100% escorted at all times and restricted from approaching any work areas where they could be exposed to hazards from TtNUS operations. If a visitor has authorization from the client and from the TtNUS Project Manager to approach our work areas, the FOL must assure that the visitor first provides documentation indicating that he/she/they have successfully completed the necessary OSHA introductory training, receive site-specific training from the SSO, and that they have been physically cleared to work on hazardous waste sites.

FIGURE 8-1

SITE-SPECIFIC TRAINING DOCUMENTATION

My signature below indicates that I am aware of the potential hazardous nature of performing field investigation activities at NASA Wallops Island, Virginia and that I have received site-specific training which included the elements presented below:

- Names of designated personnel and alternates responsible for site safety and health
- Safety, health, and other hazards present on site
- Use of personal protective equipment
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- Contents of the Health and Safety Plan
- Emergency response procedures (evacuation and assembly points)
- Incipient response procedures
- Review of the contents of relevant Material Safety Data Sheets
- Review of the use of Safe Work Permits

I have been given the opportunity to ask questions and all of my questions have been answered to my satisfaction. The dates of my training and my medical surveillance requirements indicated below are accurate to the best of my knowledge.

Name (Printed and Signature)	Site-Specific Training Date	40-Hour Training (Date)	8-Hour Refresher Training (Date)	8-Hour Supervisory Training (Date)	Medical Exam

9.0 SITE CONTROL

This section outlines the means by which TtNUS will delineate work zones and use these work zones in conjunction with decontamination procedures to prevent the spread of contaminants into previously unaffected areas of the site. It is anticipated that a three-zone approach will be used during work at this site. This approach will be comprised of an exclusion zone, a contamination reduction zone, and a support zone. It is also anticipated that this approach will control access to site work areas, restricting access by the general public, minimizing the potential for the spread of contaminants, and protecting individuals who are not cleared to enter work areas.

9.1 EXCLUSION ZONE

The exclusion zone will be considered the areas of the site of known or suspected contamination. It is anticipated that the areas around the exhaust vents will have the potential for contaminants brought to the surface. These areas will be marked and personnel will maintain safe distances. Once intrusive activities have been completed and surface contamination has been removed, the potential for exposure is again diminished and the area can then be reclassified as part of the contamination reduction zone. Therefore, the exclusion zones for this project will be limited to those areas of the site where active work (hand augering and sample collection) is being performed plus a designated area of at least 15 feet surrounding the work area. Exclusion zones will be delineated as deemed appropriate by the FOL, through means such as erecting visibility fencing, barrier tape, cones, and/or postings to inform and direct personnel.

9.1.1 Exclusion Zone Clearance

A pre-startup site visit will be conducted by members of the identified field team in an effort to identify proposed subsurface investigation locations, conduct utility clearances, and provide upfront notices concerning scheduled activities within the facility.

Subsurface activities will proceed only when utility clearance has been obtained. In the event that a utility is struck during a subsurface investigative activity, the emergency numbers provided in Section 2.0, Table 2-1, will be notified.

9.2 CONTAMINATION REDUCTION ZONE

The contamination reduction zone (CRZ) will be a buffer area between the exclusion zone and any area of the site where contamination is not suspected. This area may also serve as a focal point in supporting exclusion zone activities. This area will be delineated using barrier tape, cones, and postings to inform and direct facility personnel. Decontamination will be conducted at a central location. Equipment potentially contaminated will be bagged and taken to that location for decontamination.

9.3 SUPPORT ZONE

The support zone for this project will include a staging area where site vehicles will be parked, equipment will be unloaded, and where food and drink containers will be maintained. The support zones will be established at areas of the site where away from potential exposure to site contaminants during normal working conditions or foreseeable emergencies.

9.4 SAFE WORK PERMITS

Exclusion Zone work conducted in support of this project will be performed using Safe Work Permits (SWPs) to guide and direct field crews on a task by task basis. An example of the SWP to be used is provided in Figure 9-1. Partially completed SWPs for the work to be performed are attached to this HASP. These permits were completed to the extent possible as part of the development of this HASP. It is the SSO's responsibility to finalize and complete all blank portions of the SWPs based on current, existing conditions the day the task is to be performed, and then review that completed permit with all task participants as part of a pre-task tail gate briefing session. This will ensure that site-specific considerations and changing conditions are appropriately incorporated into the SWP, provide the SSO with a structured format for conducting the tail gate sessions, as well will also give personnel an opportunity to ask questions and make suggestions. All SWPs require the signature of the FOL or SSO.

9.5 SITE VISITORS

Site visitors for the purpose of this document are identified as representing the following groups of individuals:

- Personnel invited to observe or participate in operations by TtNUS
- Regulatory personnel (i.e., NASA, EPA, VADEQ and OSHA)
- Authorized NASA Personnel
- Other authorized visitors

Non-NASA personnel working on this project are required to gain initial access to the base by coordinating with the TtNUS FOL or designee and following established base access procedures.

Once access to the base is obtained, personnel who require site access into areas of ongoing operations will be required to obtain permission from the PM. Upon gaining access to the site, site visitors wishing to observe operations in progress will be escorted by a TtNUS representative and shall be required to meet the minimum requirements discussed below:

- Site visitors will be directed to the FOL/SSO, who will sign them into the field logbook. Information to be recorded in the logbook will include the individual's name (proper identification required), the entity which they represent, and the purpose of the visit.

- Site visitors wishing to enter the exclusion zone will be required to produce the necessary information supporting clearance to the site. This shall include information attesting to applicable training and medical surveillance as stipulated in Section 8.0 of this document. In addition, to enter the site operational zones during planned activities, visitors will be required to first go through site-specific training covering the topics stipulated in Section 8.2 of this HASP.

Once the site visitors have completed the above items, they will be permitted to enter the operational zone. Visitors are required to observe the protective equipment and site restrictions in effect at the site at the time of their visit. Visitors entering the exclusion zones during ongoing operations will be accompanied by a TtNUS representative. Visitors not meeting the requirements, as stipulated in this plan, for site clearance will not be permitted to enter the site operational zones during planned activities. Any incidence of unauthorized site visitation will cause the termination of on site activities until the unauthorized visitor is removed from the premises. Removal of unauthorized visitors will be accomplished with support from local law enforcement personnel.

9.6 SITE SECURITY

Site security will be accomplished using TtNUS field personnel. TtNUS will retain complete control over active operational areas. As this activity takes place at a Navy facility open to public access, the first line of security will take place using exclusive zone barriers, site work permits, and any existing barriers at the sites to restrict the general public. The second line of security will take place at the work site referring interested parties to the Base Contact. The Base Contact will serve as a focal point for base personnel, interested parties, and serve as the final line of security and the primary enforcement contact.

9.7 BUDDY SYSTEM

Personnel engaged in on site activities will practice the "buddy system" to ensure the safety of personnel involved in this operation.

9.8 MATERIAL SAFETY DATA SHEET (MSDS) REQUIREMENTS

TtNUS and subcontractor personnel will provide MSDSs for chemicals brought on site. The contents of these documents will be reviewed by the SSO with the user(s) of the chemical substances prior to any actual use or application of the substances on site. A chemical inventory of the chemicals used on site will be developed using the Health and Safety Guidance Manual. The MSDSs will then be maintained in a central location (i.e., temporary office) and will be available for anyone to review upon request.

9.9 COMMUNICATION

As personnel will be working in proximity to one another during field activities, a supported means of communication between field crew members will not be necessary.

External communication will be accomplished by using the telephones at predetermined and approved locations. External communication will primarily be used for the purpose of resource and emergency resource communications. Prior to the commencement of activities at the NASA Wallops Island, the FOL will determine and arrange for telephone communications.

FIGURE 9-1
SAFE WORK PERMIT

Permit No. _______________ Date: ___________________ Time: From ____________ to _____________

I. Work limited to the following (description, area, equipment used): ______________________________

II. Primary Hazards: Potential hazards associated with this task: ______________________________

III. Field Crew: ______________________________

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector ____________TtNUS

Equipment Inspection required ☐ Yes ☐ No Initials of Inspector ____________TtNUS

V. Protective equipment required

Level D ☐ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required

Yes ☐ Specify on the reverse
No ☐

Modifications/Exceptions: ______________________________

VI.

Chemicals of Concern	Hazard Monitoring	Action Level(s)	Response Measures

Primary Route(s) of Exposure/Hazard: ______________________________

(Note to FOL and/or SSO: Each item in Sections VII, VIII, and IX must be checked Yes, No, or NA)

VII. Additional Safety Equipment/Procedures

Hard-hat	☐ Yes	☐ No
Safety Glasses	☐ Yes	☐ No
Chemical/splash goggles	☐ Yes	☐ No
Splash Shield	☐ Yes	☐ No
Splash suits/coveralls	☐ Yes	☐ No
Impermeable apron	☐ Yes	☐ No
Steel toe Work shoes or boots	☐ Yes	☐ No
High Visibility vest	☐ Yes	☐ No
First Aid Kit	☐ Yes	☐ No
Safety Shower/Eyewash	☐ Yes	☐ No
Hearing Protection (Plugs/Muffs)	☐ Yes	☐ No
Safety belt/harness	☐ Yes	☐ No
Radio/Cellular Phone	☐ Yes	☐ No
Barricades	☐ Yes	☐ No
Gloves (Type –)	☐ Yes	☐ No
Work/rest regimen	☐ Yes	☐ No
Chemical Resistant Boot Covers	☐ Yes	☐ No
Tape up/use insect repellent	☐ Yes	☐ No
Fire Extinguisher	☐ Yes	☐ No
Other	☐ Yes	☐ No

Modifications/Exceptions: ______________________________

VIII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☐
Vehicle and Foot Traffic Routes Established/Traffic Control Barricades/Signs in Place	☐	☐	☐
Physical Hazards Identified and Isolated (Splash and containment barriers)	☐	☐	☐
Emergency Equipment Staged (Spill control, fire extinguishers, first aid kits, etc).	☐	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.). ☐ Yes ☐ No

If yes, SSO to complete or contact Health Sciences, Pittsburgh Office (412)921-7090

X. Special instructions, precautions: ______________________________

Permit Issued by: ______________________________ Permit Accepted by: ______________________

10.0 SPILL CONTAINMENT PROGRAM

10.1 SCOPE AND APPLICATION

It is not anticipated that bulk hazardous materials (over 55-gallons) will be generated or handled at any given time as part of this scope of work. It is also not anticipated that such spillage would constitute a danger to human health or the environment. However, as the job progresses, some potential may exist for accumulating Investigative Derived Wastes (IDW) such as decontamination fluids, soil cuttings, disposable sampling equipment and PPE.

10.2 POTENTIAL SPILL AREAS

Potential spill areas will be periodically monitored in an ongoing attempt to prevent and control further potential contamination of the environment. Currently, limited areas are vulnerable to this hazard including:

- Resource deployment
- Waste transfer
- Central staging

It is anticipated that the IDW generated as a result of this scope of work will be containerized, labeled, and staged to await further analyses. The results of these analyses will determine the method of disposal.

10.3 LEAK AND SPILL DETECTION

To establish an early detection of potential spills or leaks, a periodic walk-around by the personnel staging or disposing of drums area will be conducted during working hours to visually determine that storage vessels are not leaking. If a leak is detected, the contents will be transferred, using a hand pump, into a new vessel. The leak will be collected and contained using absorbents such as Oil-Dry, vermiculite, or sand, which are stored at the vulnerable areas in a conspicuously marked drum. This used material, too, will be containerized for disposal pending analysis. Inspections will be documented in the project logbook.

10.4 PERSONNEL TRAINING AND SPILL PREVENTION

Personnel will be instructed in the procedures for incipient spill prevention, containment, and collection of hazardous materials in the site-specific training. The FOL and the SSO will serve as the Spill Response Coordinators for this operation, should the need arise.

10.5 SPILL PREVENTION AND CONTAINMENT EQUIPMENT

The following represents the types of equipment that should be maintained at the staging areas for the purpose of supporting this Spill Prevention/Containment Program.

- Sand, clean fill, vermiculite, or other non combustible absorbent (Oil-dry)
- Drums (55-gallon U.S. DOT 1A 1 or 1 A 2)
- Shovels, rakes, and brooms
- Container labels

10.6 SPILL CONTROL PLAN

This section describes the procedures the TtNUS field crew members will employ upon the detection of a spill or leak.

1. Notify the SSO or FOL immediately upon detection of a leak or spill. Activate emergency alerting procedures for that area to remove non-essential personnel.

2. Employ the personal protective equipment stored at the staging area. Take immediate actions to stop the leak or spill by plugging or patching the container or raising the leak to the highest point in the vessel. Spread the absorbent material in the area of the spill, covering it completely.

3. Transfer the material to a new vessel; collect and containerize the absorbent material. Label the new container appropriately. Await analyses for treatment and disposal options.

4. Re-containerize spills, including 2-inch of top cover impacted by the spill. Await test results for treatment or disposal options.

It is not anticipated that a spill will occur that the field crew cannot handle. Should this occur, notification of the appropriate Emergency Response agencies will be carried out by the FOL or SSO in accordance with the procedures discussed in Section 2.0 of this HASP.

11.0 CONFINED-SPACE ENTRY

It is not anticipated, under the proposed scope of work, that confined space and permit-required confined space activities will be conducted. **Therefore, personnel under the provisions of this HASP are not allowed, under any circumstances, to enter confined spaces**. A confined space is defined as an area which has one or more of the following characteristics:

- Is large enough and so configured that an employee can bodily enter and perform assigned work.
- Has limited or restricted means for entry or exit (for example, tanks, manholes, sewers, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry).
- Is not designed for continuous employee occupancy.

Additionally, a Permit-Required Confined Space must also have one or more of the following characteristics:

- Contains or has a potential to contain a hazardous atmosphere.
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly caving walls or by a floor that slopes downward and tapers to a smaller cross-section.
- Contains any other recognized, serious, safety or health hazard.

For further information on confined space, consult the Health and Safety Guidance Manual or call the PHSO. If confined space operations are to be performed as part of the scope of work, detailed procedures and training requirements will have to be addressed.

12.0 MATERIALS AND DOCUMENTATION

The TtNUS Field Operations Leader (FOL) shall ensure the following materials/documents are taken to the project site and used when required.

- A complete copy of this HASP
- Health and Safety Guidance Manual
- Incident Reports
- Medical Data Sheets
- Material Safety Data Sheets for chemicals brought on site, including decontamination solutions, fuels, sample preservatives, calibration gases, etc.
- A full-size OSHA Job Safety and Health Poster (posted in the site trailer)
- Training/Medical Surveillance Documentation Form (Blank)
- First-Aid Supply Usage Form
- Emergency Reference Form (Section 2.0, extra copy for posting)
- Directions to the Hospital

12.1 MATERIALS TO BE POSTED AT THE SITE

The following documentation is to be posted or maintained at the site for quick reference purposes. In situations where posting these documents is not feasible (such as no office trailer), these documents should be separated and immediately accessible.

- **Chemical Inventory Listing (posted)** - This list represents all chemicals brought on-site, including decontamination solutions, sample preservations, fuel, etc. This list should be posted in a central area.

- **MSDSs (maintained)** - The MSDSs should also be in a central area accessible to all site personnel. These documents should match all the listings on the chemical inventory list for all substances employed on-site. It is acceptable to have these documents within a central folder and the chemical inventory as the table of contents.

- **The OSHA Job Safety & Health Protection Poster (posted)** - This poster should be conspicuously posted in places where notices to employees are normally posted, as directed by 29 CFR 1903.2 (a)(1). Each FOL shall ensure that this poster is not defaced, altered, or covered by other material. The law also states that reproductions or facsimiles of the poster shall be at least 8 1/2 by 14 inches with 10 point type.

- **Site Clearance (maintained)** - This list is found within the training section of the HASP (Figure 8-1). This list identifies all site personnel, dates of training (including site-specific training), and medical surveillance. The list indicates not only clearance, but also status. If personnel do not meet these requirements, they do not enter the site while site personnel are engaged in activities.

- **Emergency Phone Numbers and Directions to the Hospital(s) (posted)** - This list of numbers and directions will be maintained at all phone communications points and in each site vehicle.

- **Medical Data Sheets/Cards (maintained)** - Medical Data Sheets will be filled out by on-site personnel and filed in a central location. The Medical Data Sheet will accompany any injury or illness requiring medical attention to the medical facility. A copy of this sheet or a wallet card will be given to all personnel to be carried on their person.

- **Personnel Monitoring (maintained)** - All results generated through personnel sampling (levels of airborne toxins, noise levels, etc.) will be posted to inform individuals of the results of that effort.

- **Placards and Labels (maintained)** - Where chemical inventories have been separated because of quantities and incompatibilities, these areas will be conspicuously marked using DOT placards and acceptable [Hazard Communication 29 CFR 1910.1200(f)] labels.

The purpose of maintaining or posting this information, as stated above, is to allow site personnel quick access. Variations concerning location and methods of presentation are acceptable providing the objective is accomplished.

13.0 ACRONYMS / ABBREVIATIONS

BG	Background
BZ	Breathing Zone
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	Chain of Custody
CSP	Certified Safety Professional
CRZ	Contamination Reduction Zone
DPT	Direct Push Technology
FFTA	Former Fire Training Area
FOL	Field Operations Leader
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSM	Health and Safety Manager
IDW	Investigation Derived Waste
MB	Mainbase
ML	Mainland
MSDS	Material Safety Data Sheet
N/A	Not Available
ORC	Oxygen Releasing Compounds
OSHA	Occupational Safety and Health Administration (U.S. Department of Labor)
PID	Photoionization Detector
PPM	Parts Per Million
PHSO	Project Health and Safety Officer
PPE	Personal Protective Equipment
SSO	Site Safety Officer
SWP	Safe Work Permit
TBD	To be determined
PM	Project Manager
TtNUS	Tetra Tech NUS, Inc.
VOCs	Volatile Organic Compounds
WWF	Wallops Flight Facility
WI	Wallops Island
WOD	Waste Oil Dump

ATTACHMENT I

MEDICAL DATA SHEET

MEDICAL DATA SHEET

This Medical Data Sheet must be completed by on-site personnel and kept in the command post during the conduct of site operations. This data sheet will accompany any personnel when medical assistance is needed or if transport to hospital facilities is required.

Project ______________________________

Name ______________________ Home Telephone __________

Address ______________________________

Age __________ Height ______________ Weight ____________

Person to notify in the event of an emergency: Name: ______________________

Phone: ______________________

Drug or other Allergies: ______________________________

Particular Sensitivities : ______________________________

Do You Wear Contacts? ______________________________

What medications are you presently using? ______________________________

____

Name, Address, and Phone Number of personal physician: ______________________

____

____

Note: Health Insurance Portability and Accountability Act (HIPAA) Requirements

HIPAA took effect April 14, 2003. Loosely interpreted, HIPAA regulates the disclosure of Protected Health Information (PHI) by the entity collecting that information. PHI is any information about health status (such as that you may report on this Medical Data Sheet), provision of health care, or other information. HIPAA also requires TtNUS to ensure the confidentiality of PHI. This Act can affect the ability of the Medical Data Sheet to contain and convey information you would want a Doctor to know if you were incapacitated. So before you complete the Medical Data Sheet understand that this form will not be maintained in a secure location. It will be maintained in a file box or binder accessible to other members of the field crew so that the can accompany an injured party to the hospital.

DO NOT include information that you do not wish others to know, only information that may be pertinent in an emergency situation or treatment.

______________________ ______________________ __________

Name (Print clearly) Signature Date

ATTACHMENT II

INCIDENT REPORT FORM

TETRA TECH, INC.
Safety Excellence

TETRA TECH, INC.
INCIDENT REPORT

Report Date	Report Prepared By	Incident Report Number

INSTRUCTIONS:

All incidents (including those involving subcontractors under direct supervision of Tetra Tech personnel) must be documented on the IR Form.

Complete any additional parts to this form as indicated below for the type of incident selected.

