N60200.AR.008726
NAS CECIL FIELD
5090.3a

EMAIL TRANSMITTING FIELD TASK MODIFICATION REQUEST FORM FOR SITE 5 DIRECT PUSH TECHNOLOGY AND SAMPLING AND ANALYSIS PLAN WITH ATTACHMENTS NAS CECIL FIELD FL

2/25/2012

TETRA TECH

Cecil Field _ Site 5 FTMR Form for UFP SAP modification _ DPT Investigation effort _ electronic submission

Simcik, Robert

Sent: Saturday, February 25, 2012 8:43 AM

To: Sanford, Art F CTR OASN (EI&E), BRAC PMO SE [art.sanford.ctr@navy.mil]; Davidson, Mark E CIV NAVFACHQ, BRAC PMO [mark.e.davidson@navy.mil]; Martin, Stacin CIV NAVFAC LANT, EV [stacin.martin@navy.mil]; Debbie Vaughn-Wright [Vaughn-Wright.Debbie@epamail.epa.gov]; Grabka, David [David.Grabka@dep.state.fl.us]; Michael.Halil@CH2M.com; Jessica Keener (keenerj@solutions-ies.com); Boerio, Megan; Jonnet, Mark; Simcik, Robert

Attachments: FTMR 03 _ Site 5 DPT Inves~1.pdf (2 MB)

Attached is the Field Task Modification Request Form for the Site 5 DPT Investigation, along with the UFP-SAP pages that required updates based on the DPT investigation plan and the associated SOPs. This FTMR is to replace the Abbreviated Work Plan for Site 5 sent January 6, 2012, according to EPA comments received January 12, 2012 and discussion at the February 15 BCT meeting. Therefore, the Abbreviated Work Plan will be removed from the DWS and replaced with this document, and it is recommended that all hard copies be disposed of, as well. Hard copies of this FTMR and attachments have been distributed to the appropriate locations and the document will be loaded onto the Cecil Field DWS.

Your review and comments are appreciated and this Modification to the UFP SAP will be incorporated during the next annual review. Field efforts to implement this proposed work is anticipated to be conducted next period so your timely review is appreciated.

Please let us know if you have any questions.

Thanks, Rob

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TETRA TECH NUS
FIELD TASK MODIFICATION REQUEST FORM

LTM/NAS Cecil Field	**CTO JM09, 112G02267**	**03**
Project/Installation Name	CTO & Project Number	Task Mod. Number
SAP for Long Term Monitoring at IR Sites 3, 5, 16, 17, 21, 57, and 58, March 2011	**Site 5**	**2/20/12**
Modification To (e.g. Work Plan)	Site/Sample Location	Date

Activity Description: At Site 5, five monitoring wells are being sampled on an annual basis to monitor the groundwater COC concentrations by comparing the results against FDEP Groundwater Cleanup Target Levels (GCTLs) and Natural Attenuation Default Criteria (NADCs). COCs include select volatile organic compounds (VOCs), select semi-volatile organic compounds (SVOCs), and vanadium. In addition to COCs, NA parameters are being collected. Annual LTM results at Site 5 indicate that a few COC concentrations in wells CEF-005-LTM01, CEF-005-LTM02, CEF-005-LTM04, and CEF-005-LTM05 continue to be greater than FDEP GCTLs as shown in Figure 1 (Solutions-IES). Concentrations in upgradient monitoring well CEF-005-LTM01 have exhibited exceedances of contaminants that are not being detected in other wells at the site during recent sampling events, as shown in attached Figure 2. Because CEF-005-LTM01has been recognized as the upgradient well, and there are currently several COCs with concentrations exceeding GCTLs, USEPA identified the need for an upgradient monitoring well that has contaminant concentrations less than the FDEP GCTLs. Well CEF-005-07S is upgradient of CEF-005-LTM01, but the well is damaged and cannot be sampled. DPT (Direct Push Technology) sampling is recommended to be conducted to delineate the extent of the groundwater contamination plume upgradient of the identified source area. The samples will be analyzed for select VOCs, select SVOCs, and vanadium. The samples will be collected at ten locations at a depth of 10 feet bgs, and at four locations at depths of 10 feet bgs and 20 feet bgs. The DPT sample locations are identified on Figure 2. Based on the results of the DPT groundwater samples, up to three additional monitoring wells may be installed to monitor contamination in this area.

The attached documents provide DPT sampling standards to be used. The Field Guidance document provides the DPT sampling methods to be used, the map identifies the locations of the samples, and the table provides the sample IDs.

Reason for Change: The United States Environmental Protection Agency (EPA) provided comments on a basewide 5-Year Review, submitted in April 2011 (Tetra Tech, 2011), that questioned COCs concentrations in upgradient well CEF-005-LTM01 and recommended that further delineation contamination in this area be conducted. During the November 2011 Base Realignment and Closure (BRAC) Cleanup Team (BCT) meeting, it was decided that eighteen groundwater samples would be collected in the area near wells CEF-005-LTM01 and –LTM04 by DPT (BCT, 2011) to investigate and delineate COC contamination in this area.

Recommended Disposition: Verification of acceptance of the modification to the SAP to include additional DPT sampling outlined in the attached documents of this FTMR via e-mail approval from Tetra Tech PM, BRAC PMO RPM, and FDEP (attached in project file). All worksheets that required significant changes due to the differences between this DPT Investigation and the existing LTM program described in the UFP-SAP were updated to apply to the DPT Investigation, and are attached to this FTMR.

T. E. Johnston — 2-22-12

Quality Assurance Manager (QAPP lead developer) — Date

Approved Disposition:

____

____

____

____

Project/Task Order Manager (Signature) — 2/27/12 Date

Distribution:

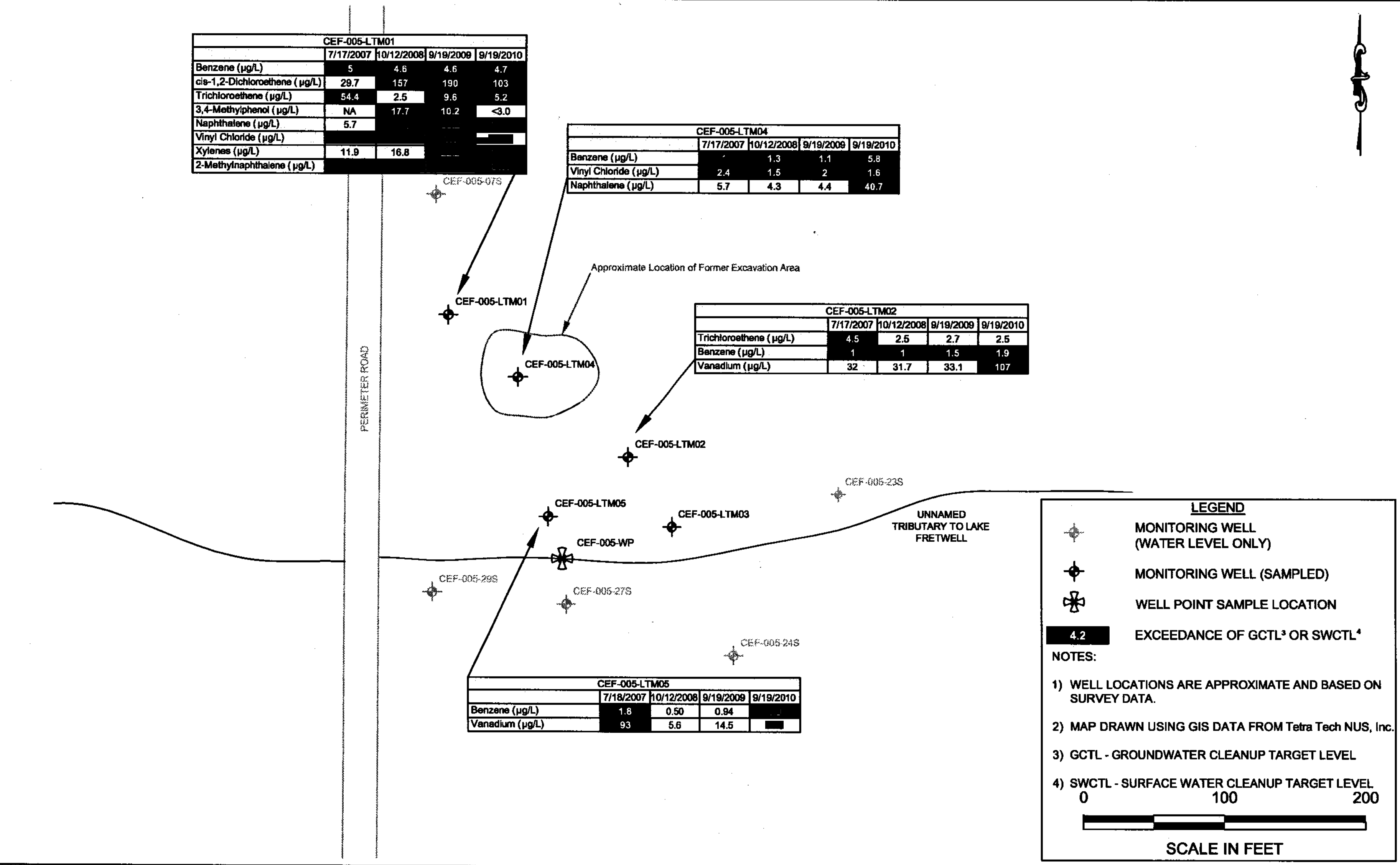
Program/Project File – 112G02267	Other: ______________________
Project/Task Order Manager – Robert Simcik	______________________
Field Operations Leader – David Siefken	______________________
BRAC PMO RPM – Art Sanford	

CC:
Mark Davidson – BRAC PMO
Debbie Vaughn-Wright – USEPA
David Grabka – FDEP
Stacin Martin – NAVFAC Atlantic
Mike Halil – CH2MHill
Jessica Keener – Solutions-IES

ATTACHMENT 1

Figures

FILE	DATE	PROJECT MANAGER	CHECKED BY	DRAFTER	PROJECT NUMBER
Figure 4.pdf	11/29/2010	BMR	XXX	HRG	8030.08A2.NAVF



CEF-005-LTM01	7/17/2007	10/12/2008	9/19/2009	9/19/2010
Benzene (µg/L)	5	4.6	4.6	4.7
cis-1,2-Dichloroethene (µg/L)	29.7	157	190	103
Trichloroethene (µg/L)	54.4	2.5	9.6	5.2
3,4-Methylphenol (µg/L)	NA	17.7	10.2	<3.0
Naphthalene (µg/L)	5.7	[illegible]	[illegible]	[illegible]
Vinyl Chloride (µg/L)	[illegible]	[illegible]	[illegible]	[redacted]
Xylenes (µg/L)	11.9	16.8	[illegible]	[illegible]
2-Methylnaphthalene (µg/L)	[illegible]	[illegible]	[illegible]	[illegible]

CEF-005-LTM04	7/17/2007	10/12/2008	9/19/2009	9/19/2010
Benzene (µg/L)	[illegible]	1.3	1.1	5.8
Vinyl Chloride (µg/L)	2.4	1.5	2	1.6
Naphthalene (µg/L)	5.7	4.3	4.4	40.7

CEF-005-LTM02	7/17/2007	10/12/2008	9/19/2009	9/19/2010
Trichloroethene (µg/L)	4.5	2.5	2.7	2.5
Benzene (µg/L)	1	1	1.5	1.9
Vanadium (µg/L)	32	31.7	33.1	107

CEF-005-LTM05	7/18/2007	10/12/2008	9/19/2009	9/19/2010
Benzene (µg/L)	1.8	0.50	0.94	[illegible]
Vanadium (µg/L)	93	5.6	14.5	[redacted]

LEGEND

- MONITORING WELL (WATER LEVEL ONLY)
- MONITORING WELL (SAMPLED)
- WELL POINT SAMPLE LOCATION
- 4.2 EXCEEDANCE OF GCTL[3] OR SWCTL[4]

NOTES:

1) WELL LOCATIONS ARE APPROXIMATE AND BASED ON SURVEY DATA.
2) MAP DRAWN USING GIS DATA FROM Tetra Tech NUS, Inc.
3) GCTL - GROUNDWATER CLEANUP TARGET LEVEL
4) SWCTL - SURFACE WATER CLEANUP TARGET LEVEL