TYPE OF INCIDENT (Check all that apply)	Additional Form(s) Required for this type of incident	
Near Miss (No losses, but could have resulted in injury, illness, or damage)	☐	Complete IR Form Only
Injury or Illness	☐	Complete Form IR-A; Injury or Illness
Property or Equipment Damage, Fire, Spill or Release	☐	Complete Form IR-B; Damage, Fire, Spill or Release
Motor Vehicle	☐	Complete Form IR-C; Motor Vehicle

INFORMATION ABOUT THE INCIDENT

Description of Incident

____

____

____

Date of Incident	Time of Incident
	____________ AM ☐ PM ☐ *OR* Cannot be determined ☐
Weather conditions at the time of the incident	**Was there adequate lighting?**
	____________________ Yes ☐ No ☐

Location of Incident

______________________ Was location of incident within the employer's work environment? Yes ☐ No ☐

Street Address	City, State, Zip Code and Country
Project Name	**Client:**
Tt Supervisor or Project Manager	**Was supervisor on the scene?**
	Yes ☐ No ☐

WITNESS INFORMATION (attach additional sheets if necessary)

Name	Company
Street Address	**City, State and Zip Code**
Telephone Number(s)	

CORRECTIVE ACTIONS

Corrective action(s) immediately taken by unit reporting the incident:

____

____

____

Corrective action(s) still to be taken (by whom and when):

____

____

____

ROOT CAUSE ANALYSIS LEVEL REQUIRED

Root Cause Analysis Level Required: Level - 1 ☐ Level - 2 ☐ None ☐

Root Cause Analysis Level Definitions

Level - 1	**Definition:** A Level 1 RCA is conducted by an individual(s) with experience or training in root cause analysis techniques and will conduct or direct documentation reviews, site investigation, witness and affected employee interviews, and identify corrective actions. Activating a Level 1 RCA and identifying RCA team members will be at the discretion of the Corporate Administration office. The following events may trigger a Level 1 RCA: ▪ Work related fatality ▪ Hospitalization of one or more employee where injuries result in total or partial permanent disability ▪ Property damage in excess of $75,000 ▪ When requested by senior management
Level - 2	**Definition:** A Level 2 RCA is self performed within the operating unit by supervisory personnel with assistance of the operating unit HSR. Level 2 RCA will utilize the 5 Why RCA methodology and document the findings on the tools provided. The following events will require a Level 2 RCA: ▪ OSHA recordable lost time incident ▪ Near miss incident that could have triggered a Level 1 RCA ▪ When requested by senior management

Complete the Root Cause Analysis Worksheet and Corrective Action form. Identify a corrective action(s) for each root cause identified within each area of inquiry.

NOTIFICATIONS

Title	Printed Name	Signature	Telephone Number	Date
Project Manager or Supervisor				
Site Safety Coordinator or Office H&S Representative				
Operating Unit H&S Representative				
Other: ______________________				

The signatures provided above indicate that appropriate personnel have been notified of the incident.

INSTRUCTIONS:

Complete all sections below for incidents involving injury or illness.
Do NOT leave any blanks.
Attach this form to the IR FORM completed for this incident.

Incident Report Number: (From the IR Form)	

EMPLOYEE INFORMATION

Company Affiliation

Tetra Tech Employee? ☐ TetraTech subcontractor employee (directly supervised by Tt personnel)? ☐

Full Name	**Company (if not Tt employee)**
Street Address, City, State and Zip Code	**Address Type**
______________________________ ______________________________	Home address (for Tt employees) ☐ Business address (for subcontractors) ☐

Telephone Numbers

Work: ____________	Home: ____________	Cell: ____________

Occupation (regular job title)	**Department**
Was the individual performing regular job duties?	**Time individual began work**
Yes ☐ No ☐	______ AM ☐ PM ☐ *OR* Cannot be determined ☐

Safety equipment

Provided? Yes ☐ No ☐

Used? Yes ☐ No ☐ If no, explain why

____

____

____

Type(s) provided:

- ☐ Hard hat
- ☐ Gloves
- ☐ Eye protection
- ☐ Safety shoes
- ☐ Respirator
- ☐ Protective clothing
- ☐ High visibility vest
- ☐ Fall protection
- ☐ Machine guarding
- ☐ Other (list)

____

NOTIFICATIONS

Name of Tt employee to whom the injury or illness was first reported	**Was H&S notified within one hour of injury or illness?**
	Yes ☐ No ☐
Date of report	**H&S Personnel Notified**
Time of report	**Time of Report**

If subcontractor injury, did subcontractor's firm perform their own incident investigation?

Yes ☐ No ☐ If yes, request a copy of their completed investigation form/report and attach it to this report.

INJURY / ILLNESS DETAILS

What was the individual doing just before the incident occurred? Describe the activity as well as the tools, equipment, or material the individual was using. Be specific. Examples: "Climbing a ladder while carrying roofing materials"; "Spraying chlorine from a hand sprayer"; "Daily computer key-entry"

____

____

____

What Happened? Describe how the injury occurred. Examples: "When ladder slipped on wet floor and worker fell 20 feet"; "Worker was sprayed with chlorine when gasket broke during replacement"; Worker developed soreness in wrist over time"

____

____

____

____

Describe the object or substance that directly harmed the individual: Examples: "Concrete floor"; "Chlorine"; "Radial Arm Saw". If this question does not apply to the incident, write "Not Applicable".

____

____

MEDICAL CARE PROVIDED

Was first aid provided at the site: Yes ☐ No ☐ If yes, describe the type of first aid administered and by whom?

____

Was treatment provided away from the site: Yes ☐ No ☐ If yes, provide the information below.

Name of physician or health care professional	**Facility Name**
Street Address, City State and Zip Code	**Type of Care?**
______________________________ ______________________________	Was individual treated in emergency room? Yes ☐ No ☐ Was individual hospitalized overnight as an in-patient? Yes ☐ No ☐ Did the individual die? Yes ☐ No ☐ If yes, date: __________ Will a worker's compensation claim be filed? Yes ☐ No ☐
Telephone Number	

NOTE: Attach any police reports or related diagrams to this report.

SIGNATURES

I have reviewed this report and agree that all the supplied information is accurate

Affected individual (print)	**Affected individual (signature)**	**Telephone Number**	**Date**

This form contains information relating to employee health and must be used in a manner that protects the confidentiality of the employee to the extent possible while the information is being used for occupational safety and health purposes.

INSTRUCTIONS:

Complete all sections below for incidents involving property/equipment damage, fire, spill or release.
Do NOT leave any blanks.
Attach this form to the IR FORM completed for this incident.

Incident Report Number: (From the IR Form)	

TYPE OF INCIDENT (Check all that apply)

Property Damage ☐ Equipment Damage ☐ Fire or Explosion ☐ Spill or Release ☐

INCIDENT DETAILS

Results of Incident: Fully describe damages, losses, etc.

____

____

____

Response Actions Taken:

____

____

____

Responding Agency(s) (i.e. police, fire department, etc.)	**Agency(s) Contact Name(s)**

DAMAGED ITEMS (List all damaged items, extent of damage and estimated repair cost)

Item:	**Extent of damage:**	**Estimated repair cost**

SPILLS / RELEASES (Provide information for spilled/released materials)

Substance	**Estimated quantity and duration**	**Specify Reportable Quantity (RQ)**
		______________ Exceeded? Yes ☐ No ☐ NA ☐

FIRES / EXPLOSIONS (Provide information related to fires/explosions)

Fire fighting equipment used? Yes ☐ No ☐ If yes, type of equipment: ______________________________

NOTIFICATIONS

Required notifications	**Name of person notified**	**By whom**	**Date / Time**
Client: ______________ Yes ☐ No ☐			
Agency: ______________ Yes ☐ No ☐			
Other: ______________ Yes ☐ No ☐			

Who is responsible for reporting incident to outside agency(s)? Tt ☐ Client ☐ Other ☐ Name: ____________________

Was an additional written report on this incident generated? Yes ☐ No ☐ If yes, place in project file.

INSTRUCTIONS:

Complete all sections below for incidents involving motor vehicle accidents. Do NOT leave any blanks. Attach this form to the IR FORM completed for this incident.

Incident Report Number: (From the IR Form)	

INCIDENT DETAILS

Name of road, street, highway or location where accident occurred	**Name of intersecting road, street or highway if applicable**

County	**City**	**State**

Did police respond to the accident?	**Did ambulance respond to the accident?**
Yes ☐ No ☐	Yes ☐ No ☐
Name and location of responding police department	**Ambulance company name and location**
Officer's name/badge #	

Did police complete an incident report? Yes ☐ No ☐ If yes, police report number: ____________________
Request a copy of completed investigation report and attach to this form.

VEHICLE INFORMATION

How many vehicles were involved in the accident? ______________ (Attach additional sheets as applicable for accidents involving more than 2 vehicles.)

Vehicle Number 1 – Tetra Tech Vehicle		**Vehicle Number 2 – Other Vehicle**	
Vehicle Owner / Contact Information		**Vehicle Owner / Contact Information**	
Color		**Color**	
Make		**Make**	
Model		**Model**	
Year		**Year**	
License Plate #		**License Plate #**	
Identification #		**Identification #**	
Describe damage to vehicle number 1		**Describe damage to vehicle number 2**	
Insurance Company Name and Address		**Insurance Company Name and Address**	
Agent Name		**Agent Name**	
Agent Phone No.		**Agent Phone No.**	
Policy Number		**Policy Number**	

DRIVER INFORMATION

Vehicle Number 1 – Tetra Tech Vehicle		Vehicle Number 2 – Other Vehicle	
Driver's Name		**Driver's Name**	
Driver's Address		**Driver's Address**	
Phone Number		**Phone Number**	
Date of Birth		**Date of Birth**	
Driver's License #		**Driver's License #**	
Licensing State		**Licensing State**	
Gender	Male ☐ Female ☐	**Gender**	Male ☐ Female ☐
Was traffic citation issued to Tetra Tech driver? Yes ☐ No ☐		Was traffic citation issued to driver of other vehicle? Yes ☐ No☐	
Citation #		**Citation #**	
Citation Description		**Citation Description**	

PASSENGERS IN VEHICLES (NON-INJURED)

List all non-injured passengers (excluding driver) in each vehicle.
Driver information is captured in the preceding section.
Information related to persons injured in the accident (non-Tt employees) is captured in the section below on this form.
Injured Tt employee information is captured on FORM IR-A

Vehicle Number 1 – Tetra Tech Vehicle		Vehicle Number 2 – Other Vehicle	
How many passengers (excluding driver) in the vehicle? ____		How many passengers (excluding driver) in the vehicle? ____	
Non-Injured Passenger Name and Address		**Non-Injured Passenger Name and Address**	
Non-Injured Passenger Name and Address		**Non-Injured Passenger Name and Address**	
Non-Injured Passenger Name and Address		**Non-Injured Passenger Name and Address**	

INJURIES TO NON-TETRATECH EMPLOYEES

Name of injured person 1				Address of injured person 1		
Age	**Gender**	**Car No.**	**Location in Car**	**Seat Belt Used?**	**Ejected from car?**	**Injury or Fatality?**
	Male ☐ Female ☐			Yes ☐ No ☐	Yes ☐ No ☐	Injured ☐ Died ☐
Name of injured person 2				**Address of injured person 2**		
Age	**Gender**	**Car No.**	**Location in Car**	**Seat Belt Used?**	**Ejected from car?**	**Injury or Fatality?**
	Male ☐ Female ☐			Yes ☐ No ☐	Yes ☐ No ☐	Injured ☐ Died ☐

OTHER PROPERTY DAMAGE

Describe damage to property other than motor vehicles	
Property Owner's Name	**Property Owner's Address**

COMPLETE AND SUBMIT DIAGRAM DEPICTING WHAT HAPPENED

National Aeronautics and Space Administration

NASA Mishap Report

MASTER FILE NO.

NOTE: Fill in unshaded blocks within 24 hours. Please print or type. See reverse for instructions.

GENERAL INFORMATION

1. NAME OF ORGANIZATION
2. MISHAP DATE *(MMDDYYYY)*
3. MISHAP TIME *(24 hrs.)*
4. ORG. FILE NO.

5. MISHAP CATEGORY *(Check as appropriate)*

TYPE A	TYPE B	TYPE C	INCIDENT
1 ☐ DEATH	2 ☐ LOST TIME	2 ☐ LOST TIME	4 ☐ INJURY
2 ☐ LOST TIME	3 ☐ PERM. DISABILITY	4 ☐ INJURY	6 ☐ DAMAGE
4 ☐ INJURY	4 ☐ INJURY	6 ☐ DAMAGE	
6 ☐ DAMAGE	5 ☐ HOSPITALIZATION	7 ☐ TEST FAILURE	MISSION FAILURE ☐
7 ☐ TEST FAILURE	6 ☐ DAMAGE		
	7 ☐ TEST FAILURE		

6. CLOSE CALL ☐
7. LEVEL OF POTENTIAL
8. BLDG. NO./LOCATION
9. SPECIFIC AREA
10. MISSION AFFECTED
11. PROGRAM IMPACT

12. DESCRIPTION OF MISHAP *(Sequence of events, extent of damage and injuries, cause, if known, etc. Use additional sheets if necessary.)*

PERSONNEL INVOLVED

13. NAME *(Last, first, middle initial)*
14. AGE
15. SEX ☐ M ☐ F
16. ORGANIZATION *(CODE)*/POSITION

17. SHIFT WORKED ☐ 1 ☐ 2 ☐ 3
18. HOURS OF CONTINUOUS DUTY BEFORE MISHAP
19. FIRST AID ONLY ☐ YES ☐ NO
20. FATALITY ☐ YES ☐ NO
21. INJURY TYPE *(Code)*

22. BODY PART(S) AFFECTED *(Codes)*

23. DAYS LOST: NO. ☐ TOTAL ☐ CONTINUING

24. CAUSE(S) OF INJURY *(Codes)*: PRIMARY | CONTRIB. | POTENTIAL

25. MISHAP ENVIRONMENT *(Codes)*: AGENCY | ACTIVITY

26. HAS EMPLOYEE RECEIVED TRAINING/CERTIFICATION APPLICABLE TO TASK? ☐ YES ☐ NO

EQUIPMENT/PROPERTY DAMAGED

27. CLASS OF EQUIPMENT/PROPERTY DAMAGED

1 ☐ FLIGHT HARDWARE	4 ☐ PRESSURE VESSEL	7 ☐ OTHER
2 ☐ GROUND SUPPORT EQUIPMENT (GSE)	5 ☐ MOTOR VEHICLE	
3 ☐ FACILITY	6 ☐ AIRCRAFT	

28. SPECIFIC ITEM DAMAGED

29. SERIAL/NEMS NO.
30. SYSTEM/SUBSYSTEM AFFECTED
31. CAUSE(S) OF DAMAGE *(Codes)*: PRIMARY | CONTRIB. | POTENTIAL
32. COST: ESTIMATE | FINAL

33. SUBMITTED BY *(Name, title, mail code)* | SIGNATURE | PHONE NO. | DATE

CORRECTIVE ACTION

34. ACTION PLAN *(Provide estimated completion date for each action. Use extra sheets if necessary)*

35. APPROVED *(Name, title, mail code)* | SIGNATURE | PHONE NO. | DATE

36. NASA SAFETY CONCURRENCE WITH CORRECTIVE ACTION PLAN *(Branch chief or higher)*

CONCUR *(Name, title, mail code)* | SIGNATURE | PHONE NO. | DATE

NASA SAFETY OFFICE USE ONLY

37. LESSONS LEARNED ☐ YES ☐ NO
REF. NO. *(If Yes)*

38. TYPE OF INVESTIGATION 1 ☐ BOARD 2 ☐ TEAM 3 ☐ INVESTIGATOR

39. STATUS ☐ OPEN ☐ CLOSED

40. APPROVAL FOR CLOSURE
NAME AND TITLE | PHONE NO.
SIGNATURE | DATE

CODES

ITEM 21. **INJURY TYPE** - Enter one of the following codes to identify the category of injury:

(H01)	Abrasion	(H04)	Contusion, Bruise	(I09)	Internal Injuries
(C02)	Avulsion	(I03)	Dermatitis	(H06)	Laceration
(C01)	Amputation	(I96)	Multiple Injuries	(P00)	Pain
(H02)	Bites, Stings	(E06)	Electrical Shock	(J00)	Oxygen Deficiency
(H07)	Punctures	(I04)	Exhaustion	(Z68)	Shock, Trauma
(A00)	Burn, Chemical	(F07)	Fracture	(G03)	Strain, Sprain
(B00)	Burn, Thermal	(I06)	Hernia	(T06)	Toxicosis
(Z76)	Concussion	(I00)	Inhalation, Absorption, Ingestion	(Z98)	Other/Unknown
(G06)	Exposure				

ITEM 22. **BODY PART(S) AFFECTED** - Enter up to 3 of the following body part codes. (The first code entered should indicate Section of Body.):

Section of Body		Part of Body					
(A00)	Body in general	(D10)	Abdomen	(F35)	Foot	(B16)	Mouth/Teeth
(D00)	Torso (Chest)	(F21)	Ankle	(E22)	Forearm	(C05)	Neck
(B00)	Head/Facial	(E13)	Upper Arm	(D53)	Groin	(B06)	Nose
(E00)	Upper Extremities	(D30)	Back	(E30)	Hand	(E11)	Shoulder
(F00)	Lower Extremities	(F22)	Calf/Skin	(D43)	Heart	(D46)	Side/Rib(s)
		(B03)	Ear(s)	(F33)	Heel	(D32)	Spine
		(E12)	Elbow	(D54)	Hip	(F34)	Toe(s)
		(B12)	Eye(s)	(B14)	Jaw	(D33)	Vertebra(e)
		(B10)	Face	(F11)	Knee	(E21)	Wrist
		(E31)	Finger(s)	(F10)	Leg		

ITEMS 24 AND 31. **CAUSES OF INJURY AND/OR DAMAGE** - Select up to 3 of the following codes to identify the causes of injury and/or damage: (Refer to NMI 8621.1E for definitions of Primary, Contributing and Potential Causes.) NOTE: Primary Cause <u>must</u> be indicated.