0 100 200

SCALE IN FEET

Solutions-IES
Industrial & Environmental Services
1101 NOWELL ROAD
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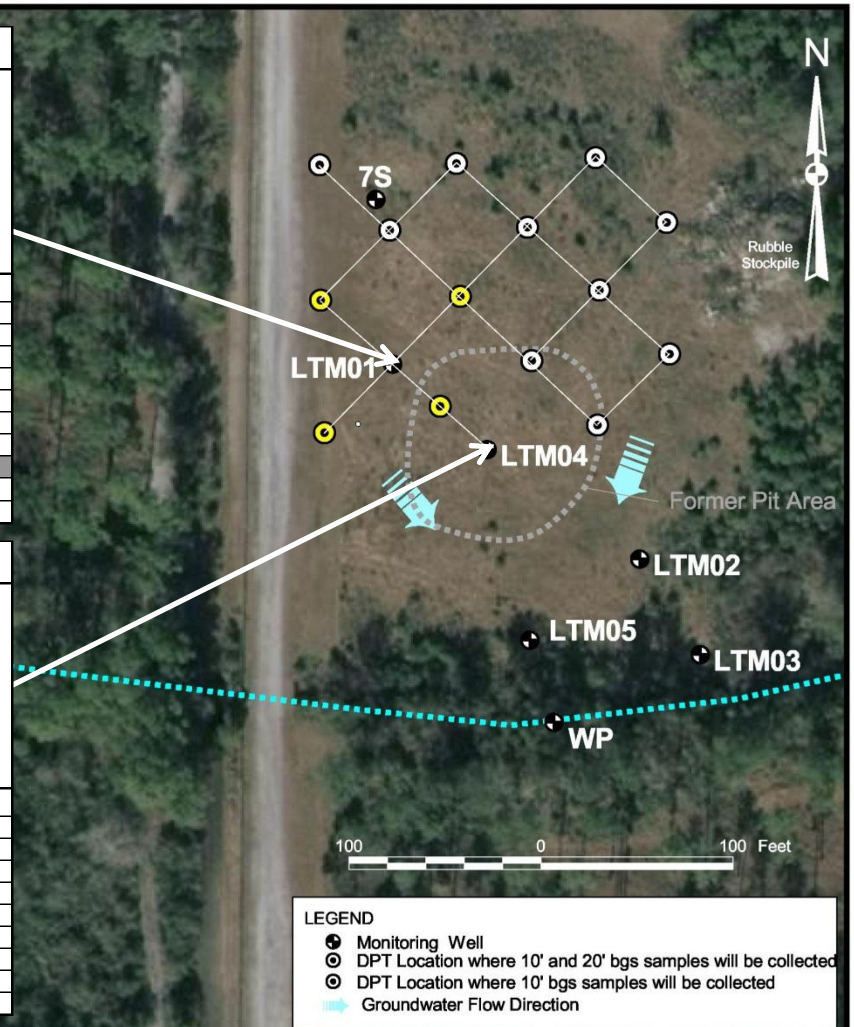
CONTAMINANT CONCENTRATION MAP
SITE 5 - NAS CECIL FIELD
JACKSONVILLE, FLORIDA
SEPTEMBER 2010

FIGURE: 1

J:\Project Files\Cecil Field\Cecil Field 2\CAD\Current Drawings\Site 5\8030-SITE5X.dwg, 4, 1:1

Well ID	Sample Date	VOCs (µg/L)					SVOCs (µg/L)	
		Benzene	*cis*-1,2-Dichloroethene	Trichloroethene	Vinyl Chloride	Xylenes (total)	Naphthalene	2-Methylnaphthalene
GCTL (µg/L)		1	70	3	1	20	14	28
CEF-005-LTM01	07/05/2005	0.7	10.6	10.2	<0.50	11.9	14.5	15.8
	01/05/2006	1.8	50.5	45.3	0.56	32.6	NA	NA
	07/10/2006	1.1	13.8	21.5	<1	12.1	21.4	18.8
	01/16/2007	1.7	6	23.9	<0.50	7.4	14.8	10
	07/17/2007	5	29.7	54.4	<0.50	11.9	5.7	2.7 F
	10/12/2008	4.6	157	2.5	0.82 I	16.8	17.1	13.5
	9/19/2009	4.6	190	9.6	1.1 I	22.2	35.2	21.7
	9/19/2010	4.7	103	5.2	<0.56	21.7	38.3	31.4
	9/12/2011	11.3	46.3	21.1	0.39 I	24.4	24.5	12.6
		11.7	47.1	21.1	0.34 I	25.5	20.5	10.6

Well ID	Sample Date	VOCs (µg/L)					SVOCs (µg/L)	
		Benzene	*cis*-1,2-Dichloroethene	Trichloroethene	Vinyl Chloride	Xylenes (total)	Naphthalene	2-Methylnaphthalene
GCTL (µg/L)		1	70	3	1	20	14	28
CEF-005-LTM04	07/05/2005	1.3	26.4	<0.50	11.2	15.5	14.1	8.5
	01/05/2006	2.1	12.3	<0.50	16.5	4.5	NA	NA
	07/11/2006	3.9	34.2	<1	5.7	27	<5.3	<5.3
	01/16/2007	2.5	18.4	<0.50	1.8	12.8	12.6	4.2 F
	07/17/2007	1	10.4	<0.50	2.4	1.9 F	5.7	4 F
	10/12/2008	1.3	3.9	<0.32	1.5	<1.2	4.3 I	<0.96
	9/19/2009	1.1	3.2	<0.32	2	<1.2	4.4 I	<0.96
	9/19/2010	5.8	8.5	<0.24	1.6	2.2 I	40.7	7.3
	9/12/2011	8.6	4.8	<0.26	0.43 I	6.3	102	24.4



DRAWN BY MJJ	DATE 15Dec11
CHECKED BY	DATE
COST/SCHEDULE-AREA	
SCALE AS NOTED	

NAVFAC

DPT LOCATION MAP
OPERABLE UNIT 2, SITE 5
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NUMBER 2267

APPROVED BY | DATE

APPROVED BY | DATE

DRAWING NO. FIGURE 2 | REV 0

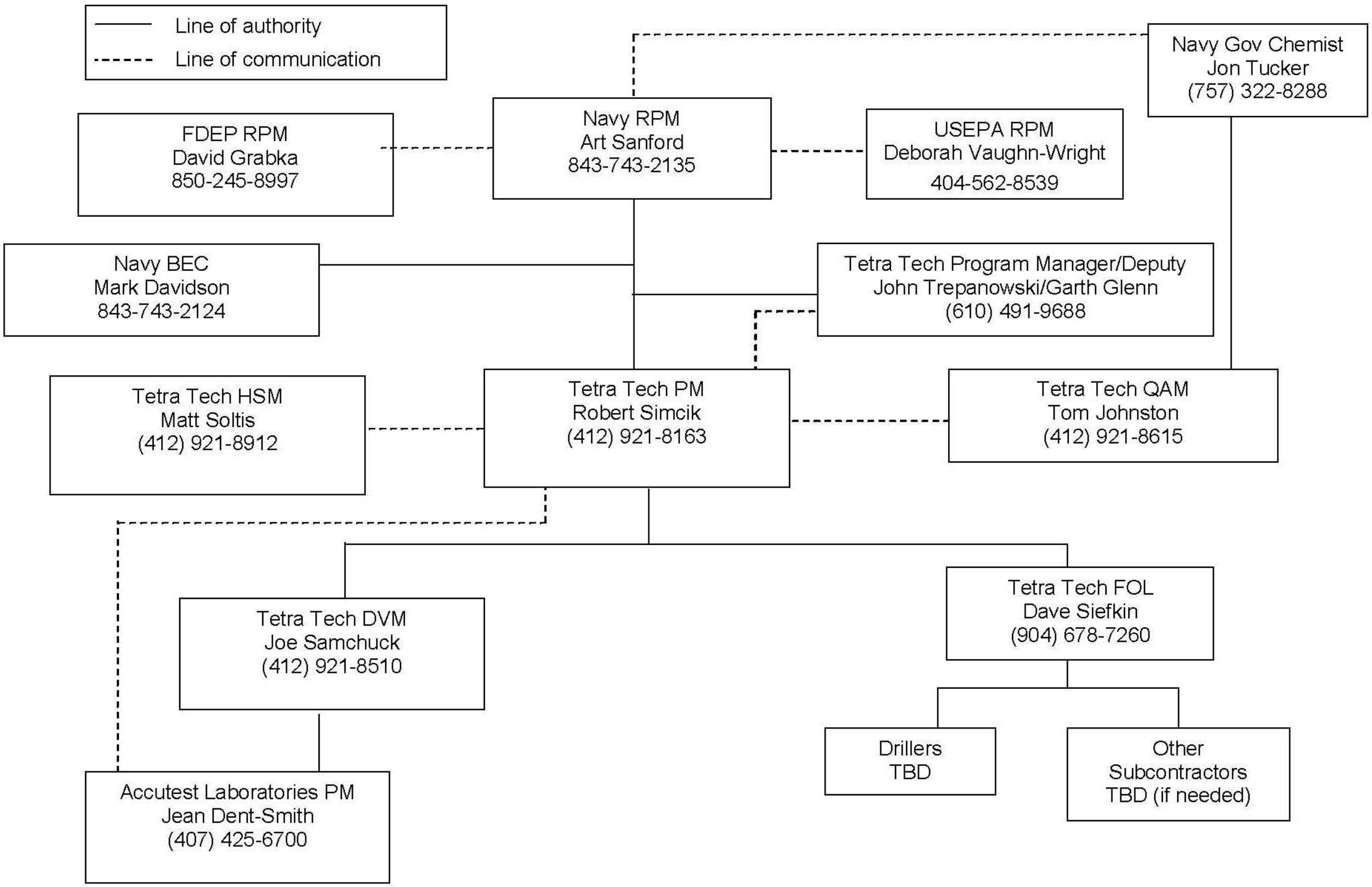
\GIS\NAS_CecilField\Site-05_20111027.apr 15Dec11 MJJ Layout01-01

ATTACHMENT 2

Updated UFP-SAP Worksheets

SAP Worksheet #5 -- Project Organizational Chart

(UFP-QAPP Manual Section 2.4.1)



SAP Worksheet #9 -- Project Scoping Session Participants Sheet

(UFP-QAPP Manual Section 2.5.1)

Project Name: Former NAS Cecil Field PM: Rob Simcik	Site Name: IR Site 5 Site Location: Jacksonville, Florida				
Date of Session: November 9, 2011 **Scoping Session Purpose:** NAS Cecil Field Base Realignment and Closure (BRAC) Cleanupt Team (BCT) Meeting, including discussion on the work plan to delineate contamination around upgradient well CEF-005-LTM01.					
Name	**Title**	**Affiliation**	**Phone #**	**E-Mail Address**	**Project Role**
Debbie Vaughn-Wright	USEPA Remediation Project Manager (RPM)	USEPA Region 4	(404) 562-8539	Vaughn-Wright.Debbie@epamail.epa.gov	EPA RPM
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Megan Boerio	Project Engineer	Tetra Tech	(412) 921-7271	megan.boerio@tetratech.com	Project Engineer
Robert Simcik, PE	PM	Tetra Tech	(412) 921-8361	rob.simcik@tetratech.com	Tetra Tech PM
Mark Jonnet	Project Environmental Geographic Information System (EGIS) Specialist	Tetra Tech	(412) 921-8622	Mark.Jonnet@tetratech.com	EGIS/ Engineer
Art Sanford	Navy RPM	BRAC PMO	(843) 743-2135	art.sanford.ctr@navy.mil	Navy RPM
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Stacin Martin	LANT RPM	NAVFAC LANT	(757) 322-4780	stacin.martin@navy.mil	LANT RPM
Jessica Keener	Basic Ordering Agreement (BOA) Project Manager	Solutions-IES	(919) 873-1060 ext. 126	keenerj@solutions-ies.com	BOA RPM
Mike Halil	CH2M Hill PM Remedial Action Contactor (RAC)	CH2MHill	(904) 777-4812 ext. 233	Michael.Halil@CH2M.com	RAC RPM

Comments/Decisions:

The group discussed the concentrations detected in upgradient well CEF-005-LTM01 in Septemnber 2009, September 2010, and September 2011. Tetra Tech was directed to investigate the source of contamination and install permanent wells to address the concern. The team discussed two potential paths forward, including a DPT investigation in the area of the well in question, and the abandonment and reinstalling/resampling of CEF-005-LTM01 and the damaged well CEF-005-07S. The decision was for a

DPT investigation to be conducted, with 18 groudwater samples being collected and analyzed for select VOCs, SVOCs, and vanadium. Based on the results of the DPT investigation, additional monitoing wells could be installed and added to the monitoing program.

Action Items:

Tetra Tech to submit an Abbreviated Work Plan and do the DPT sampling as proposed during the meeting presentation.

SAP Worksheet #11 -- Project Quality Objectives/Systematic Planning Process Statements

(UFP-QAPP Manual Section 2.6.1)

11.1 PROBLEM DEFINITIONS

11.1.B Sites 5 – Oil Disposal Area Northwest

Previous investigations at OU 2, Site 5 indicate the presence of VOC, SVOC, and vanadium groundwater contamination from past operating practices in groundwater at and downgradient of Site 5. LTM consisting of annual collection and analysis of groundwater samples is being conducted to verify whether contaminants are migrating offsite at unacceptable concentrations and whether NA is occurring, and LTM must continue. During recent sampling events, contamination in the upgradient well (CEF-005-LTM01) has been detected, incidcating that the original conceptual site model (CSM) has changed. Additional investigation is needed to determine the extent of contamination upgradient of Site 5 so the Project Team can update the conceptual site model (CSM), that will provde the basis for determing whether and how the LTM program must be modified.

11.2 INFORMATION INPUTS

11.2.1 Previously Collected Data and COCs

The usable data from previous investigations and LTM events and the results of this DPT investigation are needed to evaluate current site conditions, contaminant trends, and to delineate the contamination in the northern portion of the site. The full list of analytes is listed by site in Worksheet #15. The required analyses as agreed upon by the BCT are presented below.

11.2.2 Required Analyses and Frequency of Monitoring by Site

Site 5 – Oil Disposal Area Northwest		
Matrix	**Analytes**	**Frequency**
Groundwater	7 VOCs, 4 SVOCs, Vanadium, NA parameters	DPT investigation is a one-time event

11.2.3 Analytical Methods

Analytical methods were selected to be the same as those used previously, or at least comparable to previously used analytical methods with respect to precision, accuracy, representativeness, comparability, completeness, and sensitivity (PARCCS) parameters. See Worksheets #20 and #23 for a list of the analytical methods applicable to each site.

11.2.4 Sampling Methods

The sampling method for this investigation is DPT. See Worksheet #21 for a list of sampling methods.

11.2.5 Project Action Levels

Project action levels (PALs) for groundwater are the FDEP GCTLs from Florida State Rule Chapter 62-777 Table I. The GCTLs can be found online at http://www.dep.state.fl.us/waste/quick_topics/rules/documents/62-777/TableIGroundwaterCTLs4-17-05.pdf. Several of the GCTLs are the state primary standards, which can be found online at http://www.dep.state.fl.us/water/drinkingwater/standard.htm.