(C) Communications
- (1) Paging Warning Inadequate
- (2) Problem Reporting/ Tracking Inadequate
- (3) Schedule Conflicts
- (4) Task Coordination/ Planning Inadequate
- (5) Task Supervision Inadequate
- (6) Test Team Briefing Inadequate

(E) Equipment Failure
- (1) Design Deficiency
- (2) Maintenance
- (3) Material Failure
- (4) Material Defects

(F) Fire/Explosion
- (1) Chemical Change
- (2) Fuel/Oxidizer Near Ignition Source
- (3) Pressure Release/Implosion
- (4) High Heat Source

(A) Handling
- (1) Design Deficiency
- (2) Deviation from Procedure

(O) Hazardous Operation
- (1) Arrangement
- (2) Improper Illumination
- (3) Improper Ventilation
- (4) Improper Clothing
- (5) Improper Guarding
- (6) Unsafe Equipment
- (7) Deviation from Procedure
- (8) Improper Protection

(H) Human Factors
- (1) Distraction
- (2) Fatigue
- (3) Safety Violation
- (4) Lack of Experience
- (5) Working Environment
- (6) Lack of Authority
- (7) Lack of Attention
- (8) Misjudgment of Conditions

(N) Natural Phenomenon
- (1) Lightning
- (2) Wind
- (3) Rain
- (4) Hail
- (5) Earthquake

(T) Organizational Deficiency
- (1) Lack of Training
- (2) Lack of Certification
- (3) Expired Certification

(P) Procedure
- (1) Requirements Inadequate
- (2) Procedure Deficiency
- (3) Technical Data Deficiency

(M) Toxic Material
- (1) Design Deficiency
- (2) Improper Handling

ITEM 25. **MISHAP ENVIRONMENT**

AGENCY - Enter up to 3 <u>Agency</u> codes:

(A)	Animals	(L)	Material
(B)	Boilers/Pressure Vessels	(M)	Mechanical Power/ Transmission Apparatus
(C)	Chemicals	(N)	Prime Movers and Pumps
(D)	Conveyors	(O)	Radiation/Radiating Substances
(E)	Dust	(P)	Vehicles
(F)	Electrical Apparatus	(Q)	Working/Walking Surfaces (Stairs, Platforms, etc.)
(G)	Elevators	(S)	Temperature Extremes
(H)	Hand Tools	(T)	Electrical Current
(I)	Highly Flammable, Hot/ Toxic Substances	(Z)	Agency Not Elsewhere Classified
(J)	Hoisting Apparatus Cranes, Winches, etc.)		
(K)	Machines		

ACTIVITY - Enter up to 3 <u>Activity</u> codes:

(A)	Striking Against	(M)	Dropped, Spilled, Splashed
(B)	Struck By	(N)	Lifting, Moving
(C)	Caught In/On/Between	(P)	Ascending/Descending
(D)	Fall on Same Level	(Q)	Twisting/Turning
(E)	Fall to Different Level	(R)	Over-Exertion
(F)	Slip (not fall)/Trip	(S)	Pushing/Pulling
		(Z)	Activity Not Elsewhere Classified

ATTACHMENT III

EQUIPMENT INSPECTION

Unit/Serial No#:______________________________________ **Inspection Date:** _____/_____/_____

Equipment Inspection Checklist for Drill Rigs

Company:____

Unit/Serial No#:__________________________________

Inspection Date: _____/_____/_____ **Time:**______:______

Equipment Type:________________________________
(e.g, Drill Rigs Hollow Stem, Mud Rotary, Direct Push, HDD)

Project Name:_______________________________________

Project No#:____________________________________

Yes	No	NA	Requirement	Comments
			Emergency Stop Devices	
☐	☐	☐	• Emergency Stop Devices (At points of operation)	
☐	☐	☐	• Have all emergency shut offs identified been communicated to the field crew?	
☐	☐	☐	• Has a person been designated as the Emergency Stop Device Operator?	
			Highway Use	
☐	☐	☐	• Cab, mirrors, safety glass?	
☐	☐	☐	• Turn signals, lights, brake lights, etc. (front/rear) for equipment approved for highway use?	
☐	☐	☐	• Seat Belts?	
☐	☐	☐	• Is the equipment equipped with audible back-up alarms and back-up lights?	
☐	☐	☐	• Horn and gauges	
☐	☐	☐	• Brake condition (dynamic, park, etc.)	
☐	☐	☐	• Tires (Tread) or tracks	
☐	☐	☐	• Windshield wipers	
☐	☐	☐	• Exhaust system	
☐	☐	☐	• Steering (standard and emergency)	
☐	☐	☐	• Wheel Chocks?	
☐	☐	☐	• Are tools and material secured to prevent movement during transport? Especially those within the cab?	
☐	☐	☐	• Are there flammables or solvents or other prohibited substances stored within the cab?	
☐	☐	☐	• Are tools or debris in the cab that may adversely influence operation of the vehicle (in and around brakes, clutch, gas pedals)	

Unit/Serial No#:____________________________________ **Inspection Date: _____/_____/_____**

Yes	No	NA	Requirement	Comments
☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐	Fluid Levels: • Engine oil • Transmission fluid • Brake fluid • Cooling system fluid • Hoses and belts • Hydraulic oil	
☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	High Pressure Hydraulic Lines • Obvious damage • Operator protected from accidental release • Coupling devices, connectors, retention cables/pins are in good condition and in place	
☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐	Mast Condition • Structural components/tubing • Connection points • Pins • Welds • Outriggers • Operational • Plumb (when raised)	
☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐	Hooks • Are the hooks equipped with Safety Latches? • Does it appear that the hook is showing signs of wear in excess of 10% original dimension? • Is there a bend or twist exceeding 10% from the plane of an unbent hook? • Increase in throat opening exceeding 15% from new condition • Excessive nicks and/or gouges • Clips • Number of U-Type (Crosby) Clips (cable size 5/16 – 5/8 = 3 clips minimum) (cable size 3/4 – 1 inch = 4 clips minimum) (cable size 1 1/8 – 1 3/8 inch = 5 clips minimum)	

Unit/Serial No#:____________________________________ **Inspection Date:** _____/_____/_____

Yes	No	NA	Requirement	Comments
			Power cable and/or hoist cable	
☐	☐	☐	• Reduction in Rope diameter π (5/16 wire rope>1/64 reduction nominal size -replace) (3/8 to 1/2 wire rope>1/32 reduction nominal size-replace) (9/16 to 3/4 wire rope>3/64 reduction nominal size-replace)	
☐	☐	☐	• Number of broken wires (6 randomly broken wires in one rope lay) (3 broken wires in one strand)	
☐	☐	☐	• Number of wire rope wraps left on the Running Drum at nominal use (≥3 required)	
☐	☐	☐	- Lead (primary) sheave is centered on the running drum	
☐	☐	☐	• Lubrication of wire rope (adequate?)	
☐	☐	☐	• Kinks, bends – Flattened to > 50% diameter	
			Hemp/Fiber rope (Cathead/Split Spoon Hammer)	
☐	☐	☐	• Minimum ¾; maximum 1 inch rope diameter (Inspect for physical damage)	
☐	☐	☐	• Rope to hammer is securely fastened	
			Safety Guards –	
☐	☐	☐	• Around rotating apparatus (belts, pulleys, sprockets, spindles, drums, flywheels, chains) all points of operations protected from accidental contact?	
☐	☐	☐	• Hot pipes and surfaces exposed to accidental contact?	
☐	☐	☐	• High pressure lines	
☐	☐	☐	• Nip/pinch points	
			Operator Qualifications	
☐	☐	☐	• Does the operator have proper licensing where applicable, (e.g., CDL)?	
☐	☐	☐	• Does the operator, understand the equipment's operating instructions?	
☐	☐	☐	• Is the operator experienced with this equipment?	
☐	☐	☐	• Is the operator 21 years of age or more?	

Unit/Serial No#:______________________________________ **Inspection Date: _____/_____/_____**

Yes	No	NA	Requirement	Comments
			PPE Required for Drill Rig Exclusion Zone	
☐	☐	☐	• Hardhat	
☐	☐	☐	• Safety glasses	
☐	☐	☐	• Work gloves	
☐	☐	☐	• Chemical resistant gloves______________________________	
☐	☐	☐	• Steel toed Work Boots	
☐	☐	☐	• Chemical resistant Boot Covers	
☐	☐	☐	• Apron	
☐	☐	☐	• Coveralls Tyvek, Saranex, cotton)__________________________	
			Other Hazards	
☐	☐	☐	• Excessive Noise Levels? ___________dBA	
☐	☐	☐	• Chemical hazards (Drilling supplies - Sand, bentonite, grout, fuel, etc.)	
☐	☐	☐	- MSDSs available?	
☐	☐	☐	• Will On-site fueling occur	
☐	☐	☐	- Safety cans available?	
☐	☐	☐	- Fire extinguisher (Type/Rating -__________ _)	

Approved for Use ☐ Yes ☐ No ☐ See Comments

____ ____

Site Health and Safety Officer Operator

ATTACHMENT IV

SAFE WORK PERMITS

SAFE WORK PERMIT FOR
MOBILIZATION AND DEMOBILIZATION
NASA WALLOPS FLIGHT FACILITY

Permit No. ________________ Date: ____________________ Time: From ___________ to _______

I. Work limited to the following (description, area, equipment used): Mobilization and Demobilization activities

II. Primary Hazards lifting; pinches and compression; slip, trip, and fall hazards, heavy equipment; vehicle and foot traffic; ambient temperature extremes; insect animal bites and stings and poisonous plants, and inclement weather.

III. Field Crew: ______________________________

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector ____________ TtNUS
Equipment Inspection required ☐ Yes ☐ No Initials of Inspector ____________ TtNUS

V. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required
Yes ☐ Specify on the reverse
No ☒

Modifications/Exceptions: ______________________________

VI. Chemicals of Concern	**Hazard Monitoring**	**Action Level(s)**	**Response Measures**
None anticipated	None required		

Primary Route(s) of Exposure/Hazard: Contaminants are not anticipated to be encountered during these tasks. Refer to manufacturer MSDS to determine necessary protective measures for any chemical brought on site in support of site activities.

(Note to FOL and/or SHSO: Each item in Sections VII, VIII, and IX must be checked Yes, No, or NA)

VII. Additional Safety Equipment/Procedures

Item	Yes	No	Item	Yes	No
Hard-hat	☐	☐	Hearing Protection (Plugs/Muffs)	☐	☐
Safety Glasses	☐	☐	Safety belt/harness	☐	☒
Chemical/splash goggles	☐	☒	Radio/Cellular Phone	☐	☐
Splash Shield	☐	☒	Barricades	☐	☒
Splash suits/coveralls	☐	☒	Gloves (Type – (cotton/leather)	☐	☐
Impermeable apron	☐	☒	Work/rest regimen	☐	☐
Steel toe Work shoes/boots	☒	☐	Chemical resistant boot covers	☐	☒
High Visibility vest	☐	☐	Tape up/use insect repellent	☐	☐
First Aid Kit	☒	☐	Fire Extinguisher	☒	☐
Safety Shower/Eyewash	☒	☐	Other	☐	☐

Modifications/Exceptions: Safety glasses will be required if eye hazard are present. Reflective vests for high traffic areas. Tyvek coverall if there is a potential for soiling work clothes. Hard hats at SSO discretion if overhead hazards exist. Hearing protection at SSO discretion.

VIII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☒
Vehicle and Foot Traffic Routes Established/Traffic Control Barricades/Signs in Place	☐	☐	☒
Physical Hazards Identified and Isolated (Splash and containment barriers)	☐	☐	☐
Emergency Equipment Staged (Spill control, fire extinguishers, first aid kits, etc).	☐	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.). ☐ Yes ☐ No
If yes, SHSO to complete or contact Health Sciences, Pittsburgh Office (412)921-7090

X. Special instructions, precautions: Obtain MSDS for chemicals brought on site, add them to Chemical Inventory, and review them for any additional PPE requirements. Use safe lifting practices. Preview work locations for slip, trip, fall and other hazards that need to be communicated to field personnel.

Permit Issued by: ______________________________ Permit Accepted by: ______________________

SAFE WORK PERMIT FOR
MONITORING WELL INSTALLATION AND ORC® INJECTION
NASA WALLOPS FLIGHT FACILITY

Permit No. ______________ Date: __________________ Time: From ____________ to ________

I. Work limited to the following (description, area, equipment used): Monitoring well installation using DPT technique and ORC® injection using direct push technology (DPT) technique .

II. Primary Hazards: Contact with site contaminants; transfer of contamination; pinch/compression; noise; energized systems; heavy lifting; slip, trip and fall; vehicular and foot traffic; ambient temperature extremes; insect/animal bites and stings, poisonous plants, inclement weather

III. Field Crew: ____

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector _____TtNUS
Equipment Inspection required ☐ Yes ☐ No Initials of Inspector _____TtNUS

V. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required
Yes ☐ Specify on the reverse
No ☒

Modifications/Exceptions: ____

VI.

Chemicals of Concern	Hazard Monitoring	Action Level(s)	Response Measures
Benzene and Vinyl Chloride	PID with 10.6 eV lamp	Any sustained readings > 10 ppmin the worker breathing zone	Evacuate area until no dust is visiblel levels return to background
Dust from ORC		visible dust	

Primary Route(s) of Exposure/Hazard: Inhalation of airborne contaminants is most likely route or exposure. Incidental ingestion and contact with contaminants will be prevented through the use of PPE and safe work practices. Airborne dusts are unlikely to be generated during this activity, if present control through area wetting methods

(Note to FOL and/or SSO: Each item in Sections VII, VIII, and IX must be checked Yes, No, or NA)

VII. Additional Safety Equipment/Procedures

Item	Yes	No	Item	Yes	No
Hard-hat	☒	☐	Hearing Protection (Plugs/Muffs)	☒	☐
Safety Glasses	☒	☐	Safety belt/harness	☐	☒
Chemical/splash goggles	☐	☒	Radio/Cellular Phone	☐	☐
Splash shield	☐	☒	Barricades	☐	☐
Splash suits/coveralls	☒	☐	Gloves (Type – nitrile/work)	☒	☐
Impermeable apron	☒	☒	Work/rest regimen	☐	☐
Steel toe work shoes/boots	☒	☐	Chemical resistant boot covers	☐	☐
High visibility vest	☐	☐	Tape up/use insect repellent	☐	☐
First Aid Kit	☐	☐	Fire extinguisher	☒	☐
Safety Shower/Eyewash	☐	☒	Other	☐	☐

Modifications/Exceptions: Coveralls if the potential for soiling work clothing exists. Other PPE is possible based on conditions (rain gear, rubber boots, etc.)

VIII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☐
Vehicle and Foot Traffic Routes Established/Traffic Control Barricades/Signs in Place	☐	☐	☐
Physical Hazards Identified and Isolated (Splash and containment barriers)	☐	☐	☐
Emergency Equipment Staged (Spill control, fire extinguishers, first aid kits, etc).	☐	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.). ☐ Yes ☒ No
If yes, SSO to complete or contact Health Sciences, Pittsburgh Office (412)921-7090

X. Special instructions, precautions: Review MSDS for ORC Products in Attachment VI. Use safe lifting/carrying techniques. Inspect equipment prior to use. Ensure emergency stop devices are functional and test daily.

Permit Issued by:______________________________ Permit Accepted by:______________________________

SAFE WORK PERMIT FOR
MULTIMEDIA SAMPLING
NASA WALLOPS FLIGHT FACILITY

Permit No. ________________ Date: ____________________ Time: From ________________ to ________

I. Work limited to the following (description, area, equipment used): Multi-media sampling including groundwater and IDW.

II. Primary Hazards: Chemical contamination; transfer contamination; pinches and compressions; noise; lifting; slips, trips and falls; vehicular and foot traffic ambient temperature extremes; insect/animal bites, stings, poisonous plants and inclement weather.

III. Field Crew: ____________________

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector ______________TtNUS
Equipment Inspection required ☐ Yes ☐ No Initials of Inspector ______________TtNUS

V. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required
Yes ☐ Specify on the reverse
No ☒

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety shoes, and surgical style gloves. Coveralls and snake chaps will be worn near insect/snake areas.

VI.

Chemicals of Concern	Hazard Monitoring	Action Level(s)	Response Measures
Benzene and Vinyl	PID with 10.6 eV lamp	Any sustained readings	Evacuate area until
Chloride		> 10 ppmin the worker	no dust is visiblel
		breathing zone	levels return to
Dust from ORC		visible dust	background

Primary Route(s) of Exposure/Hazard: Inhalation.

(Note to FOL and/or SHSO: Each item in Sections VII, VIII, and IX must be checked Yes, No, or NA)

VII. Additional Safety Equipment/Procedures

Item	Yes	No	Item	Yes	No
Hard-hat	☐	☐	Hearing Protection (Plugs/Muffs)	☐	☐
Safety Glasses	☒	☐	Safety belt/harness	☐	☒
Chemical/splash goggles	☐	☐	Radio/Cellular Phone	☐	☒
Splash Shield	☐	☒	Barricades	☐	☐
Splash suits/coveralls	☐	☐	Gloves (Type – Nitrile Surgeons)	☒	☐
Impermeable apron	☐	☒	Work/rest regimen	☐	☐
Steel toe Work shoes or boots	☒	☐	Chemical Resistant Boot Covers	☐	☐
High Visibility vest	☒	☐	Tape up/use insect repellent	☐	☐
First Aid Kit	☒	☐	Fire Extinguisher	☐	☐
Safety Shower/Eyewash	☐	☐	Other	☐	☐

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety shoes, and surgical style gloves. Coveralls and snake chaps will be worn near insect/snake areas.

VIII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☐
Vehicle and Foot Traffic Routes Established/Traffic Control Barricades/Signs in Place	☐	☐	☐
Physical Hazards Identified and Isolated (Splash and containment barriers)	☐	☐	☐
Emergency Equipment Staged (Spill control, fire extinguishers, first aid kits, etc).	☐	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.). ☐ Yes ☒ No
If yes, SHSO to complete or contact Health Sciences, Pittsburgh Office (412)921-7090

X. Special instructions, precautions: Potential exposures via skin contact and hand to mouth activities will be prevented through the use of PPE and appropriate decontamination and personal hygiene practices. Avoid areas of known or suspected insect/animal nesting or habitat, tape up, and use repellants.

Permit Issued by:______________________________ Permit Accepted by:________________________

SAFE WORK PERMIT FOR
GEOGRAPHIC SURVEYING
NASA WALLOPS FLIGHT FACILITY

Permit No. ________________ Date: ____________________ Time: From ______________ to __________

I. Work limited to the following (description, area, equipment used): Geographic Survey

II. Primary Hazards: Slips, trips and falls, ambient temperature extremes, inclement weather, insect/animal bites or stings, poisonous plants.

III. Field Crew: ____________________

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector _____TtNUS
Equipment Inspection required ☐ Yes ☐ No Initials of Inspector _____TtNUS

V. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required
Yes ☐ Specify on the reverse
No ☐

Modifications/Exceptions: ____________________

VI. Chemicals of Concern	**Hazard Monitoring**	**Action Level(s)**	**Response Measures**
None expected during this task.			

Primary Route(s) of Exposure/Hazard: ____________________

(Note to FOL and/or SSO: Each item in Sections VII, VIII, and IX must be checked Yes, No, or NA)

VII. Additional Safety Equipment/Procedures

Item	Yes	No	Item	Yes	No
Hard-hat	☐	☒	Hearing protection (Plugs/Muffs)	☐	☒
Safety glasses	☐	☒	Safety belt/harness	☐	☒
Chemical/splash goggles	☐	☒	Radio/cellular phone	☐	☐
Splash shield	☐	☒	Barricades	☐	☐
Splash suits/coveralls	☐	☒	Gloves (Type – _________)	☐	☒
Impermeable apron	☐	☒	Work/rest regimen	☐	☐
Steel toe work shoes or boots	☒	☐	Chemical resistant boot covers	☐	☒
High visibility vest	☐	☐	Tape up/use insect repellent	☐	☐
First aid kit	☐	☐	Fire extinguisher	☐	☐
Safety shower/eyewash	☐	☒	Other	☐	☐

Modifications/Exceptions: ____________________

VIII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☐
Vehicle and Foot Traffic Routes Established/Traffic Control Barricades/Signs in Place	☐	☐	☐
Physical Hazards Identified and Isolated (Splash and containment barriers)	☐	☐	☐
Emergency Equipment Staged (Spill control, fire extinguishers, first aid kits, etc).	☐	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.). ☐ Yes ☐ No
If yes, SHSO to complete or contact Health Sciences, Pittsburgh Office (412)921-7090

X. Special instructions, precautions: ____________________

Permit Issued by: ____________________ Permit Accepted by: ____________________

SAFE WORK PERMIT FOR
DECONTAMINATION ACTIVITIES
NASA WALLOPS FLIGHT FACILITY

Permit No. ________________ Date: ____________________ Time: From ________________ to ________

I. Work limited to the following (description, area, equipment used): Decontamination sampling equipment activities .

II. Primary Hazards: Chemical contamination; decontamination fluids; noise; lifting; flying projectiles; slip, trip, and fall; vehicle and foot traffic; ambient temperature extremes and inclement weather.

III. Field Crew: ____________

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector ______________TtNUS
Equipment Inspection required ☐ Yes ☐ No Initials of Inspector ______________TtNUS

V. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required
Yes ☐ Specify on the reverse
No ☒

Modifications/Exceptions: ____________

VI. Chemicals of Concern	Hazard Monitoring	Action Level(s)	Response Measures
Benzene and Vinyl Chloride	PID with 10.6 eV lamp	Any sustained readings > 10 ppmin the worker breathing zone	Evacuate area until levels return to background
Dust from ORC		visible dust	no dust is visiblel

Primary Route(s) of Exposure/Hazard: Contaminants are not anticipated to be present at concentrations that pose a health threat to site workers.

(Note to FOL and/or SHSO: Each item in Sections VII, VIII, and IX must be checked Yes, No, or NA)

VII. Additional Safety Equipment/Procedures

Item		Item	
Hard-hat	☐ Yes ☒ No	Hearing Protection (Plugs/Muffs)	☐ Yes ☒ No
Safety Glasses	☒ Yes ☐ No	Safety belt/harness	☐ Yes ☒ No
Chemical/splash goggles	☐ Yes ☐ No	Radio/Cellular Phone	☐ Yes ☐ No
Splash Shield	☐ Yes ☐ No	Barricades	☐ Yes ☐ No
Splash suits/coveralls	☐ Yes ☐ No	Gloves (Type – Nitrile)	☒ Yes ☐ No
Impermeable apron	☐ Yes ☐ No	Work/rest regimen	☐ Yes ☐ No
Steel toe Work shoes/boots	☒ Yes ☐ No	Chemical Resistant Boot Covers	☒ Yes ☐ No
High Visibility vest	☒ Yes ☐ No	Tape up/use insect repellent	☐ Yes ☐ No
First Aid Kit	☐ Yes ☐ No	Fire Extinguisher	☐ Yes ☐ No
Safety Shower/Eyewash	☐ Yes ☐ No	Other	☐ Yes ☐ No

Modifications/Exceptions: PPE selection is largely dependent upon conditions and tasks being performed.