In addition to GCTLs, vanadium concentrations from this investigation must be compared to the Inorganic Background Data Set (IBDS) values to determine whether the vanadium concentrations exceed the background concentration range. The IBDS values are base-specific background screening levels statistically determined by Harding Lawson Associates (HLA) in 1998 from data collected throughout NAS Cecil Field (HLA, 1998).

A full list of project action levels (PALs) is included within Worksheet # 15. The BCT has ensured that the selected laboratory's Limits of Quantitation (LOQs) are generally low enough to measure constituent concentrations in site media that are less than the PALs in order to conduct comparisons of site data to the PALs. Results of a magnitude between the LOQ and detection limit (DL) will be "J" flagged to indicate that the reported results are less precise than results that are greater than the LOQ. The BCT will accept these analytical results as usable (without additional qualification) unless quality evaluations indicate that the data quality has been compromised. If, for any analyte in any site medium, the PAL is less than the laboratory DL, the BCT accepts the laboratory LOQ as the PAL for decision making purposes, as is suggested in "Guidance for the Selection of Analytical Methods for the Evaluation of Practical Quantitation Limits" (FDEP, 2006).

Given the exploratory nature of this investigation, field QC samples are not required. Instead, agreement of results across sampling locations and with previous data will be used to identify outliers that indicate a potential data quality concerns and adherence to sample collection and analysis protocols will be monitored closely. See also Section 11.6.

11.3 STUDY BOUNDARIES

Data must be collected in the vicinity of the upgrdient well (CEF-005-LTM-01) and well CEF-005--07S to investigate recent detections of contamination where it was not expected.

The temporal constraint for this investigation is the amount of time that is required to mobilize to the site, collect 18 DPT samples, and demobilize. This is a one-time DPT sampling event.

Figure 10B-1 in the UFP-SAP presents the locations of the target groundwater populations and the relationship of these populations to Site 5. The vertical and horizontal boundaries of the DPT investigation are limited to the sampling point locations shown on Figure 2.

11.4 ANALYTIC APPROACH

A direct comparison of concentrations in the groundwater DPT samples will be made against the appropriate action levels, including IBDS values (vanadium only). PALs are detailed for each COC in Worksheet #15.

The decision rules for this investigation are as follows:

Decision Rule #1:
If any COC groundwater concentrations in the DPT samples exceed their respective GCTL (and, for vanadium, the vanadium IBDS), then update the CSM and determine the most appropriate location(s) for additional monitoring well(s) to provide an upgradient well outside the delineated groundwater plume with no GCTL exceedances for the analyzed COCs and proceed with the normal LTM program; otherwise, replace well CEF-005-07S and sample the replacement well then proceed to Decision Rule 2.

Note. Installation of new upgradient wells in response to a GCTL exceedance may include, for example, reinstallation of CEF-005-07S as well as installation of no more than three new wells. The intent will be to select a location where groundwater is not contaminated and where at least one upgradient well can be installed. The Project Team does not expect to install more than three wells as the site is relatively small and there are existing LTM wells at the site.

Decision Rule #2:
If the replacement well for CEF-005-07S yields at least one COC concentration greater than its GCTL (or in the case of vanadium also its IBDS), then convene the project team to re-evaluate the CSM and determine an appropriate path forward; otherwise, continue with the normal LTM program and use CEF-005-07S as the upgradient well.

11.5 PERFORMANCE CRITERIA

This monitoring program depends heavily on biased sampling where sample locations have been preselected for the DPT investigation**.** Direct comparisons of measured concentrations to PALs are prescribed. Measurement performance criteria were chosen to be comparable to previous work completed at Site 5 to improve data comparability. After data are collected, the BCT will use the data review criteria and the criteria described in Worksheet #37 of the SAP to determine whether data of sufficient type, quantity, and quality have been collected to support project objectives. The tendency will be to declare the data set to be sufficient if all intended data have been collected and no significant quality issues are identified. If any data gaps are identified, the BCT will determine, based on the number and severity of data gaps, whether to collect more data or to accept the limitations incurred as a result of the data gaps.

11.6 PLAN FOR OBTAINING DATA

The sampling design is presented in Worksheet #17.

SAP Worksheet #12 -- Measurement Performance Criteria Table

(UFP-QAPP Manual Section 2.6.2)

Measurement Performance Criteria Table – Field QC Samples

No blanks or duplicates are required for the DPT sampling event. See Worksheet #12 of the UFP-SAP regarding QC samples for permanent monitoring well sampling.

SAP Worksheet #14 -- Summary of Project Tasks

(UFP-QAPP Manual Section 2.8.1)

14.1 FIELD INVESTIGATION TASK PLAN

Sampling at Site 5 includes the following tasks:

- Mobilization/Demobilization
- Site-Specific Health and Safety Training
- Monitoring Equipment Calibration
- DPTGroundwater Sampling
- Well Abandonment
- Permanent Monitoring Well Installation
- Groundwater Sampling
- Investigation-Derived Waste (IDW) Management
- Field Decontamination Procedures
- Field Documentation Procedures

Additional project activities include the following tasks:

- Analytical Tasks
- Data Management
- Data Review

Mobilization/Demobilization

Mobilization shall consist of the delivery of all equipment, materials, and supplies to the site, the complete assembly in satisfactory working order of all such equipment at the site, and the satisfactory storage at the site of all such materials and supplies. Tetra Tech will coordinate with the

Base to identify locations for the storage of equipment and supplies. Site-specific Health and Safety Training will be provided to all subcontractors as part of the site mobilization.

Demobilization shall consist of the prompt and timely removal of all equipment, materials, and supplies from the site following completion of the work. Demobilization includes the cleanup and removal of IDW generated during the conduct of the investigation.

Site-Specific Health and Safety Training

Site-specific health and safety training will be provided to all field staff and subcontractors as part of the site mobilization and is also addressed in Worksheet #8 of the UFP-SAP. A photoionization detector (PID) will be used as field instrumentation for health and safety purposes.

Monitoring Equipment Calibration

These procedures are described in Worksheet #22.

DPT Groundwater Sampling

Groundwater samples will be collected by DPT. Worksheets #17 and #18 specify the groundwater sample locations and analytes for this investigation. Worksheet #23 specifies the analytical methods to be used.

Prior to sampling, decontaminated DPT rods and a sealed-screen groundwater sampler will be advanced to the appropriate depth. Once at the appropriate depth, the screen will be exposed on the groundwater sampler and groundwater will be allowed to fill the sampling device. Dedicated sampling tubing will be lowered to the appropriate depth and a peristaltic pump will be used to draw the groundwater to the ground surface. Purging of the groundwater sampler will be conducted and a water quality meter will be used to monitor groundwater stabilization parameters. A significant effort will be made to obtain adequate turbidity levels in groundwater during purging; however, it should be noted that desirable turbidity levels are difficult to achieve with this method of groundwater sampling. As described in FDEP SOP 001/01 FS 2212, if naturally occurring conditions prevent purged groundwater from attaining turbidity levels less than the acceptable level of 20 Nephelometric Turbidity Units (NTUs), the sample may still be collected at the discretion of the sampling team leader and the results will be assessed with respect to a potential turbidity-associated bias (FDEP, 2008). After sample collection, the DPT rods and sealed-screen groundwater sampler will be removed from the sampling point and decontaminated to prevent cross-contamination of groundwater samples. Following sample collection, the groundwater samples will be placed on ice and delivered via FedEx under chain of custody to the selected laboratory for analysis.