VIII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☐
Vehicle and Foot Traffic Routes Established/Traffic Control Barricades/Signs in Place	☐	☐	☐
Physical Hazards Identified and Isolated (Splash and containment barriers)	☐	☐	☐
Emergency Equipment Staged (Spill control, fire extinguishers, first aid kits, etc).	☐	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.). ☐ Yes ☐ No
If yes, SHSO to complete or contact Health Sciences, Pittsburgh Office (412)921-7090

X. Special instructions, precautions: Potential exposures via skin contact and hand to mouth activities will be prevent through the use of PPE and appropriate decontamination and personal hygiene practices.

Permit Issued by: ____________________ Permit Accepted by: ____________________

SAFE WORK PERMIT FOR
DECONTAMINATION ACTIVITIES
NASA WALLOPS FLIGHT FACILITY

Permit No. ______________ Date: __________________ Time: From ____________ to _________

I. Work limited to the following (description, area, equipment used): IDW management, moving and storage

II. Primary Hazards: Potential hazards associated with this task: spill; strains and sprains; back injuries compressions

III. Field Crew: ______________________________

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector _____TtNUS
Equipment Inspection required ☐ Yes ☐ No Initials of Inspector _____TtNUS

V. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐
Modifications/Exceptions: ______________________________

Respiratory equipment required
Yes ☐ Specify on the reverse
No ☒

VI.

Chemicals of Concern	**Hazard Monitoring**	**Action Level(s)**	**Response Measures**
None expected during this task			

Primary Route(s) of Exposure/Hazard: absorption

(Note to FOL and/or SSO: Each item in Sections VII, VIII, and IX must be checked Yes, No, or NA)

VII. Additional Safety Equipment/Procedures

Item	Yes	No	Item	Yes	No
Hard-hat	☐	☐	Hearing Protection (Plugs/Muffs)	☐	☒
Safety Glasses	☐	☐	Safety belt/harness	☐	☒
Chemical/splash goggles	☐	☒	Radio/Cellular Phone	☐	☐
Splash Shield	☐	☒	Barricades	☐	☒
Splash suits/coveralls	☐	☐	Gloves (Type – work)	☒	☐
Impermeable apron	☐	☒	Work/rest regimen	☐	☐
Steel toe work shoes or boots	☒	☐	Chemical Resistant Boot Covers	☐	☒
High Visibility vest	☐	☐	Tape up/use insect repellent	☐	☐
First Aid Kit	☐	☐	Fire Extinguisher	☐	☒
Safety Shower/Eyewash	☐	☒	Other	☐	☐

Modifications/Exceptions: ______________________________

VIII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☐
Vehicle and Foot Traffic Routes Established/Traffic Control Barricades/Signs in Place	☐	☐	☐
Physical Hazards Identified and Isolated (Splash and containment barriers)	☐	☐	☐
Emergency Equipment Staged (Spill control, fire extinguishers, first aid kits, etc).	☐	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.). ☐ Yes ☒ No
If yes, SSO to complete or contact Health Sciences, Pittsburgh Office (412)921-7090

X. Special instructions, precautions: Inspect drums used to store IDW prior to use. Disperse IDW evenly. Use proper lifting practices and obtain assistance when handling heavy drums.

Permit Issued by: ______________________ Permit Accepted by: ______________________

ATTACHMENT V

OSHA POSTER

Job Safety and Health

It's the law!

OSHA

Occupational Safety and Health Administration
U.S. Department of Labor

EMPLOYEES:

- You have the right to notify your employer or OSHA about workplace hazards. You may ask OSHA to keep your name confidential.
- You have the right to request an OSHA inspection if you believe that there are unsafe and unhealthful conditions in your workplace. You or your representative may participate in that inspection.
- You can file a complaint with OSHA within 30 days of retaliation or discrimination by your employer for making safety and health complaints or for exercising your rights under the *OSH Act*.
- You have the right to see OSHA citations issued to your employer. Your employer must post the citations at or near the place of the alleged violations.
- Your employer must correct workplace hazards by the date indicated on the citation and must certify that these hazards have been reduced or eliminated.
- You have the right to copies of your medical records and records of your exposures to toxic and harmful substances or conditions.
- Your employer must post this notice in your workplace.
- You must comply with all occupational safety and health standards issued under the *OSH Act* that apply to your own actions and conduct on the job.

EMPLOYERS:

- You must furnish your employees a place of employment free from recognized hazards.
- You must comply with the occupational safety and health standards issued under the *OSH Act*.

Free assistance in identifying and correcting hazards or complying with standards is available to employers, without citation or penalty, through OSHA-supported consultation programs in each state.

This free poster available from OSHA –
The Best Resource for Safety and Health

1-800-321-OSHA
www.osha.gov

OSHA 3165-12-06R

ATTACHMENT VI

MSDS ORC INJECTION

Oxygen Release Compound (ORC®)
MATERIAL SAFETY DATA SHEET (MSDS)

Last Revised: October 18, 2005

Section 1 - Material Identification

Supplier:

REGENESIS
1011 Calle Sombra
San Clemente, CA 92673
Phone: 949.366.8000
Fax: 949.366.8090
E-mail: info@regenesis.com

Chemical Description:	A mixture of Magnesium Peroxide (MgO_2), Magnesium Oxide (MgO), and Magnesium Hydroxide [$Mg(OH)_2$]
Chemical Family:	Inorganic Chemical
Trade Name:	Oxygen Release Compound (ORC®)
Product Use:	Used to remediate contaminated soil and groundwater (environmental applications)

Section 2 – Chemical Identification

CAS#	Chemical
14452-57-4	Magnesium Peroxide (MgO_2)
1309-48-4	Magnesium Oxide (MgO)
1309-42-8	Magnesium Hydroxide [$Mg(OH)_2$]
7758-11-4	Dipotassium Phosphate (HK_2O_4P)
7778-77-0	Monopotassium Phosphate (H_2KO_4P)
Assay:	25-35% Magnesium Peroxide (MgO_2)

Section 3 - Physical Data

Melting Point:	**Not Determined (ND)**
Boiling Point:	**ND**
Flash Point:	**Not Applicable (NA)**
Self-Ignition Temperature:	**NA**
Thermal Decomposition:	**Spontaneous Combustion possible at ≈ 150°C**
Density:	**0.6 – 0.8 g/cc**
Solubility:	**Reacts with Water**
pH:	**Approximately 10 in saturated solution**
Appearance:	**White Powder**
Odor:	**None**
Vapor Pressure:	**None**
Hazardous Decomposition Products:	**Not Known**
Hazardous Reactions:	**Hazardous Polymerization will not occur**
Further Information:	**Non-combustible, but will support combustion**

Section 4 – Reactivity Data

Stability:	**Product is stable unless heated above 150 °C. Magnesium Peroxide reacts with water to slowly release oxygen. Reaction by product is Magnesium Hydroxide**
Conditions to Avoid:	**Heat above 150 °C. Open Flames.**
Incompatibility:	**Strong Acids. Strong Chemical Agents.**
Hazardous Polymerization:	**None known.**

Section 5 - Regulations

Permissible Exposure Limits in Air	**Not Established. Should be treated as a nuisance dust.**

Section 6 – Protective Measures, Storage and Handling

Technical Protective Measures

Storage:	**Keep in tightly closed container. Keep away from combustible material.**
Handling:	**Use only in well ventilated areas.**

Personal Protective Equipment (PPE)

Respiratory Protection:	**Recommended (HEPA Filters)**
Hand Protection:	**Wear suitable gloves.**
Eye Protection:	**Use chemical safety goggles.**
Other:	**NA**
Industrial Hygiene:	**Avoid contact with skin and eyes**
Protection Against Fire & Explosion:	**NA**
Disposal:	**Dispose via sanitary landfill per state/local authority**
Further Information:	**Not flammable, but may intensify a fire**
After Spillage/Leakage/Gas Leakage:	**Collect in suitable containers. Wash remainder with copious quantities of water.**
Extinguishing Media:	**NA**
Suitable:	**Carbon Dioxide, dry chemicals, foam**
Further Information:	**Self contained breathing apparatus or approved gas mask should be worn due to small particle size. Use extinguishing media appropriate for surrounding fire.**
First Aid:	**After contact with skin, wash immediately with plenty of water and soap. In case of contact with eyes, rinse immediately with plenty of water and seek medical attention.**

Section 7 – Information on Toxicology

Toxicity Data:	**Not Available**

Section 8 – Information on Ecology

Water Pollution Hazard Raging (WGK):	**0**

Section 9 – Further Information

After the reaction of magnesium peroxide with water to form oxygen, the resulting material, magnesium hydroxide, is mildly basic. The amounts of magnesium oxide (magnesia) and magnesium hydroxide in the initial product have an effect similar to lime, but with lower alkalinity.

The information contained in this document is the best available to the supplier at the time of writing, but is provided without warranty of any kind. Some possible hazards have been determined by analogy to similar classes of material. The items in this document are subject to change and clarification as more information become available.

APPENDIX E

TtNUS SOPs

TABLE OF CONTENTS

SECTION **PAGE**

ATTACHMENTS

1.0 PURPOSE

The purpose of this procedure is to provide general reference information regarding the sampling of groundwater wells.

2.0 SCOPE

This procedure provides information on proper sampling equipment, onsite water quality testing, and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology.

3.0 GLOSSARY

Conductivity – Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions, their total concentration, mobility, valence, and relative concentrations, and on temperature of measure. Conductivity is highly dependent on temperature and should be reported at a particular temperature, i.e., 20.2 mS/cm at 14°C.

Dissolved Oxygen (DO) – DO levels in natural and wastewater depend on the physical, chemical, and biochemical activities in the water sample.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode, immersed in water, as referenced against a standard hydrogen electrode.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

pH Paper - Indicator paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution's pH.

Salinity – The measurement of dissolved salts in a given mass of solution. Note: most field meters determined salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or % (e.g., 35 ppt will equal 3.5%).

Turbidity – Turbidity in water is caused by suspended matter, such as clay, silt, fine organic and inorganic matter. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

4.0 RESPONSIBILITIES

Project Hydrogeologist - Responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), and equipment to be used, and providing detailed input in this regard to the project plan documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of the site sampling personnel.

Project Geologist/Field Sample Technician - is primarily responsible for the proper acquisition of the groundwater samples. He/she is also responsible for the actual analyses of onsite water quality samples, as well as instrument calibration, care, and maintenance. When appropriate, such responsibilities may be performed by other qualified personnel (e.g., field technicians).

5.0 PROCEDURES

5.1 General

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of analysis in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach shall be followed prior to sample acquisition:

1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended prior to sampling. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, extensive evacuation prior to sample withdrawal is not as critical.

2. For wells that can be purged dry, the well shall be evacuated and allowed to recover to 75% full capacity prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is required.

3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:

   - A submersible pump or the intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level drops. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. Once this is accomplished, a bailer or other approved device may be used to collect the sample for analysis.

   - The intake line of the sampling pump (or the submersible pump itself) unless otherwise directed shall be placed near the center of the screened section, and approximately one casing volume of water shall be pumped from the well at a low purge rate, equal to the well's recovery rate (low flow sampling).

Stratification of contaminants may exist in the aquifer. Concentration gradients as a result of mixing and dispersion processes, layers of variable permeability, and the presence of separate-phase product (i.e., floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column as it naturally occurs at that point, thus the result is the collection of a non-representative sample.

5.2 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform with the guidelines expressed in SOP SA-6.1.

The following equipment shall be on hand when sampling groundwater wells (reference SOPs SA-6.1 and SA-7.1):

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler, ice, labels and chain-of-custody documents.

- Field tools and instrumentation - Multi-parameters water quality meter capable of measuring ORP, pH, temperature, DO, specific conductance, turbidity and salinity or individual meters (as applicable), pH paper, camera and film (if appropriate), appropriate keys (for locked wells), water level indicator.

- Pumps

  - Shallow-well pumps: Centrifugal, bladder, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.

  - Deep-well pumps: Submersible pump and electrical power-generating unit, or bladder pumps where applicable.

- Other sampling equipment - Bailers and inert line with tripod-pulley assembly (if necessary).

- Pails - Plastic, graduated.

- Decontamination solutions - Deionized water, potable water, laboratory detergents, 10% nitric acid solution (as required), and analytical-grade solvent (e.g., pesticide-grade isopropanol), as required.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

5.3 Calculations of Well Volume

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the site logbook or field notebook or on a sample log sheet form (see SOP SA-6.3):

- Obtain all available information on well construction (location, casing, screens, etc.).

- Determine well or inner casing diameter.

- Measure and record static water level (depth below ground level or top of casing reference point).

- Determine depth of well by sounding using a clean, decontaminated, weighted tape measure.
- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).
- Calculate one static well volume in gallons $V = (0.163)(T)(r^2)$ 1

where:	V	=	Static volume of well in gallons.
	T=		Thickness of water table in the well measured in feet (i.e., linear feet of static water).
	r	=	Inside radius of well casing in inches.
	0.163	=	A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

5.4 Evacuation of Static Water (Purging)

5.4.1 General

The amount of purging a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pumped until the parameters such as temperature, specific conductance, pH, and turbidity (as applicable), have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook, field notebook, or on standardized data sheets.

5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.

- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.

<u>Suction Pumps</u>

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, and peristaltic pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics.

<u>Air-Lift Samplers</u>

This group of pump samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Air (or gas)-lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation, or loss of volatile organics.

<u>Submersible Pumps</u>

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch-diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components can be difficult and time-consuming.

5.5 <u>Onsite Water Quality Testing</u>

This section describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH

- Specific Conductance
- Temperature
- Dissolved Oxygen (DO)
- Oxidation-Reduction Potential (ORP)
- Turbidity
- Salinity

This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous site. The procedures and equipment described are applicable to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, and colloidal material or suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Since instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use. Most meters used to measure field parameters require calibration on a daily basis. Refer to SOP 6.3 for example equipment calibration log.

5.5.1 Measurement of pH

5.5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken.

Two methods are given for pH measurement: the pH meter and pH indicator paper. The indicator paper is used when only a rough estimate of the pH is required, and the pH meter when a more accurate measurement is needed. The response of a pH meter can be affected to a slight degree by high levels of colloidal or suspended solids, but the effect is usually small and generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

5.5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution created by the addition of the water sample reacting with the indicator compound on the paper. Various types of pH papers are available, including litmus (for general acidity or alkalinity determination) and specific pH range hydrion paper.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to (in this instance, hydrogen) ion concentration across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to the ion concentration is generated and measured.

5.5.1.3 Equipment

The following equipment is needed for taking pH measurements:

- Stand-alone portable pH meter, or combination meter (e.g., Horiba U-10), or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs).
- Buffer solutions, as specified by the manufacturer.
- pH indicator paper, to cover the pH range 2 through 12.
- Manufacturer's operation manual.

5.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

The following procedure is used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

- Inspect the instrument and batteries prior to initiation of the field effort.
- Check the integrity of the buffer solutions used for field calibration. Buffer solutions need to be changed often as a result of degradation upon exposure to the atmosphere.
- If applicable, make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).
- Calibrate on a daily use basis (or as recommended by manufacturer) following manufacturer's instructions. Record calibration data on an equipment calibration log sheet.
- Immerse the electrode(s) in the sample. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.
- Read and record the pH of the sample. pH shall be recorded to the nearest 0.01 pH unit. Also record the sample temperature.
- Rinse the electrode(s) with deionized water.
- Store the electrode(s) in an appropriate manner when not in use.

Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted.

pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper and proceed with successively narrower range paper until the sample pH is adequately determined.

5.5.2 Measurement of Specific Conductance

5.5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance. Most conductivity meters in use today display specific conductance (SC); units of milliSiemens per centimeter, which is the conductivity normalized to temperature @ 25°C. This format (SC) is the required units recorded on the groundwater sample log field form (Attachment B).

5.5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, while the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or sodium chloride, respectively) are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not dissociate in aqueous solution, conduct a current very poorly, if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

5.5.2.3 Equipment

The following equipment is needed for taking specific conductance (SC) measurements:

- Stand alone portable conductivity meter, or combination meter (e.g., Horiba U-10), or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

A variety of conductivity meters are available which may also be used to monitor salinity and temperature. Probe types and cable lengths vary, so equipment must be obtained to meet the specific requirement of the sampling program.

5.5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.
- Calibrate on a daily use basis (or as recommended by manufacturer), according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet. Potassium chloride solutions with a SC closest to the values expected in the field shall be used for calibration.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the electrode in the sample and measure the conductivity.
- Read and record the results in a field logbook or sample log sheet.
- Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for details.

5.5.3 Measurement of Temperature

5.5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

5.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury filled, dial-type thermometers or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).. In addition, various meters such as specific conductance or dissolved oxygen meters, which have temperature measurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

5.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of cross-contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.

- Record values in a field logbook or sample log sheet.

If a temperature meter or probe is used, the instrument shall be calibrated according to manufacturer's recommendations.

5.5.4 Measurement of Dissolved Oxygen

5.5.4.1 General

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time if the sample is not adequately preserved.

The monitoring method discussed herein is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible, and is not susceptible to interference caused by color, turbidity, colloidal material or suspended matter.

5.5.4.2 Principles of Equipment Operation

Dissolved oxygen probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH^-) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, while leaving the surface of the solution undisturbed.

Dissolved oxygen probes are relatively unaffected by interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide, which are not easily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted in the field log book and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer.

5.5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

- Stand alone portable dissolved oxygen meter, or combination meter (e.g., Horiba U-10), or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

5.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

Probes differ as to specifics of use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure the dissolved oxygen concentration:

- The equipment shall be calibrated and have its batteries checked before going to the field.
- The probe shall be conditioned in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
- The instrument shall be calibrated in the field according to manufacturer's recommendations or in a freshly air-saturated water sample of known temperature.
- Record all pertinent information on an equipment calibration sheet.
- Rinse the probe with deionized water.
- Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane by stirring the sample. Probes without stirrers placed in wells can be moved up and down.
- Record the dissolved oxygen content and temperature of the sample in a field logbook or sample log sheet.
- Rinse the probe with deionized water.
- Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable, since sample handling is not involved. This however, may not always be practical.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen solubilization and positive test interferences.

5.5.5 Measurement of Oxidation-Reduction Potential

5.5.5.1 General

The oxidation-reduction potential (ORP) provides a measure of the tendency of organic or inorganic compounds to exist in an oxidized state. The ORP parameter therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of oxidized to reduced species in the sample.

5.5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and is dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as dissolved oxygen, may be correlated with ORP to provide a knowledge of the quality of the solution, water, or wastewater.

5.5.5.3 Equipment

The following equipment is needed for measuring the oxidation-reduction potential of a solution:

- Combination meters with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring oxidation-reduction potential:

- The equipment shall be checked using the manufacturer's recommended reference solution and have its batteries checked before going to the field.

- Thoroughly rinse the electrode with deionized water.

- If the probe does not respond properly to the recommended reference solution, then verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of a test solution is altered. The ORP will increase when the pH of a test solution decreases, and the ORP will decrease if the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note the ORP drops sharply when the caustic is added (i.e., pH is raised) thus indicating the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions or the probe should be replaced.

- Record all pertinent information on an equipment calibration log sheet.

5.5.6 Measurement of Turbidity

5.5.6.1 General

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample. Turbidity in water is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and microscopic organisms, including plankton.

It is important to obtain a turbidity reading immediately after taking a sample, since irreversible changes in turbidity may occur if the sample is stored too long.

5.5.6.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method. This method is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the scattered light intensity, the higher the turbidity.

Formazin polymer is used as the reference turbidity standard suspension because of its ease of preparation combined with a higher reproducibility of its light-scattering properties than clay or turbid natural water. The turbidity of a specified concentration of formazin suspension is defined as 40 nephelometric units. This same suspension has an approximate turbidity of 40 Jackson units when measured on the candle turbidmeter. Therefore, nephelometric turbidity units (NTU) based on the formazin preparation will approximate units derived from the candle turbidimeter but will not be identical to them.

5.5.6.3 Equipment

The following equipment is needed for turbidity measurement:

- Light meter (e.g., LaMotte 2020) which calibrates easily using test cells with standards of 0.0 NTUs, and 10 NTUs, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.6.4 Measurement Techniques for Turbidity

The steps involved in taking turbidity measurements utilizing an electrode (e) or light meter (l) are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the electrode with one or more portions of the sample to be tested or with deionized water (applies to "e").
- Fill the light meters glass test cell with ~5 ml of sample, screw on cap, wipe off glass, place test cell in light meter and close the lid (applies to "l").
- Immerse the electrode in the sample and measure the turbidity (applies to "e").
- The reading must be taken immediately as suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.
- Read and record the results in a field logbook or sample log sheet. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.

- Rinse the electrode or test cell with deionized water.

5.5.7 Measurement of Salinity

5.5.7.1 General

Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Note: Most field meters determined salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or % (e.g., 35 ppt will equal 3.5%).

5.5.7.2 Principles of Equipment Operation

Salinity is determined automatically from the meter's conductivity and temperature readings according to algorithms (found in *Standard methods for the Examination of Water and Wastewater*). Depending on the meter, the results are displayed in either ppt or %. The salinity measurements are carried out in reference to the conductivity of standard seawater (*corrected to S = 35*).

5.5.7.3 Equipment

The following equipment is needed for Salinity measurements:

- Multi-parameter water quality meter capable of measuring conductive, temperature and converting them to salinity (e.g., Horiba U-10 or YSI 600 series).
- Calibration Solution, as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.7.4 Measurement Techniques for Salinity

The steps involved in taking Salinity measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate before going into the field.

- Check the expiration date (etc.) of the solutions used for field calibration.

- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.

- Rinse the cell with the sample to be tested.

- Immerse the multi-probe in the sample and measure the salinity. Read and record the results in a field logbook or sample log sheet.

- Rinse the probes with deionized water.

5.6 Sampling

5.6.1 Sampling Plan

The sampling approach consisting of the following, shall be developed as part of the project plan documents which are approved prior to beginning work in the field:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).
- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.
- Sample preservation requirements.
- Work schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

5.6.2 Sampling Methods

The collection of a groundwater sample consists of the following steps:

1. The site Health & Safety Officer (or designee) will first open the well cap and use volatile organic detection equipment (PID or FID) on the escaping gases at the well head to determine the need for respiratory protection.
2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data on a groundwater sampling log sheet (see Attachment B); then calculate the fluid volume in the well pipe (as previously described in this SOP).
3. Calculate well volume to be removed as stated in Section 5.3.
4. Select the appropriate purging equipment (see Attachment A). If an electric submersible pump with packer is chosen, go to Step 10.
5. Lower the purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner (as applicable). Lower the purging device, as required, to maintain submergence.

6. Measure the rate of discharge frequently. A graduated bucket or cylinder and stopwatch are most commonly used.

7. Observe the peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics.

8. Purge a minimum of three to five casing volumes before sampling. In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Purged water shall be collected in a designated container and disposed in an acceptable manner.

9. If sampling using a pump, lower the pump intake to midscreen (or the middle of the open section in uncased wells) and collect the sample. If sampling with a bailer, lower the bailer to just below the water surface.

10. (For pump and packer assembly only). Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

11. In the event that recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record this occurrence in the site logbook.

12. Fill sample containers (preserve and label as described in SOP SA-6.1).

13. Replace the well cap and lock as appropriate. Make sure the well is readily identifiable as the source of the samples.

14. Process sample containers as described in SOP SA-6.1.

15. Decontaminate equipment as described in SOP SA-7.1.

5.7 Low Flow Purging and Sampling

5.7.1 Scope & Application

Low flow purging and sampling techniques are sometimes required for groundwater sampling activities. The purpose of low flow purging and sampling is to collect groundwater samples that contain "representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at or near natural flow conditions. The minimum stress procedure emphasizes negligible water level drawdown and low pumping rates in order to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 1 inch or more and a saturated screen, or open interval, length of ten feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semi-volatile organic compounds, pesticides, PCBs, metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This procedure is not designed to collect non-aqueous phase liquids samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs), using the low flow pumps.

The procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 10 NTU and to achieve a water level drawdown of less than 0.3 feet during purging and sampling. If these goals cannot be achieved, sample collection can take place provided the remaining criteria in this procedure are met.

5.7.2 Equipment

The following equipment is required (as applicable) for low flow purging and sampling:

- Adjustable rate, submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon).
- Disposable clear plastic bottom filling bailers may be used to check for and obtain samples of LNAPLs or DNAPLs.
- Tubing - Teflon, Teflon-lined polyethylene, polyethylene, PVC, Tygon, or stainless steel tubing can be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements.
- Water level measuring device, 0.01 foot accuracy, (electronic devices are preferred for tracking water level drawdown during all pumping operations).
- Interface probe, if needed.
- Flow measurement supplies.
- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.
- Indicator parameter monitoring instruments - pH, turbidity, specific conductance, and temperature. Use of a flow-through cell is recommended. Optional Indicators - ORP, salinity, and dissolved oxygen, flow-through cell is required. Standards to perform field calibration of instruments.
- Decontamination supplies.
- Logbook(s), and other forms (see Attachments B and C).
- Sample Bottles.
- Sample preservation supplies (as required by the analytical methods).
- Sample tags and/or labels.
- Well construction data, location map, field data from last sampling event (if available).
- Field Sampling Plan.
- PID or FID instrument for measuring VOCs (volatile organic compounds).

5.7.3 Purging and Sampling Procedure

Open monitoring well, measure head space gases using PID/FID. If there is an indication of off gassing when opening the well, wait 3-5 minutes to permit water level an opportunity to reach equilibrium.

Measure and record the water level immediately prior to placing the pump in the well.

Lower pump or tubing slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of sediment that may be present in the bottom of the well. Collection of turbidity-free water samples may be difficult if there is three feet or less of standing water in the well.

Start with the initial pump rate set at approximately 0.1 liters/minute. Use a graduated cylinder and stopwatch to measure the pumping rate. Adjust pumping rates as necessary to prevent drawdown from exceeding 0.3 feet during purging. If no drawdown is noted, the pump rate may be increased (to a max of 0.4 liters/minute) to expedite the purging and sampling event. The pump rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If groundwater is drawn down below the top of the well screen, purging will cease or the well will be pumped to dryness and the well will be allowed to recover before purging continues. Slow recovering wells will be identified and purged at the beginning of the workday. If possible, samples will be colleted from these wells within the same workday and no later than 24 hours after the start of purging.

Measure the well water level using the water level meter every 5 to 10 minutes. Record the well water level on the Low-Flow Purge Data Form (Attachment C).

Record on the Low-Flow Purge Data Form every 5 to 10 minutes the water quality parameters (pH, specific conductance, temperature, turbidity, oxidation-reduction potential, dissolved oxygen and salinity or as specified by the approved site specific work plan) measured by the water quality meter and turbidity meter. If the cell needs to be cleaned during purging operations, continue pumping (allow the pump to discharge into a container) and disconnect the cell. Rinse the cell with distilled/deionized water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Low-Flow Purge Data Form.

Measure the flow rate using a graduated cylinder. Remeasure the flow rate any time the pump rate is adjusted.

During purging, check for the presence of bubbles in the flow-through cell. The presence of bubbles is an indication that connections are not tight. If bubbles are observed, check for loose connections.

After stabilization is achieved, sampling can begin when a minimum of two saturated screen volumes have been removed and three consecutive readings, taken at 5 to 10 minute intervals, are within the following limits:

- pH ±0.2 standard units
- Specific conductance ±10%
- Temperature ±10%
- Turbidity less than 10 NTUs
- Dissolved oxygen ±10%

If the above conditions have still not been met after the well has been purged for 4 hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters from the Low-Flow Purge Data Form onto the Groundwater Sample Log Form.

VOC samples are preferably collected first, directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples: (1) Collect the non-VOCs samples first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample and record the new flow rate; (2) reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel), or clamp which should reduce the flow rate by constricting the end of the tubing; (3) insert a narrow diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, collect sample from the narrow diameter tubing.

Prepare samples for shipping as per SOP SA-6.1.

6.0 REFERENCES

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ATTACHMENT A

PURGING EQUIPMENT SELECTION

Diameter Casing		Bailer	Peristaltic Pump	Vacuum Pump	Air-lift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-Inch	Water level <25 feet	X	X	X	X	X			
	Water Level >25 feet	X			X				
2-Inch	Water level <25 feet	X	X	X	X	X	X		
	Water Level >25 feet	X			X		X		
4-Inch	Water level <25 feet	X	X	X	X	X	X	X	X
	Water Level >25 feet	X			X		X	X	X
6-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X
8-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 2

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	Dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 feet of submergence	$220-350	Requires compressed gas; custom sizes and materials available; acts as piezometer.
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	Portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	$500-600	AC/DC; variable speed control available; other models may have different flow rates.
ECO Pump Corp.	SAMPLifier	Portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	$400-700	AC, DC, or gasoline-driven motors available; must be primed.
Geltek Corp.	Bailer 219-4	Portable; grab (positive displacement)	1.66/38	Teflon®	No limit	1,075 mL	$120-135	Other sizes available.
GeoEngineering, Inc.	GEO-MONITOR	Dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	Probably 0-150	Approximately 1 liter for each 10 feet of submergence	$185	Acts as piezometer; requires compressed gas.
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	Portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2,800 mL/min	$1,500-3,000	Requires compressed gas; other models available; AC, DC, manual operation possible.
IEA	Syringe Sampler	Portable; grab (positive displacement)	1.75/43	SS, Teflon®	No limit	850 mL sample volume	$1,100	Requires vacuum and/or pressure from hand pump.
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	Portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Detrin®, acetal	0-150	0-7,500 mL/min	$990	Requires compressed gas (40 psi minimum).
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	Portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4,500 mL/min	$3,500	DC operated.
Leonard Mold and Die Works, Inc.	GeoFilter Small Diameter Well Pump (#0500)	Portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3,500 mL/min	$1,400-1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Detrin®	No limit	Approximately 250 mL	$125-160	Other materials and models available; for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	Dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2,000 mL/min	$300-400	Requires compressed gas; piezometric level indicator; other materials available.

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 3

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	Portable; peristaltic (suction)	<0.5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	$1,200-1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin® PP, Viton®, acrylic, PE	0-500	0-1,800 mL/min	$2,600-2,700	Requires compressed gas; water level indicator and flow meter; custom models available.
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1,100	250 mL/flushing cycle	$250-350	Requires compressed gas; SS available; piezometer model available; dedicated model available.
Solinst Canada Ltd.	5W Water Sampler	Portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	$1,300-1,800	Requires compressed gas; custom models available.
TIMCO Mfg. Co., Inc.	Std. Bailer	Portable; grab (positive displacement)	1.66/Custom	PVC, PP	No limit	250 mL/ft of bailer	$20-60	Other sizes, materials, models available; optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	$100-200	Requires compressed gas; other sizes, materials, models available; no solvents used.
Tole Devices Co.	Sampling Pump	Portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4,000 mL/min	$800-1,000	Compressed gas required; DC control module; custom built.

Construction Material Abbreviations:

- PE Polyethylene
- PP Polypropylene
- PVC Polyvinyl chloride
- SS Stainless steel
- PC Polycarbonate
- EPDM Ethylene-propylene diene (synthetic rubber)

Other Abbreviations:

- NA Not applicable
- AC Alternating current
- DC Direct current

NOTE: Other manufacturers market pumping devices which could be used for groundwater sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983.

ATTACHMENT B
GROUNDWATER SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: ____________
Project No.: ____________

[ ] Domestic Well Data
[x] Monitoring Well Data
[ ] Other Well Type: ____________
[ ] QA Sample Type: ____________

Sample ID No.: ____________
Sample Location: ____________
Sampled By: ____________
C.O.C. No.: ____________
Type of Sample:
[X] Low Concentration
[ ] High Concentration

SAMPLING DATA:

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	ORP	Other
Time:	Visual	Standard	mS/cm	Degrees C	NTU	mg/l	mV	NA
Method:								

PURGE DATA:

Date:	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	ORP	Other
Method:								
Monitor Reading (ppm):			SEE LOW FLOW PURGE DATA SHEET					
Well Casing Diameter & Material Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

ATTACHMENT C
LOW FLOW PURGE DATA SHEET

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: ____________________
PROJECT NUMBER: ____________________

WELL ID: ____________________
DATE: ____________________

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	pH (S.U.)	S. Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celcius)	ORP mV	Salinity % or ppt	Comments

SIGNATURE(S): ____________________

PAGE___OF___

TABLE OF CONTENTS

SECTION **PAGE**

TABLE OF CONTENTS (Continued)

FIGURES

NUMBERS **PAGE**

1.0 PURPOSE

The purpose of this document is to establish standard procedures and technical guidance on borehole and sample logging.

2.0 SCOPE

These procedures provide descriptions of the standard techniques for borehole and sample logging. These techniques shall be used for each boring logged to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Geologist. Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used on site, the Site Geologist must make sure that each field geologist is properly trained in logging procedures. A brief review or training session may be necessary prior to the start up of the field program and/or upon completion of the first boring.

5.0 PROCEDURES

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

5.1 Materials Needed

When logging soil and rock samples, the geologist or engineer may be equipped with the following:

- Rock hammer
- Knife
- Camera
- Dilute hydrochloric acid (HCl)
- Ruler (marked in tenths and hundredths of feet)
- Hand Lens

5.2 Classification of Soils

All data shall be written directly on the boring log (Figure 1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

FIGURE 1
BORING LOG (EXAMPLE)

BORING LOG

Page ___ of ___

PROJECT NAME: ______________________ BORING NUMBER: ______________________
PROJECT NUMBER: ______________________ DATE: ______________________
DRILLING COMPANY: ______________________ GEOLOGIST: ______________________
DRILLING RIG: ______________________ DRILLER: ______________________

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	MATERIAL DESCRIPTION: Color	MATERIAL DESCRIPTION: Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	PID/FID Reading (ppm): Sampler BZ	PID/FID Reading (ppm): Borehole**	PID/FID Reading (ppm): Driller BZ**

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated response read.

Remarks: ______________________

Drilling Area Background (ppm): ______

Converted to Well: Yes ______ No ______ Well I.D. #: ______________________

FIGURE 1 (CONTINUED)

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE-GRAINED SOILS — More Than Half of Material is LARGER Than No. 200 Sieve Size

FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)			GROUP SYMBOL	TYPICAL NAMES
GRAVELS (50% (+) > 1/4" ø)	CLEAN GRAVELS (Low % Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel-sand mixtures, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.
	GRAVELS W/FINES (High % Fines)	Non-plastic fines (for identification procedures, see ML)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures.
		Plastic fines (for identification procedures, see CL)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.
SANDS 50% (+) < 1/4" ø	CLEAN SANDS (Low % Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.
	SANDS W/FINES (High % Fines)	Non-plastic fines (for identification procedures, see ML)	SM	Silty sands, poorly graded sand-silt mixtures.
		Plastic fines (for identification procedures, see CL)	SC	Clayey sands, poorly graded sand-clay mixtures.

FINE-GRAINED SOILS — More Than Half of Material is SMALLER Than No. 200 Sieve Size

FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights) — Identification Procedures on Fraction Smaller than No. 40 Sieve Size	DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)	GROUP SYMBOL	TYPICAL NAMES
SILTS AND CLAYS Liquid Limit <50	None to Slight	Quick to Slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.
	Medium to High	None to Very Slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
	Slight to Medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity.
SILTS AND CLAYS Liquid Limit >50	Slight to Medium	Slow to None	Slight to Medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
	High to Very High	None	High	CH	Inorganic clays of high plasticity, fat clays.
	Medium to High	None to Very Slow	Slight to Medium	OH	Organic clays of medium to high plasticity.
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.			Pt	Peat and other organic soils

Boundary classifications: Soils possessing characteristics of two groups are designated by combining group symbols. For example, GW-GC, well graded gravel-sand mixture with clay binder.
All sieve sizes on this chart are U.S. Standard.

DENSITY OF GRANULAR SOILS

DESIGNATION	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT
Very Loose	0-4
Loose	5-10
Medium Loose	11-30
Dense	31-50
Very Dense	Over 50

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC. COMPRESSIVE STRENGTH (TONS/SQ. FT.)	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very Soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb.
Medium Stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb.
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb.
Very Stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail.
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail.

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)			ROCK BROKENNESS		
Descriptive Terms	Screwdriver or Knife Effects	Hammer Effects	Descriptive Terms	Abbreviation	Spacing
Soft	Easily Gouged	Crushes when pressed with hammer	Very Broken	(V. Br.)	0-2"
Medium Soft	Can be Gouged	Breaks (one blow); crumbly edges	Broken	(Br.)	2"-1'
Medium Hard	Can be scratched	Breaks (one blow); sharp edges	Blocky	(Bl.)	1'-3'
Hard	Cannot be scratched	Breaks conchoidally (several blows); sharp edges	Massive	(M.)	3'-10'

LEGEND:

SOIL SAMPLES - TYPES	ROCK SAMPLES - TYPES	WATER LEVELS
S-2" Split-Barrel Sample	X-NX (Conventional) Core (~2-1/8" O.D.)	12/18 ▽ 12.6' Initial Level w/Date & Depth
ST-3" O.D. Undisturbed Sample	Q-NQ (Wireline) Core (~1-7/8" O.D.)	
O - Other Samples, Specify in Remarks	Z - Other Core Sizes, Specify in Remarks	12/18 ▼ 12.6' Stabilized Level w/Date & Depth

5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Figure 1 (Continued).
This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse-grained soils shall be divided into rock fragments, sand, or gravel. The terms sand and gravel not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term rock fragments shall be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges typically observed indicate little or no transport from their source area, and therefore the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used it shall be followed by a size designation such as "(1/4 inchΦ-1/2 inchΦ)" or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

5.2.2 Color

Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors. Samplers tend to smear the sample surface creating color variations between the sample interior and exterior.

The term "mottled" shall be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

Soil Color Charts shall not be used unless specified by the project manager.

5.2.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are noncohesive (particles do not adhere well when compressed). Finer-grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split-barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.3. Those designations are:

Designation	Standard Penetration Resistance (Blows per Foot)
Very loose	0 to 4
Loose	5 to 10
Medium dense	11 to 30
Dense	31 to 50
Very dense	Over 50

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140-pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, or SC (see Figure 1).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Figure 2.

Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Figure 1).

The consistency of cohesive soils is determined either by blow counts, a pocket penetrometer (values listed in the table as Unconfined Compressive Strength), or by hand by determining the resistance to penetration by the thumb. The pocket penetrometer and thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample in the split-barrel sampler. The sample shall be broken in half and the thumb or penetrometer pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. Consistency shall not be determined solely by blow counts. One of the other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are shown in Figure 2.

5.2.4 Weight Percentages

In nature, soils are comprised of particles of varying size and shape, and are combinations of the various grain types. The following terms are useful in the description of soil:

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
Trace	0 - 10 percent
Some	11 - 30 percent
Adjective form of the soil type (e.g., "sandy")	31 - 50 percent

FIGURE 2

CONSISTENCY FOR COHESIVE SOILS

Consistency	Standard Penetration Resistance (Blows per Foot)	Unconfined Compressive Strength (Tons/Sq. Foot by pocket penetration)	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented with difficulty by thumbnail

Examples:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.
- Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.
- Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.
- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

5.2.5 Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire drilling job.

Laboratory tests for water content shall be performed if the natural water content is important.

5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Figure 3.

5.2.7 Texture/Fabric/Bedding

The texture/fabric/bedding of the soil shall be described. Texture is described as the relative angularity of the particles: rounded, subrounded, subangular, and angular. Fabric shall be noted as to whether the particles are flat or bulky and whether there is a particular relation between particles (i.e., all the flat particles are parallel or there is some cementation). The bedding or structure shall also be noted (e.g., stratified, lensed, nonstratified, heterogeneous varved).

5.2.8 Summary of Soil Classification

In summary, soils shall be classified in a similar manner by each geologist/engineer at a project site. The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (Optional)
- Soil types
- Moisture content
- Stratification
- Texture, fabric, bedding
- Other distinguishing features

FIGURE 3

BEDDING THICKNESS CLASSIFICATION

Thickness (metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3'	Massive
30 cm - 1 meter	1.0' - 3.3'	Thick Bedded
10 cm - 30 cm	4" - 1.0'	Medium Bedded
3 cm - 10 cm	1" - 4"	Thin Bedded
1 cm - 3 cm	2/5" - 1"	Very Thin Bedded
3 mm - 1 cm	1/8" - 2/5"	Laminated
1 mm - 3 mm	1/32" - 1/8"	Thinly Laminated
< 1 mm	<1/32"	Micro Laminated

(Weir, 1973 and Ingram, 1954)

5.3 Classification of Rocks

Rocks are grouped into three main divisions: sedimentary, igneous and metamorphic. Sedimentary rocks are by far the predominant type exposed at the earth's surface. The following basic names are applied to the types of rocks found in sedimentary sequences:

- Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.
- Siltstone - Made up of granular materials less than 1/16 to 1/256 mm in diameter. Fractures irregularly. Medium thick to thick bedded.
- Claystone - Very fine-grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.
- Shale - A fissile very fine-grained rock. Fractures along bedding planes.
- Limestone - Rock made up predominantly of calcite ($CaCO_3$). Effervesces strongly upon the application of dilute hydrochloric acid.
- Coal - Rock consisting mainly of organic remains.
- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. Conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

In classifying a sedimentary rock the following hierarchy shall be noted:

- Rock type
- Color
- Bedding thickness
- Hardness
- Fracturing
- Weathering
- Other characteristics

5.3.1 Rock Type

As described above, there are numerous types of sedimentary rocks. In most cases, a rock will be a combination of several grain types, therefore, a modifier such as a sandy siltstone, or a silty sandstone can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, etc.