Well Abandonment

The well identified for abandonment will be sealed and the well casing removed in accordance with the Tetra Tech SOP GH-2.9. Well abandonment paper work will be completed and filed as required.

Permanent Monitoring Well Installation

Monitoring well(s) will be installed and developed for groundwater sampling according to the Tetra Tech SOP GH-2.8. The well will be constructed in a manner similar to the existing wells at Site 5. The well will be installed to a depth of 13 feet below ground surface, with a 10-foot screen, from 3-feet to 13-feet.

Groundwater Sampling – Permanent Wells

Groundwater samples will be collected using low-flow purging techniques (discharge rate of less than 1 liter per minute) with a peristaltic pump using Teflon tubing dedicated to each well. When a well is developed for sampling, a water quality meter will be used to monitor pH, ORP, DO, turbidity, and conductivity. All groundwater samples will be collected using the procedures specified in FS 2200, Groundwater Sampling (FDEP, 2008a). Worksheets #17 and #18 specify the groundwater sample locations and analytes for this investigation. Worksheet #23 specifies the analytical methods to be used.

Prior to groundwater sample collection, the monitoring well will be purged. Both purging and sampling operations will be conducted at a flow rate that results in a groundwater turbidity measurement of 20 nephelometric turbidity units (NTUs) or less (inherent turbidity will be minimized to the greatest extent possible using low flow techniques; individual well conditions and local geology may preclude meeting the 20 NTU criteria).

The sample aliquot for VOC analysis will be the last one collected; the Teflon tubing will be slowly pulled out of the well to minimize agitation of the water in the monitoring well, and then the contents of the tubing will be transferred to a VOC vial. After collection, the samples will be placed in a cooler, chilled with ice, and shipped under chain-of-custody protocol to the off-site laboratory for analysis.

Investigation-Derived Waste Management

IDW generated during the activities will be managed in accordance with the HASP and will be conducted in an environmentally responsible manner consistent with NAS Cecil Field and regulatory requirements (e.g., designation of staging areas). The objectives of the IDW management are to:

- Manage IDW in a manner that prevents contamination of uncontaminated areas (by IDW), and that is protective of human health and the environment.
- Minimize IDW, thereby reducing costs and the potential for human or ecological exposure to contaminated materials.
- Comply with federal and state requirements that are ARARs.

Used personal protective equipment (PPE), such as gloves, will be bagged and disposed of as regular trash in an appropriate facility waste container.

Field Decontamination Procedures

Decontamination of major equipment and sampling equipment will be in general accordance with FS 1000, Cleaning / Decontamination Procedures (FDEP, 2008b).

Field Documentation Procedures

Pre-preserved, certified-clean bottleware will be supplied by the subcontracted laboratory. Matrix-specific sample logsheets will be maintained for each sample collected. In addition, sample collection information will be recorded in bound field notebooks or specific field forms. Samples will be packaged and shipped according to FS 1000, General Sampling Procedures (FDEP, 2008b).

Field documentation will include a summary of all field activities which will be properly recorded in a bound logbook with consecutively numbered pages that cannot be removed. Logbooks will be assigned to field personnel and will be stored in a secured area when not in use.

At a minimum, the following information will be recorded in the site logbook:

- Name of the person to whom the logbook is assigned.
- Project name.
- Project start date.
- Names and responsibilities of on-site project personnel including subcontractor personnel.
- Arrival/departure of site visitors.
- Arrival/departure of equipment.
- Sampling activities and sample log sheet references.
- Description of subcontractor activities.
- Sample pick-up information, including chain-of-custody numbers, air bill numbers, carrier, time, and date.
- Description of borehole or monitoring well installation activities and operations.
- Health and safety issues.
- Description of photographs including date, time, photographer, roll and picture number, location, and compass direction of photograph.

All entries will be written in ink and no erasures will be made. If an incorrect entry is made, striking a single line through the incorrect information will make the correction; the person making the correction will initial and date the change.

Analytical Tasks

Accutest is a current Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) accredited laboratory. A copy of the laboratory certification for Accutest can be found in Appendix B of the UFP-SAP. Analyses will be performed in accordance with the analytical methods identified in Worksheet #19 of the SAP. Accutest is expected to meet the PALs to the extent identified in Worksheet #15. Accutest will perform chemical analysis following laboratory-specific SOPs (Worksheets #19 and #23) developed based on the analytical methods listed in Worksheets #19 and #30 of the SAP. Copies of the Laboratory SOPs are included in Appendix B of the SAP.

Data Management

Data Handling and Management - After the field investigation is completed, the field sampling log sheets will be organized by date and filed in the project file. The field logbooks for this project will be used only for this site, and will also be categorized and maintained in the project file after the completion of the field program. Project personnel completing concurrent field sampling activities may maintain multiple field logbooks. When possible, logbooks will be segregated by sampling activity. The field logbooks will be titled based on date and activity. The data handling procedures to be followed by the laboratories will meet the requirements of the technical specification. The electronic data results will be downloaded into the Tetra Tech database.

Data Tracking and Control - The Tetra Tech PM (or designee) is responsible for the overall tracking and control of data generated for the project.

- Data Tracking: Data is tracked from its generation to its archiving in the project-specific files. The Tetra Tech PM (or designee) is responsible for tracking the samples collected and shipped to the subcontracted laboratory. Upon receipt of the data packages from the analytical laboratory, the PM will verify that the data packages are complete and results for all samples have been delivered by the analytical laboratory.

- Data Storage, Archiving, and Retrieval: After the data are verified, the data packages are entered into the file system and archived in secure files. The field records including field logbooks, sample logs, chain-of-custody records, and field calibration logs will be submitted by the FOL to be entered into the file system prior to archiving in secure project files. At the completion of the Navy contract, the records will be stored by Tetra Tech and eventually handed over to NAVFAC. The data will also be archived in secure files.

- Data Security: The project files are restricted to designated personnel only. Access to the data files is restricted to qualified personnel only. File and data backup procedures are routinely performed.

Assessment and Oversight – Refer to Worksheet #32 of the UFP-SAP for assessment findings and corrective actions and Worksheet #33 of the UFP-SAP for QA management reports.

Data Review

Data verification is described in Worksheet #34 of the UPF-SAP. Data validation is described in Worksheets #35 and #36 of the UFP-SAP. Usability assessment is described in Worksheet #37 of the UFP-SAP.