Grain size is the basis for the classification of clastic sedimentary rocks. Figure 4 is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. For example, the division between siltstone and claystone may not be measurable in the field. The boundary shall be determined by use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a hand lens, the rock is a siltstone. If the grains are not distinguishable with a hand lens, the rock is a claystone.

FIGURE 4

GRAIN SIZE CLASSIFICATION FOR ROCKS

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4 - 64 mm
Granules	2 - 4 mm
Very Coarse Sand	1 - 2 mm
Coarse Sand	0.5 - 1 mm
Medium Sand	0.25 - 0.5 mm
Fine Sand	0.125 - 0.25 mm
Very Fine Sand	0.0625 - 0.125 mm
Silt	0.0039 - 0.0625 mm

After Wentworth, 1922

5.3.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples shall be classified while wet, when possible, and air cored samples shall be scraped clean of cuttings prior to color classifications.

Rock color charts shall not be used unless specified by the Project Manager.

5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification (see Figure 3) will also be used for rock classification.

5.3.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

- Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).

- Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.

- Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.

- Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage here of the works "scratch" and "gouge." A scratch shall be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

5.3.5 Fracturing

The degree of fracturing or brokenness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

- Very broken (V. BR.) - Less than 2-inch spacing between fractures
- Broken (BR.) - 2-inch to 1-foot spacing between fractures
- Blocky (BL.) - 1- to 3-foot spacing between fractures
- Massive (M.) - 3 to 10-foot spacing between fractures

The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage.

Method of Calculating RQD
(After Deere, 1964)

$$RQD\ \% = r/l \times 100$$

r = Total length of all pieces of the lithologic unit being measured, which are greater than 4 inches length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.

l = Total length of the coring run.

5.3.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

- Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.
- Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.
- Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.
- Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two rock units. These can be sharp or gradational.
- Stratification (parallel, cross stratified).
- Description of any filled cavities or vugs.
- Cementation (calcareous, siliceous, hematitic).
- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

- Seam - Thin (12 inches or less), probably continuous layer.
- Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."
- Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."
- Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."
- Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

The preceding sections describe the classification of sedimentary rocks. The following are some basic names that are applied to igneous rocks:

- Basalt - A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.
- Rhyolite - A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.
- Granite - A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.
- Diorite - A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.
- Gabbro - A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse-grained dark igneous rock.

The following are some basic names that are applied to metamorphic rocks:

- Slate - A very fine-grained foliated rock possessing a well developed slaty cleavage. Contains predominantly chlorite, mica, quartz, and sericite.
- Phyllite - A fine-grained foliated rock that splits into thin flaky sheets with a silky sheen on cleavage surface.
- Schist - A medium to coarse-grained foliated rock with subparallel arrangement of the micaceous minerals which dominate its composition.
- Gneiss - A coarse-grained foliated rock with bands rich in granular and platy minerals.
- Quartzite - A fine- to coarse-grained nonfoliated rock breaking across grains, consisting essentially of quartz sand with silica cement.

5.4 Abbreviations

Abbreviations may be used in the description of a rock or soil. However, they shall be kept at a minimum. Following are some of the abbreviations that may be used:

C	-	Coarse	Lt	-	Light	Yl	-	Yellow
Med	-	Medium	BR	-	Broken	Or	-	Orange
F	-	Fine	BL	-	Blocky	SS	-	Sandstone
V	-	Very	M	-	Massive	Sh	-	Shale
Sl	-	Slight	Br	-	Brown	LS	-	Limestone
Occ	-	Occasional	Bl	-	Black	Fgr	-	Fine-grained
Tr	-	Trace						

5.5 Boring Logs and Documentation

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceding sections shall be used to complete the logs. A sample boring log has been provided as Figure 5.

The field geologist/engineer shall use this example as a guide in completing each boring log. Each boring log shall be fully described by the geologist/engineer as the boring is being drilled. Every sheet contains space for 25 feet of log. Information regarding classification details is provided either on the back of the boring log or on a separate sheet, for field use.

5.5.1 Soil Classification

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.
- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology at 13.7 feet, shall be lined off at the proportional location between the 13- and 14-foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.
- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split-spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.
- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.
- The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart on back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.

FIGURE 5
COMPLETED BORING LOG (EXAMPLE)

BORING LOG

Page 1 of 1

PROJECT NAME: NSB- SITE
PROJECT NUMBER: 9594
DRILLING COMPANY: SOILTEST CO.
DRILLING RIG: CME- 55
BORING NUMBER: SB/MW 1
DATE: 3/8/96
GEOLOGIST: SJ CONTI
DRILLER: R. ROCK

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
S-1	0.0	7/6	1.5/2.0		M DENSE	BRN	SILTY SAND - SOME	SM	MOIST SL. ORG.	5	0	0	0
@ 0800	2.0	9/10			↓	TO BLK	ROCK FR. - TR BRICKS		ODOR				
						↓	(FILL)		FILL TO 4'±				
	4.0			4.0	↓	↓	↓						
S-2 @		5/7	2.0/2.0		M DENSE	BRN	SILTY SAND - TR FINE	SM	MOIST - W ODOR	10	0	-	-
0810	6.0	9/8					GRAVEL		NAT. MATL. TOOK SAMPLE				
	•			7'± ▽					SB01-0406 FOR ANALYSIS				
	8.0			8.0	↓	↓	↓						
S-3 @		6/8	1.9/2.0		DENSE	TAN BRN	FINE TO COARSE SAND	SW	WET	0	0	0	0
0820	10.0	17/16					TR. F. GRAVEL		HIT WATER @ 7'±				
	12.0			12.0	↓	↓	↓						
S-4 @		7/6	1.6/2.0		STIFF	GRAY	SILTY CLAY	CL	MOIST → WET	0	.5	-	-
0830	14.0	5/8											
	15.0			15.0	↓	↓	↓		AUGER REF @ 15'				
▼			▼	WEATHERED 16	M HARD	BRN	SILTSTONE	WBR	WEATHERED				
									LO ∠ JNTS @ 15.5				
9/5	①		4.0/5.0						WATER STAINS @ 16.5, 17.1, 17.5	0	0	0	0
				19'	↓	↓	↓	↓	LOSING SOME				
	20.0				HARD	GRAY	SANDSTONE - SOME	BR	DRILL H2O @ 17'±				
							SILTSTONE		SET TEMP 6" CAS TO 15.5				
4.9/5.0	②		5.0/5.0						SET 2" Ø PVC SCREEN 16-25	0	0	0	0
									SAND 14-25				
▲	25.0		▲	25	↓	↓	↓	↓	PELLETS 12-14				

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated response read.

• 1-20Z
1-80Z

Drilling Area Background (ppm): 0

Remarks: CME- 55 RIG, 4 1/4" ID HSA - 9" OD ±
2" SPLIT SPOONS - 140 LB HAMMER - 30" DROP
NX CORE IN BEDROCK RUN ① = 25 min, RUN ② = 15 min

Converted to Well: Yes ✓ No ______ Well I.D. #: MW-1

- Enter color of the material in the appropriate column.

- Describe material using the USCS. Limit this column for sample description only. The predominant material is described last. If the primary soil is silt but has fines (clay) - use clayey silt. Limit soil descriptors to the following:

  - Trace: 0 - 10 percent
  - Some: 11 - 30 percent
  - And/Or: 31 - 50 percent

- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.

- Enter USCS symbol - use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.

- The following information shall be entered under the "Remarks" column and shall include, but is not limited by, the following:

  - Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.

  - Angularity - describe angularity of coarse grained particles using the terms angular, subangular, subrounded, or rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.

  - Particle shape - flat, elongated, or flat and elongated.

  - Maximum particle size or dimension.

  - Water level observations.

  - Reaction with HCl - none, weak, or strong.

- Additional comments:

  - Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.

  - Indicate odor and Photoionization Detector (PID) or Flame Ionization Detector (FID) reading if applicable.

  - Indicate any change in lithology by drawing a line through the lithology change column and indicate the depth. This will help when cross-sections are subsequently constructed.

  - At the bottom of the page indicate type of rig, drilling method, hammer size and drop, and any other useful information (i.e., borehole size, casing set, changes in drilling method).

- Vertical lines shall be drawn (as shown in Figure 5) in columns 6 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.

- Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.2 Rock Classification

- Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent, and core recovery under the appropriate columns.

- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.

- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.

- Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.

- Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.

- Enter brokenness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.

- The following information shall be entered under the remarks column. Items shall include but are not limited to the following:

  - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.
  - Indicate calcareous zones, description of any cavities or vugs.
  - Indicate any loss or gain of drill water.
  - Indicate drop of drill tools or change in color of drill water.

- Remarks at the bottom of Boring Log shall include:

  - Type and size of core obtained.
  - Depth casing was set.
  - Type of rig used.

- As a final check the boring log shall include the following:

  - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.

  - If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying soil and rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole logging based on identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that shall be followed when logging cuttings are:

- Obtain cutting samples at approximately 5-foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future reference, and label the jar or bag (i.e. hole number, depth, date, etc.). Cuttings shall be closely examined to determine general lithology.

- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.

- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.

- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.

- Record this and any other useful information onto the boring log as provided in Figure 1.

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split-barrel and rock core sampling methods be used at selected boring locations during the field investigation to provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

5.6 <u>Review</u>

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

- Checking for consistency of all logs.
- Checking for conformance to the guideline.
- Checking to see that all information is entered in their respective columns and spaces.

6.0 REFERENCES

Unified Soil Classification System (USCS).

ASTM D2488, 1985.

Earth Manual, U.S. Department of the Interior, 1974.

7.0 RECORDS

Originals of the boring logs shall be retained in the project files.

TABLE OF CONTENTS

1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of monitoring wells. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be determined during the project planning phases of the investigation, and any required permits must be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

3.0 GLOSSARY

Monitoring Well - A well which is screened, cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored. Some monitoring wells may be constructed as open boreholes.

Piezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch-diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface representative of the level to which water will rise in a well cased to the screened aquifer.

Well Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a solid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of performing all phases of proper monitoring well installation and construction. The driller may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Field Geologist - The field geologist supervises and documents well installation and construction performed by the driller, and insures that well construction is adequate to provide representative groundwater data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

5.0 PROCEDURES

5.1 Equipment/Items Needed

Below is a list of items that may be needed when installing a monitoring well or piezometer:

- Health and safety equipment (hard hats, safety glasses, etc.) as required by the Site Safety Officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineer's tape, water level indicator, retractable engineers rule, electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installation tools (sledge hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 Well Design

The objectives and intended use for each monitoring well must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity).

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, groundwater flow directions and potential well locations can be determined by an experienced hydrogeologist through the review of geologic data and the site terrain. In addition, data from production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary investigative phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored interval must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the depths at which contaminants are present. Conversely, a fully penetrating well is usually not used to quantify or vertically locate a contaminant plume, since groundwater samples collected in wells that are screened over the full thickness of the water-bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of contamination in the water-bearing zone. The well diameter desired depends upon the hydraulic characteristics of the water-bearing zone, sampling requirements, drilling method and cost.

The decision concerning the monitored interval and well depth is based on the following (and possibly other) information:

- The vertical location of the contaminant source in relation to the water-bearing zone.
- The depth, thickness and uniformity of the water-bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (5 feet or less) are usually required where flow lines are not horizontal, (i.e., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs.

Standard monitoring well diameters are 2, 4, 6, or 8 inches. Drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch-diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open-hole bedrock monitoring wells are used. With smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced; however, the sampling devices that can be used are limited.

In specifying well diameter, sampling requirements must be considered (up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples), particularly if the monitored formation is known to be a low-yielding formation. The unit volume of water contained within a monitoring well is dependent on the well diameter as follows:

Casing Inside Diameter (Inch)	Standing Water Length to Obtain 1 Gallon Water (Feet)
2	6.13
4	1.53
6	0.68

If a well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells (for installation of high capacity pumps); however, in small-diameter wells in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "Schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength". Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation; risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive presentation on this topic). The two most commonly used materials are PVC and stainless steel. Properties of these two materials are compared in Attachment B. Stainless steel is a good choice where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, ease of manipulation, and widespread acceptance. The crushing strength of PVC may limit the depth of installation, but the use of Schedule 80 materials may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps required for sampling or testing. Due to this problem, the minimum well pipe size recommended for Schedule 80 wells is 4-inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe may corrode and release metal ions or chemically react with organic constituents, but this is considered a minor issue. Galvanized steel is not recommended where samples may be collected for metals analyses, as zinc and cadmium levels in groundwater samples may become elevated from leaching of the zinc coating.

Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints. Welded-joint steel casing is also acceptable. Glued PVC may release organic contaminants into the well, and therefore, should not be used if the well is to be sampled for organic constituents.

When the water-bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary, and the annular borehole space around the screened interval is artificially packed with an appropriately sized sand, selected based on formation grain size. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The site geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water-bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. For example, as a standard procedure, a Morie No. 1 or No. 10 to No. 20 U.S. Standard Sieve size filter pack is typically appropriate for a 0.020-inch slot screen; however, a No. 20 to No. 40 U.S. Standard Sieve size filter pack is typically appropriate for a 0.010-inch slot screen.

5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a medium- to coarse-grained poorly graded, silica sand and should relate to the grain size of the aquifer sediments. The quantity of sand placed in the annular space is dependent upon the length of the screened interval, but should always extend at least 1 foot above the top of the screen. At least 1 to 3 feet of bentonite pellets or equivalent shall be placed above the sand pack. Cement-bentonite grout (or equivalent) is then placed to extent from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally (i.e., no artificial sand pack installed). In this case, the natural formation material is allowed to collapse around the well screen after the well is installed. This method has been used where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets, extending to the surface. The grout effectively seals the remaining borehole annulus and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom upward, to prevent bridging, and to provide a better seal. In shallow boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of one or two assemblages of material, (e.g., cement and/or bentonite). A cement-bentonite grout, which is the most common type of grout used in monitoring well completions, normally is a mixture of cement, bentonite, and water at a ratio of one 90-pound bag of Portland Type I cement, plus 3 to 5 pounds of granular or flake-type bentonite, and 6-7 gallons of water. A neat cement consists of one ninety-pound bag of Portland Type I cement and 6-7 gallons of water. A bentonite slurry (bentonite and water mixed to a thick but pumpable mixture) is sometimes used instead of grout for deep well installations where placement of bentonite pellets is difficult. Bentonite chips are also occasionally used for annular backfill in place of grout.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets/chips or sand. A short (1- to 2-foot) section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is typically placed over the top of the well. This casing generally has a hinged cap and can be locked to prevent vandalism. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

A protective casing which is level with the ground surface (flush-mounted) is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter, manhole-type protective collar is set into the wet cement around the well with the top set level with or slightly above the pavement. An appropriately-sized id is placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

5.3 Monitoring Well Installation

Pertinent data regarding monitoring well installation shall be recorded on log sheets as depicted and discussed in SOP SA-6.3. Attachments to this referenced SOP illustrate terms and physical construction of various types of monitoring wells.

5.3.1 Monitoring Wells in Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow-stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineer's rule to ensure proper placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, the sand pack can be installed. A weighted tape measure must be used during the installation procedure to carefully monitor installation progress. The sand is slowly poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur. Centralizers may be used at the geologist's discretion, one above and one below the screen, to assure enough annular space for sand pack placement.

After the sand pack is installed to the desired depth (at least 1 foot above the top of the screen), then the bentonite pellet seal (or equivalent), can be installed in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack. Pellets should be added slowly and their fall monitored closely to ensure that bridging does not occur.

The cement-bentonite grout is then mixed and tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between aquifers. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large-diameter boring through the upper aquifer, 1 to 5 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting a large-diameter casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for installation of the monitoring well as detailed for overburden monitoring wells. Sufficient time (determined by the field geologist), must be allowed for setting of the grout prior to drilling through the confined layer.

5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 –10 feet into bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout has cured, a smaller diameter boring is continued into bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. If a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be removed when the final well installation is completed.

5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen section is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be manually driven to depths exceeding 10 feet.

Direct push sampling/monitoring point installation methods, using a direct push rig or drilling rig, are described in SOP SA-2.5.

5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only small-diameter tubes extending to the surface. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross-contamination from sampling equipment. Four manufacturers of these samplers include Timco Manufacturing Company, Inc., of Prairie du Sac, Wisconsin, BARCAD Systems, Inc., of Concord, Massachusetts, Westbay Instruments Ltd. of Vancouver, British Columbia, Canada and the University of Waterloo at Waterloo, Ontario, Canada.. Each manufacturer offers various construction materials.

5.4 Well Development Methods

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity, turbidity, and temperature taken during development may yield information (stabilized values) regarding whether sufficient development has been performed. The selection of the well development method shall be made by the field geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

5.4.1 Overpumping and Backwashing

Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods, including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.

5.4.2 Surging with a Surge Plunger

A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is aggressively moved up and down within the well to agitate the water, causing it to move in and out of the screens. This movement of water pulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

5.4.3 Compressed Air

Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus introducing air into the formation and reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping of the well is subsequently done using the air lift method.

5.4.4 High Velocity Jetting

In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

6.0 RECORDS

A critical part of monitoring well installation is recording of all significant details and events in the site logbook or field notebook. The geologist must record the exact depths of significant hydrogeological features, screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (see Attachments to SOP SA-6.3) shall be completed, ensuring the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information shall include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. Documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded, depending on whether the well is completed in overburden (single- or double-cased), as a cased well in bedrock, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The geologist shall calculate the annular space volume and have an idea of the quantity of material needed to fill the annular space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in or bridging of the backfill materials. Any problems with rig operation or down-time shall be recorded and may affect the driller's final fee.

7.0 REFERENCES

Scalf, M. R., J. F. McNabb, W. J. Dunlap, R. L. Cosby, and J. Fryberger, 1981. Manual of Groundwater Sampling Procedures. R. S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Ada, Oklahoma.

Barcelona, M. J., P. P. Gibb and R. A. Miller, 1983. A Guide to the selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

Driscoll, Fletcher G., 1986. Groundwater and Wells. Johnson Division, St. Paul, Minnesota, 1989.

ATTACHMENT A

RELATIVE COMPATIBILITY OF RIGID WELL CASING MATERIAL (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material						
	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless Steel 304	Stainless Steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Mineral Acid/ High Solids Content	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials:

1 Teflon®
2 Stainless Steel 316
3. Stainless Steel 304
4 PVC 1
5 Lo-Carbon Steel
6 Galvanized Steel
7 Carbon Steel

* Trademark of DuPont

RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material								
	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton®*	Silicone	Neoprene	Teflon®*
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/ High Solids Content	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials:

1 Teflon®
2 Polypropylene (PP)
3. PVC Flexible/PE Linear
4 Viton®
5 PE Conventional
6 Plexiglas/Lucite (PMM)
7 Silicone/Neoprene

* Trademark of DuPont

Source: Barcelona et al., 1983

ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength are not critical.
Weight	Relatively heavier.	Light-weight; floats in water.
Cost	Relatively expensive.	Relatively inexpensive.
Corrosivity	Deteriorates more rapidly in corrosive water.	Non-corrosive -- may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated hydrocarbons.
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work with in the field.
Preparation for Use	Should be steam cleaned if organics will be subsequently sampled.	Never use glue fittings -- pipes should be threaded or pressure fitted. Should be steam cleaned when used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized.	May sorb or release organic substances.

* See also Attachment A.

TABLE OF CONTENTS

SECTION **PAGE**

ATTACHMENTS

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs and reports generally initiated and maintained for documenting Tetra Tech NUS field activities.

2.0 SCOPE

Documents presented within this procedure (or equivalents) shall be used for all Tetra Tech NUS field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 GLOSSARY

None

4.0 RESPONSIBILITIES

Project Manager (PM) - The Project Manager is responsible for obtaining hardbound, controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all field documentation used in site activities (i.e., records, field reports, sample data sheets, field notebooks, and the site logbook) in the project's central file upon the completion of field work.

Field Operations Leader (FOL) - The Field Operations Leader is responsible for ensuring that the site logbook, notebooks, and all appropriate and current forms and field reports illustrated in this guideline (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time-frame.

5.0 PROCEDURES

5.1 Site Logbook

5.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major onsite activities are documented. At a minimum, the following activities/events shall be recorded or referenced (daily) in the site logbook:

- All field personnel present
- Arrival/departure of site visitors
- Time and date of H&S training
- Arrival/departure of equipment
- Time and date of equipment calibration
- Start and/or completion of borehole, trench, monitoring well installation, etc.
- Daily onsite activities performed each day
- Sample pickup information
- Health and Safety issues (level of protection observed, etc.)
- Weather conditions

A site logbook shall be maintained for each project. The site logbook shall be initiated at the start of the first onsite activity (e.g., site visit or initial reconnaissance survey). Entries are to be made for every day that onsite activities take place which involve Tetra Tech NUS or subcontractor personnel. Upon completion of the fieldwork, the site logbook must become part of the project's central file.

The following information must be recorded on the cover of each site logbook:

- Project name
- Tetra Tech NUS project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2), but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the field notebook in which the measurements are recorded (see Attachment A).

All logbook, notebook, and log sheet entries shall be made in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook pages used must be signed and dated. The site logbook must also be signed by the Field Operations Leader at the end of each day.

5.1.2 Photographs

When movies, slides, or photographs are taken of a site or any monitoring location, they must be numbered sequentially to correspond to logbook/notebook entries. The name of the photographer, date, time, site location, site description, and weather conditions must be entered in the logbook/notebook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook/notebook. If possible, such techniques shall be avoided, since they can adversely affect the accuracy of photographs. Chain-of-custody procedures depend upon the subject matter, type of camera (digital or film), and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Once processed, the slides of photographic prints shall be consecutively numbered and labeled according to the logbook/notebook descriptions. The site photographs and associated negatives and/or digitally saved images to compact disks must be docketed into the project's central file.

5.2 Field Notebooks

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a separate field notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a field notebook.

5.3 Field Forms

All Tetra Tech NUS field forms (see list in Section 6.0 of this SOP) can be found on the company's intranet site (http://intranet.ttnus.com) under Field Log Sheets. Forms may be altered or revised for project-specific needs contingent upon client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOP.

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 Sample Log Sheet

Sample Log Sheets are used to record specified types of data while sampling. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. A log sheet must be completed for each sample obtained, including field quality control (QC) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B. Adhesive labels must be completed and applied to every sample container. Sample labels can usually be obtained from the appropriate Program source electronically generated in-house, or are supplied from the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record Form

The Chain-of-Custody (COC) Record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site. One carbonless copy of the completed COC form is retained by the field crew, one copy is sent to the Project Manager (or designee), while the original is sent to the laboratory. The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing vials for VOC analysis or the cooler with the air bill attached. The air bill should then state how many coolers are included with that shipment. An example of a Chain-of-Custody Record form is provided as Attachment C. Once the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed COC form (any discrepancies between the sample labels and COC form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the Tetra Tech NUS Project Manager). The COC form is signed and copied. The laboratory will retain the copy while the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Chain-of-Custody Seal

Attachment D is an example of a custody seal. The Custody seal is an adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. The COC seals are signed and dated by the sampler(s) and affixed across the lid and body of each cooler (front and back) containing environmental samples (see SOP SA-6.1). COC seals may be available from the laboratory; these seals may also be purchased from a supplier.

5.3.1.5 Geochemical Parameters Log Sheets

Field Analytical Log Sheets are used to record geochemical and/or natural attenuation field test results.

5.3.2 Hydrogeological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

A Groundwater Level Measurement Sheet must be filled out for each round of water level measurements made at a site.

5.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. The Pumping Test Data Sheet facilitates this task by standardizing the data collection format for the pumping well and observation wells, and allowing the time interval for collection to be laid out in advance.

5.3.2.3 Packer Test Report Form

A Packer Test Report Form must be completed for each well upon which a packer test is conducted.

5.3.2.4 Boring Log

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring, or Boring Log is used for this purpose and must be completed for each soil boring performed. In addition, if volatile organics are monitored on cores, samples, cuttings from the borehole, or breathing zone, (using a PID or FID), these readings must be entered on the boring log at the appropriate depth. The "Remarks" column can be used to subsequently enter the laboratory sample number, the concentration of key analytical results, or other pertinent information. This feature allows direct comparison of contaminant concentrations with soil characteristics.

5.3.2.5 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock, stick-up or flush mount), different forms are used.

5.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician.

5.3.2.7 Miscellaneous Monitoring Well Forms

Monitoring Well Materials Certificate of Conformance should be used as the project directs to document all materials utilized during each monitoring well installation.

The Monitoring Well Development Record should be used as the project directs to document all well development activities.

5.3.2.8 Miscellaneous Field Forms - QA and Checklists

Container Sample and Inspection Sheet should be used as the project directs each time a container (drum, tank, etc.) is sampled and/or inspected.

QA Sample Log Sheet should be used at the project directs each time a QA sample is colleted, such as Rinsate Blank, Source Blank, etc.

Field Task Modification Request (FTMR) will be prepared for all deviations from the project planning documents. The FOL is responsible for initiating the FTMRs. Copies of all FTMRs will be maintained with the onsite planning documents and originals will be placed in the final evidence file.

The Field Project Daily Activities Check List and Field Project Pre-Mobilization Checklist should be used during both the planning and field effort to assure that all necessary tasks are planned for and completed. These two forms are not a requirement but a useful tool for most field work.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. An Equipment Calibration Log must be maintained for each electronic measuring device used in the field; entries must be made for each day the equipment is used or in accordance with the manufacturer's recommendations.

5.4 Field Reports

The primary means of recording onsite activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation, but are not easily useful for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain onsite for extended periods of time and are thus not accessible for timely review by project management.

5.4.1 Daily Activities Report

To provide timely oversight of onsite contractors, Daily Activities Reports are completed and submitted as described below.

5.4.1.1 Description

The Daily Activities Report (DAR) documents the activities and progress for each day's field work. This report must be filled out on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring which involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors. The DAR form can be found on the TtNUS intranet site.

5.4.1.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.1.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the Daily Activities Report to the Field Operations Leader (FOL) for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DAR reports are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the Project Manager.

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

It should be noted that in addition to summaries described herein, other summary reports may also be contractually required.

All Tetra Tech NUS field forms can be found on the company's intranet site at http://intranet.ttnus.com under Field Log Sheets.

6.0 LISTING OF TETRA TECH NUS FIELD FORMS FOUND ON THE TTNUS INTRANET SITE. HTTP://INTRANET.TTNUS.COM CLICK ON FIELD LOG SHEETS

Groundwater Sample Log Sheet
Surface Water Sample Log Sheet
Soil/Sediment Sample Log Sheet
Container Sample and Inspection Sheet
Geochemical Parameters (Natural Attenuation)
Groundwater Level Measurement Sheet
Pumping Test Data Sheet
Packer Test Report Form
Boring Log
Monitoring Well Construction Bedrock Flush Mount
Monitoring Well Construction Bedrock Open Hole
Monitoring Well Construction Bedrock Stick Up
Monitoring Well Construction Confining Layer
Monitoring Well Construction Overburden Flush Mount
Monitoring Well Construction Overburden Stick Up
Test Pit Log
Monitoring Well Materials Certificate of Conformance
Monitoring Well Development Record

Daily Activities Record
Field Task Modification Request
Hydraulic Conductivity Test Data Sheet
Low Flow Purge Data Sheet
QA Sample Log Sheet
Equipment Calibration Log
Field Project Daily Activities Checklist
Field Project Pre-Mobilization Checklist

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: ______________________________ DATE: ______________________________

SITE LEADER: ____
PERSONNEL:

TtNUS	DRILLER	SITE VISITORS
________________	________________	________________
________________	________________	________________
________________	________________	________________

WEATHER: Clear, 68EF, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.
2. Drilling activities at well ____ resumes. Rig geologist was _______________. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well ______.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _______.
4. Well ______ drilled. Rig geologist was ____________________. See Geologist's Notebook, No. 2, page ____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _________.
8. Test pit _______ dug with cuttings placed in dump truck. Rig geologist was _______________. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit ___ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.

____

Field Operations Leader

ATTACHMENT B

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090	**Project:** **Site:** **Location:**

Sample No:	**Matrix:**

Date:	**Time:**	**Preserve:**

Analysis:

Sampled by:	**Laboratory:**

ATTACHMENT C

TETRA TECH NUS, INC. **CHAIN OF CUSTODY** **NUMBER** 3413 **PAGE ___ OF ___**

PROJECT NO:	FACILITY:	PROJECT MANAGER	PHONE NUMBER	LABORATORY NAME AND CONTACT:
SAMPLERS (SIGNATURE)		FIELD OPERATIONS LEADER	PHONE NUMBER	ADDRESS
		CARRIER/WAYBILL NUMBER		CITY, STATE

STANDARD TAT ☐
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

CONTAINER TYPE PLASTIC (P) or GLASS (G)

PRESERVATIVE USED

TYPE OF ANALYSIS

DATE YEAR	TIME	SAMPLE ID	LOCATION ID	TOP DEPTH (FT)	BOTTOM DEPTH (FT)	MATRIX (GW, SO, SW, SD, QC, ETC.)	COLLECTION METHOD GRAB (G) COMP (C)	No. OF CONTAINERS									COMMENTS

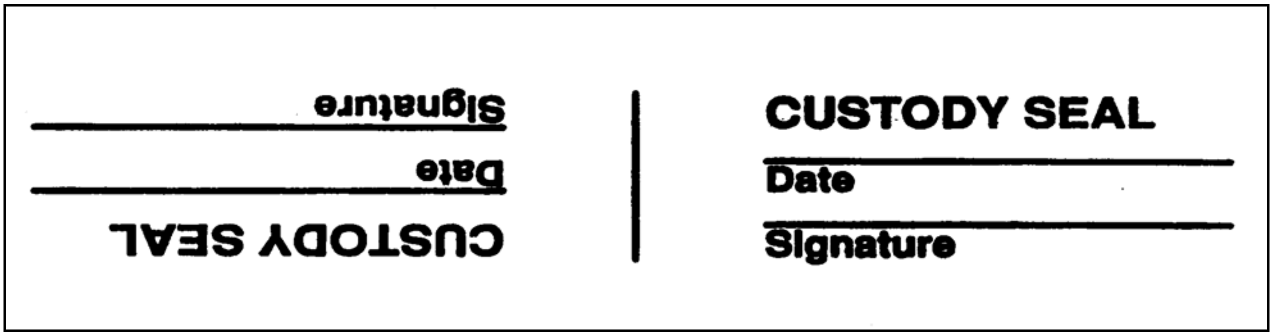
1. RELINQUISHED BY	DATE	TIME	1. RECEIVED BY	DATE	TIME
2. RELINQUISHED BY	DATE	TIME	2. RECEIVED BY	DATE	TIME
3. RELINQUISHED BY	DATE	TIME	3. RECEIVED BY	DATE	TIME
COMMENTS					

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (FIELD COPY) PINK (FILE COPY)

4/02R FORM NO. TtNUS-001

ATTACHMENT D

CHAIN-OF-CUSTODY SEAL



TETRA TECH NUS, INC.	**STANDARD OPERATING PROCEDURES**	Number SA-7.1	Page 1 of 8
		Effective Date 09/03	Revision 3
		Applicability Tetra Tech NUS, Inc.	
		Prepared Earth Sciences Department	
Subject DECONTAMINATION OF FIELD EQUIPMENT		Approved D. Senovich	

TABLE OF CONTENTS

SECTION **PAGE**

1.0 PURPOSE

Decontamination is the process of removing and/or neutralizing site contaminants that have contacted and/or accumulated on equipment. The objective/purpose of this SOP is intended to protect site personnel, general public, and the sample integrity through the prevention of cross contamination onto unaffected persons or areas. It is further intended through this procedure to provide guidelines regarding the appropriate procedures to be followed when decontaminating drilling equipment, monitoring well materials, chemical sampling equipment and field analytical equipment.

2.0 SCOPE

This procedure applies to all equipment including drilling equipment, heavy equipment, monitoring well materials, as well as chemical sampling and field analytical equipment decontamination that may be used to provide access/acquire environmental samples. Where technologically and economically feasible, single use sealed disposable equipment will be employed to minimize the potential for cross contamination. This procedure also provides general reference information on the control of contaminated materials.

3.0 GLOSSARY

Acid - For decontamination of equipment when sampling for trace levels of inorganics, a 10% solution of nitric acid in deionized water should be used. Due to the leaching ability of nitric acid, it should not be used on stainless steel.

Alconox/Liquinox - A brand of phosphate-free laboratory-grade detergent.

Decontamination Solution - Is a solution selected/identified within the Health and Safety Plan or Project-Specific Quality Assurance Plan. The solution is selected and employed as directed by the project chemist/health and safety professional.

Deionized Water (DI) - Deionized water is tap water that has been treated by passing through a standard deionizing resin column. This water may also pass through additional filtering media to attain various levels of analyte-free status. The DI water should meet CAP and NCCLS specifications for reagent grade, Type I water.

Potable Water - Tap water used from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

Pressure Washing - Employs high pressure pumps and nozzle configuration to create a high pressure spray of potable water. High pressure spray is employed to remove solids.

Solvent - The solvent of choice is pesticide-grade Isopropanol. Use of other solvents (methanol, acetone, pesticide-grade hexane, or petroleum ether) may be required for particular projects or for a particular purpose (e.g. for the removal of concentrated waste) and must be justified in the project planning documents. As an example, it may be necessary to use hexane when analyzing for trace levels of pesticides, PCBs, or fuels. In addition, because many of these solvents are not miscible in water, the equipment should be air dried prior to use. Solvents should not be used on PVC equipment or well construction materials.

Steam Pressure Washing - This method employs a high pressure spray of heated potable water. This method through the application of heat provides for the removal of various organic/inorganic compounds.

4.0 RESPONSIBILITIES

Project Manager - Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) requirements.

Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved Standards Operating Procedures or as otherwise dictated by the approved project plan(s).

Site Health and Safety Officer (SHSO) - The SHSO exercises shared responsibility with the FOL concerning decontamination effectiveness. All equipment arriving on-site (as part of the equipment inspection), leaving the site, moving between locations are required to go through a decontamination evaluation. This is accomplished through visual examination and/or instrument screening to determine the effectiveness of the decontamination process. Failure to meet these objectives are sufficient to restrict equipment from entering the site/exiting the site/ or moving to a new location on the site until the objectives are successfully completed.

5.0 PROCEDURES

The process of decontamination is accomplished through the removal of contaminants, neutralization of contaminants, or the isolation of contaminants. In order to accomplish this activity a level of preparation is required. This includes site preparation, equipment selection, and evaluation of the process. Site contaminant types, concentrations, media types, are primary drivers in the selection of the types of decontamination as well as where it will be conducted. For purposes of this SOP discussion will be provided concerning general environmental investigation procedures.

The decontamination processes are typically employed at:

- Temporary Decontamination Pads/Facilities
- Sample Locations
- Centralized Decontamination Pad/Facilities
- Combination of some or all of the above

The following discussion represents recommended site preparation in support of the decontamination process.

5.1 Decontamination Design/Constructions Considerations

5.1.1 Temporary Decontamination Pads

Temporary decontamination pads are constructed at satellite locations in support of temporary work sites. These structures are generally constructed to support the decontamination of heavy equipment such as drill rigs and earth moving equipment but can be employed for smaller articles.

The purpose of the decontamination pad is to contain wash waters and potentially contaminated soils generated during decontamination procedures. Therefore, construction of these pads should take into account the following considerations

- Site Location – The site selected should be within a reasonable distance from the work site but should avoid:

  - Pedestrian/Vehicle thoroughfares
  - Areas where control/custody cannot be maintained
  - Areas where a potential releases may be compounded through access to storm water transport systems, streams or other potentially sensitive areas.
  - Areas potentially contaminated.

- Pad – The pad should be constructed to provide the following characteristics

  - Size – The size of the pad should be sufficient to accept the equipment to be decontaminated as well as permitting free movement around the equipment by the personnel conducting the decontamination.

  - Slope – An adequate slope will be constructed to permit the collection of the water and potentially contaminated soils within a trough or sump constructed at one end. The collection point for wash waters should be of adequate distance that the decontamination workers do not have to walk through the wash waters while completing their tasks.

  - Sidewalls – The sidewalls should be a minimum of 6-inches in height to provide adequate containment for wash waters and soils. If splash represents a potential problem, splash guards should be constructed to control overspray. Sidewalls maybe constructed of wood, inflatables, sand bags, etc. to permit containment.

  - Liner – Depending on the types of equipment and the decontamination method the liner should be of sufficient thickness to provide a puncture resistant barrier between the decontamination operation and the unprotected environment. Care should be taken to examine the surface area prior to placing the liner to remove sharp articles (sticks, stones, debris) that could puncture the liner. Liners are intended to form an impermeable barrier. The thickness may vary from a minimum recommended thickness of 10 mil to 30 mil. Achieving the desired thickness maybe achieved through layering lighter constructed materials. It should be noted that various materials (rubber, polyethylene sheeting) become slippery when wet. To minimize this potential hazard associated with a sloped liner a light coating of sand maybe applied to provide traction as necessary.

  - Wash/drying Racks – Auger flights, drill/drive rods require racks positioned off of the ground to permit these articles to be washed, drained, and dried while secured from falling during this process. A minimum ground clearance of 2-feet is recommended.

  - Maintenance – The work area should be periodically cleared of standing water, soils, and debris. This action will aid in eliminating slip, trip, and fall hazards. In addition, these articles will reduce potential backsplash and cross contamination. Hoses should be gathered when not in use to eliminate potential tripping hazards.

5.1.2 Decontamination Activities at Drill Rigs/DPT Units

During subsurface sampling activities including drilling and direct push activities decontamination of drive rods, Macro Core Samplers, split spoons, etc. are typically conducted at an area adjacent to the operation. Decontamination is generally accomplished using a soap/water wash and rinse utilizing buckets and brushes. This area requires sufficient preparation to accomplish the decontamination objectives.

Buckets shall be placed within mortar tubs or similar secondary containment tubs to prevent splash and spills from reaching unprotected media. Drying racks will be employed as directed for temporary pads to permit parts to dry and be evaluated prior to use/re-use.

5.1.3 Decontamination Activities at Remote Sample Locations

When sampling at remote locations sampling devices such as trowels, pumps/tubing should be evacuated of potentially contaminated media to the extent possible. This equipment should be wrapped in plastic for transport to the temporary/centralized decontamination location for final cleaning and disposition.

5.2 Equipment Decontamination Procedures

The following represents procedures to be employed for the decontamination of equipment that may have contacted and/or accumulated contamination through site investigation activities.

5.2.1 Monitoring Well Sampling Equipment

5.2.1.1 Groundwater sampling pumps – This includes pumps inserted into the monitoring well such as Bladder pumps, Whale pumps, Redi-Flo, reusable bailers, etc.

1) Evacuate to the extent possible, any purge water within the pump.

2) Scrub using soap and water and/or steam clean the outside of the pump and tubing, where applicable.

3) Insert the pump and tubing into a clean container of soapy water. Pump a sufficient amount of soapy water through the pump to flush any residual purge water. Once flushed, circulate soapy water through the pump to ensure the internal components are thoroughly flushed.

4) Remove the pump and tubing from the container, rinse external components using tap water. Insert the pump and tubing into a clean container of tap water. Pump a sufficient amount of tap water through the pump to evacuate all of the soapy water (until clear).

5) Rinse equipment with pesticide grade isopropanol

6) Repeat item #4 using deionized water through the hose to flush out the tap water and solvent residue as applicable*.

7) Drain residual deionized water to the extent possible, allow components to air dry.

8) Wrap pump in aluminum foil or a clear clean plastic bag for storage.

5.2.1.2 Electronic Water Level Indicators/Sounders/Tapes

During water level measurements, rinsing with the extracted tape and probe with deionized water and wiping the surface of the extracted tape is acceptable. However, periodic full decontamination should be conducted as indicated below.