SAP Worksheet #15 -- Reference Limits and Evaluation Table - Site 5 – Oil Disposal Area Northwest

(UFP-QAPP Manual Section 2.8.1)

Matrix: Groundwater
Analytical Group: VOCs

Analyte	CAS Number	PAL (µg/L)	PAL Reference[1]	PQLG (µg/L)	Laboratory-specific		
					LOQ (µg/L)	LOD[2] (µg/L)	DL[2] (µg/L)
1,1-Dichloroethene	75-35-4	7	GCTL	2.3	1	0.29	0.29
Benzene	71-43-2	1	GCTL	0.3	1	0.21	0.21
cis-1,2-Dichloroethene	156-59-2	70	GCTL	23.3	1	0.32	0.32
trans-1,2-Dichloroethene	156-60-5	100	GCTL	33.3	1	0.34	0.34
Trichloroethene	79-01-6	3	GCTL	1.0	1	0.24	0.24
Vinyl Chloride	75-01-4	1	GCTL	0.3	1	0.28	0.28
Total Xylenes	1330-20-7	20	GCTL	6.7	3	0.54	0.54

1 PALs are defined as: GCTL – FDEP Groundwater Cleanup Target Levels, F.A.C. 62-777 Table I, April 2005.

2 Results will be reported to the LOQ and DL. Currently, the Accutest LIMs system only accommodates two values for reporting. The LOD is included to satisfy the requirements of the DoD QSM Version 4.1.

Matrix: Groundwater
Analytical Group: SVOCs

Analyte	CAS Number	PAL (µg/L)	PAL Reference[1]	PQLG (µg/L)	Laboratory-specific		
					LOQ (µg/L)	LOD[3] (µg/L)	DL[3] (µg/L)
1-Methylnapthalene	90-12-0	28	GCTL	9.3	5	1	0.78
2-Methylnaphthalene	91-57-6	28	GCTL	9.3	5	1	0.7
4-Methylphenol	**106-44-5**	**3.5**	**GCTL**	**1.2**	**5[2]**	**1.6[2]**	**1.5**
Naphthalene	91-20-3	14	GCTL	4.7	5	1	0.7

1 PALs are defined as: GCTL – FDEP Groundwater Cleanup Target Levels, F.A.C. 62-777 Table I, April 2005.
2 The LOQ, LOD, and DL are for 3&4-Methylphenol. 3-Methylphenol & 4-Methylphenol co-elute and are reported as 3&4-Methylphenol.
3 Results will be reported to the LOQ and DL. Currently, the Accutest LIMs system only accommodates two values for reporting. The LOD is included to satisfy the requirements of the DoD QSM Version 4.1.

Bolded rows indicate that the PAL is between the Laboratory LOQ and DL. The Project Team has agreed to accept this data for decision making if results below the LOQ are "J" qualified and the results are discussed in the uncertainties section of the Risk Assessment.

Matrix: Groundwater
Analytical Group: Metals

Analyte	CAS Number	PAL (µg/L)	PAL Reference[1]	PQLG (µg/L)	Laboratory-specific		
					LOQ (µg/L)	LOD[2] (µg/L)	DL[2] (µg/L)
Vanadium	**7440-62-2**	**4.5**	**IBDS**	**1.5**	**50**	**2**	**0.382**

1 PALs are defined as: IBDS – NAS Cecil Field Inorganic Background Data Set, (HLA, 1998).
2 Results will be reported to the LOQ and DL. Currently, the Accutest LIMs system only accommodates two values for reporting. The LOD is included to satisfy the requirements of the DoD QSM Version 4.1.

Bolded rows indicate that the PAL is between the Laboratory LOQ and DL. The Project Team has agreed to accept this data for decision making if results below the LOQ are "J" qualified and the results are discussed in the uncertainties section of the Risk Assessment.

SAP Worksheet #16 -- Project Schedule / Timeline Table

(UFP-QAPP Manual Section 2.8.2)

Activities	Organization	Dates (MM/DD/YYYY)		Deliverable	Draft Deliverable Due Date
		Anticipated Date(s) of Initiation	Anticipated Date of Completion		
Approval of Site 5 DPT Investigation Work Plan (FTMR)	USEPA and FDEP	02/27/2012	03/27/2012	NA	NA
Mobilization to Site 5	Drilling Subcontractor	04/02/2012	04/02/2012	NA	NA
DPT Sampling	Drilling Subcontractor	04/03/2012	04/05/2012	NA	NA
Demobilization	Drilling Subcontractor	04/05/2012	04/05/2012	NA	NA
Analysis of groundwater samples	Accutest	04/06/2012	04/27/2012	NA	NA
Report Preparation and Presentation of data to BCT	Tetra Tech	04/28/2012	05/11/2012	Technical Memorandum – Site 5 Plume Delineation DPT Invesitgation	05/11/2012

SAP Worksheet #17 -- Sampling Design and Rationale

(UFP-QAPP Manual Section 3.1.1)

The objective of the sampling designs is to obtain data that fulfills the DQOs presented in Worksheet #11. Fourteen DPT sampling points (from which 18 total samples will be collected) have been identified as shown on Figure 2. Tetra Tech will procure and oversee the services of a qualified drilling subcontractor to perform the DPT sampling point installation. The layout is designed in a grid using 50 foot intervals between sampling points so that a better understanding of the contamination in the area will be obtianed. Utility clearance will be conducted and verified via hand auger to a depth of 5-feet. The sampling points are located in primarily unpaved areas. The objective of the sampling of the replacement well for CEF-005-07S will be to determine if the replacement well is an appropriate upgradient well for the LTM program at Site 5.

Groundwater sampling will be conducted in accordance with Florida Department of Environmental Protection (FDEP) and Tetra Tech standard operating procedures (SOPs), as indicated in Worksheet #21 of this FTMR.

SAP Worksheet #18 -- Sampling Locations and Methods/SOP Requirements Table

(UFP-QAPP Manual Section 3.1.1)

Sampling Location / ID Number	**Matrix**	**Depth** (units)	**Analytical Group**	**Number of Samples** (identify field duplicates)	**Sampling SOP Reference**
CEF-005-DPT01 through CEF-005-DPT18	Groundwater	NA	Laboratory Analyses: 7 VOCs, 4 SVOCs, vanadium	18	FT1000 and FS2200 and SA-2.5

The replacement well for CEF-005-07S may also be included, and if so, the groundwater sampled would be analyzed for the same 12 parameters.