---

* - The solvent should be employed when samples contain oil, grease, PAHs, PCBs, and other hard to remove materials. If these are not of primary concern, the solvent step may be omitted. In addition, do not rinse PE, PVC, and associated tubing with solvents.

1) Wash with soap and water
2) Rinse with tap water
3) Rinse with deionized water

Note: In situations where oil, grease, free product, other hard to remove materials are encountered probes and exposed tapes should be washed in hot soapy water.

5.2.1.3 Miscellaneous Equipment

Miscellaneous equipment including analytical equipment (water quality testing equipment) should be cleaned per manufacturer's instructions. This generally includes wiping down the sensor housing and rinsing with tap and deionized water.

Coolers/Shipping Containers employed to ship samples are received from the lab in a variety of conditions from marginal to extremely poor. Coolers should be evaluated prior to use for

- Structural integrity – Coolers missing handles or having breaks within the outer housing should be removed and not used. Notify the laboratory that the risk of shipping samples will not be attempted and request a replacement unit.

- Cleanliness – As per protocol only volatile organic samples are accompanied by a trip blank. If a cooler's cleanliness is in question (visibly dirty/stained) or associated with noticeable odors it should be decontaminated prior to use.

  1) Wash with soap and water
  2) Rinse with tap water
  3) Dry

If these measures fail to clean the cooler to an acceptable level, remove the unit from use as a shipping container and notify the laboratory to provide a replacement unit.

5.2.2 Down-Hole Drilling Equipment

This includes any portion of the drill rig that is over the borehole including auger flights, drill stems, rods, and associated tooling that would extend over the borehole. This procedure is to be employed prior to initiating the drilling/sampling activity, then between locations.

1) Remove all soils to the extent possible using shovels, scrapers, etc. to remove loose soils.
2) Through a combination of scrubbing using soap and water and/or steam cleaning remove visible dirt/soils.
3) Rinse with tap water.
4) Rinse equipment with pesticide grade isopropanol
5) To the extent possible allow components to air dry.
6) Wrap or cover equipment in clear plastic until it is time to be used.

5.2.3 Soil/Sediment Sampling Equipment

This consists of soil sampling equipment including but not limited to hand augers, stainless steel trowels/spoons, bowls, dredges, scoops, split spoons, Macro Core samplers, etc.

1) Remove all soils to the extent possible.

2) Through a combination of scrubbing using soap and water and/or steam cleaning remove visible dirt/soils.

3) Rinse with tap water.

4) Rinse equipment with pesticide grade isopropanol

5) Rinse with deionized water

6) To the extent possible allow components to air dry.

7) If the device is to be used immediately, screen with a PID/FID to insure all solvents (if they were used) and trace contaminants have been adequately removed.

8) Once these devices have been dried wrap in aluminum foil for storage until it is time to be used.

5.3 Contact Waste/Materials

During the course of field investigations disposable/single use equipment becomes contaminated. These items include tubing, trowels, PPE (gloves, overboots, splash suits, etc.) broken sample containers.

With the exception of the broken glass, single use articles should be cleaned (washed and rinsed) of visible materials and disposed of as normal refuse. The exception to this rule is that extremely soiled materials that cannot be cleaned should be containerized for disposal in accordance with applicable federal state and local regulations.

5.3.1 Decontamination Solutions

All waste decontamination solutions and rinses must be assumed to contain the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. The waste solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.

Containerized waste rinse solutions are best stored in 55-gallon drums (or equivalent containers) that can be sealed until ultimate disposal at an approved facility. These containers must be appropriately labeled.

5.4 Decontamination Evaluation

Determining the effectiveness of the decontamination process will be accomplished in the following manner

- Visual Evaluation – A visual evaluation will be conducted to insure the removal of particulate matter. This will be done to insure that the washing/rinsing process is working as intended.

- Instrument Screening – A PID and/or an FID should be used to evaluate the presence of the contaminants or solvents used in the cleaning process. The air intake of the instrument should be passed over the article to be evaluated. A positive detection requires a repeat the decontamination process. It should be noted that the instrument scan is only viable if the contaminants are detectable within the instruments capabilities.

- Rinsate Blanks – It is recommended that Rinsate samples be collected to

  - Evaluate the decontamination procedure representing different equipment applications (pumps versus drilling equipment) and different decontamination applications.

  - Single use disposable equipment – The number of samples should represent different types of equipment as well as different Lot Numbers of single use articles.

The collection and the frequency of collection of rinsate samples are as follows:

- Per decontamination method
- Per disposable article/Batch number of disposable articles

It is recommended that an initial rinsate sample be collected early in the project to ensure that the decontamination process is functioning properly and in an effort to avoid using a contaminated batch of single use articles. It is recommended that a follow up sample be collected during the execution of the project to insure those conditions do not change. Lastly, rinsate samples collection may be driven by types of and/or contaminant levels. Hard to remove contaminants, oils/greases, some PAHs/PCBs, etc. may also support the collection of additional rinsates due to the obvious challenges to the decontamination process. This is a field consideration to be determined by the FOL.

APPENDIX F

FIELD FORMS

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Site: ____________________________ Depth to Bottom (ft.): _________________ Project Name: ____

Well: ____________________________ Static Water Level Before (ft.): _________ Project Number: ____

Date Installed: ___________________ Static Water Level After (ft.): ___________ Site Geologist: ____

Date Developed: _________________ Screen Length (ft.): __________________ Drilling Co.: ____

Dev. Method: ____________________ Specific Capacity: ___________________

Pump Type: _____________________ Casing ID (in.): ________________________

Time	Estimated Sediment Thickness (Ft.)	Cumulative Water Volume (Gal.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units _____)	Turbidity (NTU)	Remarks (odor, color, etc.)

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: ______________________________ **WELL ID.:** ______________________________

PROJECT NUMBER: ______________________________ **DATE:** ______________________________

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	pH (S.U.)	S. Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celcius)	ORP mV	Salinity % or ppt	Comments

SIGNATURE(S): ______________________________ **PAGE___OF___**

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Project Site Name: ____________________ Sample ID No.: ____________

Project No.: ____________________ Sample Location: ____________

Sampled By: ____________

[] Domestic Well Data C.O.C. No.: ____________

[] Monitoring Well Data Type of Sample:

[] Other Well Type: ____________________ [] Low Concentration

[] QA Sample Type: ____________________ [] High Concentration

SAMPLING DATA:

	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Date:								
Time:	(Visual)	(S.U.)	(mS/cm)	(^{0}C)	(NTU)	(mg/l)	(%)	
Method:								

PURGE DATA:

Date:	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Method:								
Monitor Reading (ppm):								
Well Casing Diameter & Material								
Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: ____________________ **Project No.:** ____________________
Location: ____________________ **Personnel:** ____________________
Weather Conditions: ____________________ **Measuring Device:** ____________________
Tidally Influenced: Yes ____ No ____ **Remarks:** ____________________

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Total Well Depth (feet)*	Water Level Indicator Reading (feet)*	Thickness of Free Product (feet)*	Groundwater Elevation (feet)*	Comments

* All measurements to the nearest 0.01 foot

Note: Analyte, method, and/or equipment may be deleted from form if not being performed.

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Project Site Name: ______________________ Sample ID No.: ______________________

Project No.: ______________________ Sample Location: ______________________

Sampled By: ______________________ Duplicate: ☐

Field Analyst: ______________________ Blank: ☐

Field Form Checked as per QA/QC Checklist (initials): ______

SAMPLING DATA:

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	ORP (Eh)
Time:	(Visual)	(S.U.)	(mS/cm)	(^{0}C)	(NTU)	(mg/l)	(%)	(+/- mv)
Method:								

SAMPLE COLLECTION/ANALYSIS INFORMATION:

ORP (Eh) (+/- mv)

Electrode Make & Model:______________________________________

Reference Electrode (circle one): Silver-Silver Chloride / Calomel / Hydrogen

Dissolved Oxygen:

Equipment: Chemetrics Test Kit

Concentration: ____________ ppm

Range Used:	Range	Method	Concentration ppm
☐	0 to 1 ppm	K-7510	
☐	1 to 12 ppm	K-7512	

Analysis Time: ____________

Equipment: HACH Digital Titrator OX-DT

Analysis Time:______________

Range Used:	Range	Sample Vol.	Cartridge	Multiplier
☐	1-5 mg/L	200 ml	0.200 N	0.01
☐	2-10 mg/L	100 ml	0.200 N	0.02

Titration Count	Multiplier	Concentration
__________	**x** 0.01	= mg/L
__________	**x** 0.02	= mg/L

Notes:

Carbon Dioxide:

Equipment: Chemetrics Test Kit

Concentration: ____________ ppm

Range Used:	Range	Method	Concentration ppm
☐	10 to 100 ppm	K-1910	
☐	100 to 1000 ppm	K-1920	
☐	250 to 2500 ppm	K-1925	

Analysis Time: ____________

Equipment: HACH Digital Titrator CA-DT

Range Used:	Range	Sample Vol.	Cartridge	Multiplier
☐	10-50 mg/L	200 ml	0.3636 N	0.1
☐	20-100 mg/L	100 ml	0.3636 N	0.2
☐	100-400 mg/L	200 ml	3.636 N	1.0
☐	200-1000 mg/L	100 ml	3.636 N	2.0

Titration Count		Concentration
__________	**x** 0.1	= mg/L
__________	**x** 0.2	= mg/L
__________	**x** 1.0	= mg/L
__________	**x** 2.0	= mg/L

Standard Additions: ☐ Titrant Molarity:_________ Digits Required: 1st.:________ 2nd.:________ 3rd.:________

Notes:

Hydrogen, dissolved

Equipment: Bubble strip sampling field method

Start stripper at ____________ (time)

End stripper at _____________ (time)

Total stripper time __________

Pump rate ___________ milliliters/minute

Note: Analyte, method, and/or equipment may be deleted from form if not being performed.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Tetra Tech NUS, Inc.

Project Site Name: ______________________ Sample ID No.: ______________________

Project No.: ______________________ Sample Location: ______________________

Sampled By: ______________________ Duplicate: ☐

Field Analyst: Blank: ☐

Alkalinity:

Equipment: Chemetrics Test Kit

Concentration: ___________ ppm

Range Used:	Range	Method	Concentration ppm
☐	10 to 100 ppm	K-9810	
☐	50 to 500 ppm	K-9815	
☐	100 to 1000 ppm	K-9820	

Analysis Time: ___________

Filtered: ☐

Equipment: HACH Digital Titrator AL-DT

Range Used:	Range	Sample Vol.	Cartridge	Multiplier	Titration Count	Multiplier	Concentration
☐	10-40 mg/L	100 ml	0.1600 N	0.1	_______ & _______	**x** 0.1	= mg/L
☐	40-160 mg/L	25 ml	0.1600 N	0.4	_______ & _______	**x** 0.4	= mg/L
☐	100-400 mg/L	100 ml	1.600 N	1.0	_______ & _______	**x** 1.0	= mg/L
☐	200-800 mg/L	50 ml	1.600 N	2.0	_______ & _______	**x** 2.0	= mg/L
☐	500-2000 mg/L	20 ml	1.600 N	5.0	_______ & _______	**x** 5.0	= mg/L
☐	1000-4000 mg/L	10 ml	1.600 N	10.0	_______ & _______	**x** 10.0	= mg/L

Parameter:	Hydroxide	Carbonate	Bicarbonate
Relationship:			

Standard Additions: ☐ Titrant Molarity:_________ Digits Required: 1st.:________ 2nd.:________ 3rd.:________

Notes:

Ferrous Iron (Fe^{2+}):

Equipment: DR-850 DR-8 _ _ Range: 0 - 3.00 mg/L

Program/Module: 500nm 33

Concentration: ___________ ppm

Analysis Time: ___________

Equipment: IR-18C Color Wheel Range: 0 - 10 mg/L

Notes:

Filtered: ☐

Hydrogen Sulfide (H_2S):

Range: 0 - 5 mg/L

Equipment: HS-C Other: ___________

Exceeded 5.0 mg/L range on color chart: ☐

Concentration: ___________ ppm

Analysis Time: ___________

Notes:

Sulfide (S^{2-}):

Equipment: Chemetrics Test Kit Range: 0 - 10 mg/L

Concentration: ___________ ppm

Range Used:	Range	Method	Concentration ppm
☐	0 to 1 ppm	K-9510	
☐	1 to 10 ppm	K-9510	

Analysis Time: ___________

Filtered: ☐

Equipment: DR-850 DR-8 _ _ Range: 0 - 0.70 mg/L

Program/Module: 610nm 93

Notes:

Note: Analyte, method, and/or equipment may be deleted from form if not being performed.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Tetra Tech NUS, Inc.

Project Site Name: ____________ Sample ID No.: ____________

Project No.: ____________ Sample Location: ____________

Sampled By: ____________ Duplicate: ☐

Field Analyst: Blank: ☐

Sulfate (SO_4^{2-}):

Equipment: DR-850 DR-8 _ _ Range: 0 - 70 mg/L Concentration: ________ ppm

Program/Module: ________ 91 Analysis Time: ________

Standard Solution: ☐ Results: ________ Filtered: ☐

Standard Additions: ☐ Digits Required: 0.1ml:________ 0.2ml:________ 0.3ml:________

Notes:

Nitrate (NO_3^--N):

Equipment: DR-850 DR-8 _ _ Range: 0 - 0.50 mg/L (1) Concentration: ________ ppm

Program/Module: 55 Analysis Time: ________ Filtered: ☐

Standard Solution: ☐ Results: ________ Nitrite Interference Treatment: ☐ Reagent Blank Correction: ☐

Standard Additions: ☐ Digits Required: 0.1ml:________ 0.2ml:________ 0.3ml:________

Alternate forms: NO_2 ________ $NaNO_2$ ____________ mg/L

Notes (1): If results are over limit use dilution method at step 3, 5ml sample 10ml DI result X3, range upto 1.5mg/L

Notes:

Nitrite (NO_2^--N): Concentration: ________ ppm

Equipment: DR-850 DR-8 _ _ Range: 0 - 0.350 mg/L Analysis Time: ________ Filtered: ☐

Program/Module: 62

Standard Solution: ☐ Results: ________ Reagent Blank Correction: ☐

Notes:

Manganese (Mn^{2+}): Concentration: ________ ppm

Equipment: DR-850 DR-8 _ _ Range: 0 - 20.0 mg/L Analysis Time: ________ Filtered: ☐

Program/Module: 525nm 41

Standard Solution: ☐ Results: ________ Digestion: ☐ Reagent Blank Correction: ☐

Standard Additions: ☐ Digits Required: 0.1ml:________ 0.2ml:________ 0.3ml:________

Equipment: HACH MN-5 Range: 0 - 3 mg/L

Notes:

QA/QC Checklist:

All data fields have been completed as necessary: ☐

Correct measurement units are cited in the SAMPLING DATA block: ☐

Values cited in the SAMPLING DATA block are consistent with the Groundwater Sample Log Sheet: ☐

Mulitplication is correct for each *Multiplier* table: ☐

Final calulated concentration is within the appropriate *Range Used* block: ☐

Alkalinity *Relationship* is determined appropriatly as per manufacturer (HACH) instructions: ☐

QA/QC sample (e.g., Std. Additions, etc.) frequency is appropriate as per the project planning documents: ☐

Nitrite Interference treatment was used for Nitrate test if Nitrite was detected: ☐

Title block on each page of form is initialized by person who performed this QA/QC Checklist: ☐

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME : ____________________ INSTRUMENT NAME/MODEL: ____________________

SITE NAME: ____________________ MANUFACTURER: ____________________

PROJECT No.: ____________________ SERIAL NUMBER: ____________________

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration	Post-calibration	Pre-calibration	Post-calibration		

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: ____________ BORING No.: ____________
PROJECT NUMBER: ____________ DATE: ____________
DRILLING COMPANY: ____________ GEOLOGIST: ____________
DRILLING RIG: ____________ DRILLER: ____________

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION			U S C S *	Remarks	PID/FID Reading (ppm)			
					Soil Density/ Consistency or Rock Hardness	Color	Material Classification			Sample	Sampler BZ	Borehole**	Driller BZ**

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: ____________

Drilling Area Background (ppm): ____

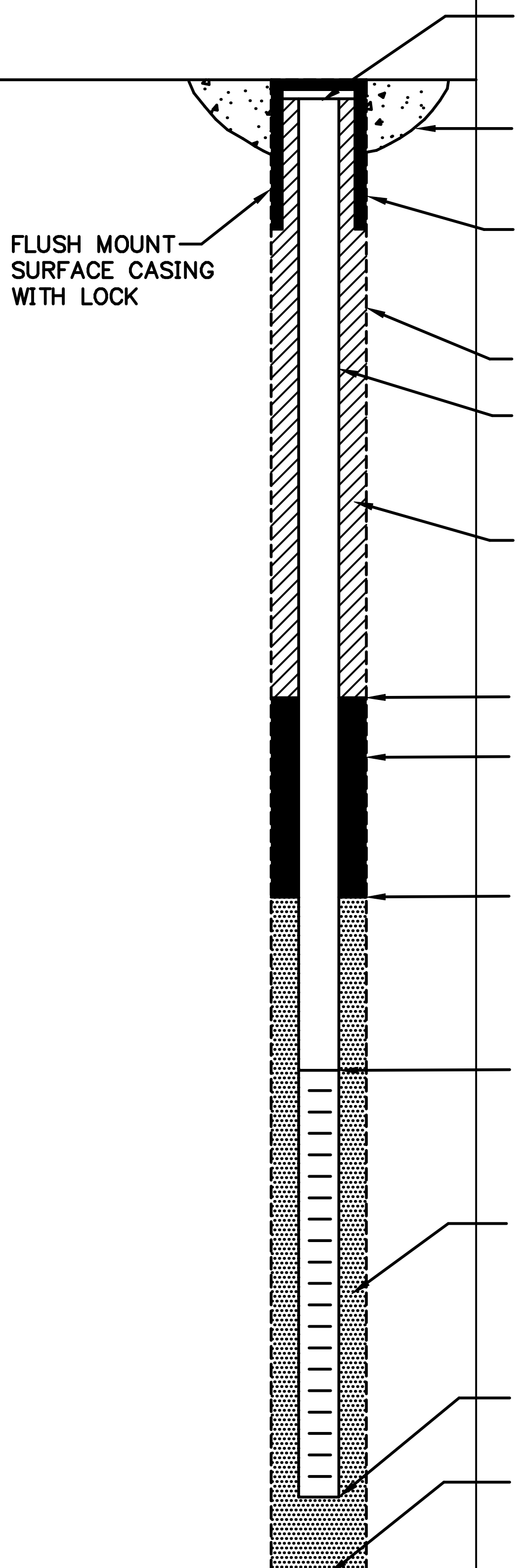
Converted to Well: Yes ______ No ______ Well I.D. #: ____________

WELL NO.: ______

Tetra Tech NUS, Inc.

OVERBURDEN
MONITORING WELL SHEET
FLUSH - MOUNT

PROJECT ______	LOCATION ______	DRILLER ______
PROJECT NO. ______	BORING ______	DRILLING METHOD ______
DATE BEGUN ______	DATE COMPLETED ______	DEVELOPMENT METHOD ______
FIELD GEOLOGIST ______		
GROUND ELEVATION ______	DATUM ______	



ELEVATION TOP OF RISER: ______

TYPE OF SURFACE SEAL: ______

TYPE OF PROTECTIVE CASING: ______

I.D. OF PROTECTIVE CASING: ______

DIAMETER OF HOLE: ______

TYPE OF RISER PIPE: ______

RISER PIPE I.D.: ______

TYPE OF BACKFILL/SEAL: ______

ELEVATION/DEPTH TOP OF SEAL: ____ / ____

TYPE OF SEAL: ______

ELEVATION/DEPTH TOP OF SAND: ____ / ____

ELEVATION/DEPTH TOP OF SCREEN: ____ / ____

TYPE OF SCREEN: ______

SLOT SIZE x LENGTH: ______

TYPE OF SAND PACK: ______

DIAMETER OF HOLE IN BEDROCK: ______

ELEVATION / DEPTH BOTTOM OF SCREEN: ____ / ____

ELEVATION / DEPTH BOTTOM OF SAND: ____ / ____

ELEVATION/DEPTH BOTTOM OF HOLE: ____ / ____

BACKFILL MATERIAL BELOW SAND: ______

ACAD: FORM_MWFM.dwg 07/20/99 INL