SAP Worksheet #20 -- Field Quality Control Sample Summary Table

(UFP-QAPP Manual Section 3.1.1)

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSDs[1]	No. of Field Blanks	No. of Equip. Blanks	No. of [Volatile Organic Aromatic (VOA)] Trip Blanks	No. of PT Samples	Total No. of Samples to Lab
SITE 5 – OIL DISPOSAL AREA NORTHWEST									
Groundwater	7 VOCs	18	NA	NA	NA	NA	NA	NA	18
	4 SVOCs	18	NA	NA	NA	NA	NA	NA	18
	Vanadium	18	NA	NA	NA	NA	NA	NA	18

1 Quality control samples will not be collected for the DPT investigation.

SAP Worksheet #21 -- Project Sampling SOP References Table

(UFP-QAPP Manual Section 3.1.2)

Reference Number	Title, Revision Date and / or Number [1]	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)	Comments
FS2200	Groundwater Sampling	FDEP	Peristaltic pump	N	
FT1000 (plus series)	Field Testing General and Series including pH, Specific Conductance, Salinity, Temperature, DO, ORP, and Turbidity	FDEP	Multi-parameter water quality meter	N	
FC1000	Field Decontamination	FDEP	Decontamination Equipment (scrub brushes, phosphate free detergent, de-ionized water)	N	
SA-2.5	Direct-Push Technology (Geoprobe®/Hydropunch™)	Tetra Tech	Peristaltic pump, polyethylene tubing, DPT rig	N	
GH-2.9	Well Abandonment	Tetra Tech	Sealing materials, drill rig, tremie pipe	N	
GH-2.8	Groundwater Monitoring Well Installation	Tetra Tech	Drilling and installation equipment, drive point installation tools, hydrogeologic equipment	N	

1 FDEP SOPs can be downloaded from http://www.dep.state.fl.us/labs/bars/sas/qa/sops.htm

SAP Worksheet #22 -- Field Equipment Calibration, Maintenance, Testing, and Inspection Table

(UFP-QAPP Manual Section 3.1.2.4)

Field Equipment	Activity	Frequency	Acceptance Criteria	Corrective Action	Resp. Person	SOP Reference	Comments
PID	Calibration and Visual Inspection	Daily	Manufacturer's Guidance	Replace	FOL or designee	Manufacturer's Guidance	
Multi-Parameter Water Quality Meter	Visual Inspection, Calibration	Daily	Manufacturer's Guidance	Replace	FOL or designee	FDEP FT 1000 through 1500 and Manufacturer's Guidance	
LaMotte Model 2008 (or similar) Turbidity Meter	Visual Inspection, Calibration	Daily	RPD of ±10% (Six measurements of two successive samples of a 20 NTU standard) Accuracy of ±10% at 20 NTU (Mean of the measured values must be 18 to 22 NTU)	Replace	FOL or designee	FT 1600, Field Measurement of Turbidity (FDEP) and Manufacturer's Guidance	If an acceptable turbidity meter model is not used, submittal of an Alternate Test Procedure application is required

SAP Worksheet #23 -- Analytical SOP References Table

(UFP-QAPP Manual Section 3.2.1)

Lab SOP Number	Title, Revision Date, and / or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?[1] (Y/N)
OP 021.7	Standard Operating Procedure for the Introduction of Volatile Organics Analytes Using Purge-and-Trap, July 2009	Definitive	VOC Preparation Groundwater	N/A	Accutest	N
MS 005.6	Analysis of Volatile Organics by GC/MS, July 2009	Definitive	VOC Analysis Groundwater	Gas Chromatograph / Mass Spectrometer (GC/MS)	Accutest	N
OP 006.7	Standard Operating Procedure for the Extraction of Base-Neutral and Acid (BNAs) Extractables from Water Samples, June 2009	Definitive	SVOC Preparation Groundwater	N/A	Accutest	N
MS 006.7	Analysis of Semivolatile Organics by GC/MS, July 2009	Definitive	SVOC Analysis Groundwater	GC/MS	Accutest	N

Lab SOP Number	Title, Revision Date, and / or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?[1] (Y/N)
MET 103.8	Digestion of Water Samples for Metals Analysis by ICP, April 2009	Definitive	Metals Digestion Groundwater	N//A	Accutest	N
MET 100.10	Metals by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP), April 2009	Definitive	Metals Analysis Groundwater	Inductively Coupled Plasma – Atomic Emission Spectrometer (ICP-AES)	Accutest	N

Laboratory SOPs are included as Appendix B.

SAP Worksheet #25 -- Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

(UFP-QAPP Manual Section 3.2.3)

Instrument / Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person [2]	SOP Reference [1]
GC/MS	Injector port, column maintenance, source cleaning.	VOCs SVOCs	Leak test, column and injector port inspection, source insulator integrity.	Need for maintenance determined by passing calibration and BFB and DFTPP tunes.	Passing BFB and DFTPP tunes and CCV, passing Internal Standard response.	Column clipping and/or reconditioning, seal and liners replacement, filaments and insulators as needed	Analyst	MS 005.6 MS 006.7
ICP-AES	Torch, nebulizer, spray chamber, autosampler, and pump tubing maintenance.	Metals	Check connections, flush lines, and clean nebulizer.	Frequency determined by instrument remaining in calibration and free of interference.	Acceptable calibration or CCV	Reconnect sample pathways, recalibrate, re-analyze affected samples.	Analyst	MET 100.10

1 Specify the appropriate reference letter or number from the Analytical SOP References table (Worksheet No.23).

2 Name or title of responsible person may be used.

SAP Worksheet #28 -- Laboratory QC Samples Table

(UFP-QAPP Manual Section 3.4)

Matrix	Groundwater
Analytical Group	VOCs
Analytical Method/ SOP Reference	SW-846 8260B Accutest MS 005.6

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria (MPCs)
Method Blank	One per batch of 20 samples or less.	No target compounds >½ the LOQ, except common lab contaminants, which must be < LOQ.	Re-prepare and reanalyze all samples with positive results. If insufficient amount of sample is available, apply B flag to all affected sample results	Analyst, Laboratory Supervisor and Data Reviewer	Bias / Contamination	Same as Method/SOP QC Acceptance Limits.
System Monitoring Compounds (SMC)/ Surrogates	4 per sample: Dibromofluoromethane 1,2-Dichloroethane-d4 Toluene-d8 4-Bromofluorobenzene	Laboratory-specific limits provided in Appendix D.	Check for possible matrix effects. If none found, reanalyze affected sample if sufficient sample is available. Qualify data as needed.	Analyst, Laboratory Supervisor and Data Reviewer	Accuracy / Bias	Same as Method/SOP QC Acceptance Limits.
Laboratory Control Sample (LCS)	One per batch of 20 samples or less.	Laboratory-specific limits provided in Appendix D.	Re-prepare and reanalyze all samples with positive results. If insufficient amount of sample is available, apply qualifier to all affected sample results.	Analyst, Laboratory Supervisor and Data Reviewer	Accuracy / Bias	Same as Method/SOP QC Acceptance Limits.
Internal Standards (IS)	4 per sample: Fluorobenzene Chlorobenzene-d5 1,4-Dichlorobenene-d4 Tert Butyl Alcohol-d10	Retention time +/- 30 seconds from retention time (RT) of the ICAL midpoint standard, and the Extracted Ion Current Profile (EICP) area within -50% to +100 % of ICAL midpoint standard.	Inspect instrument for malfunctions. Check for possible matrix effects. If none found, reanalyze affected sample if sufficient sample is available. Qualify data as needed.	Analyst, Laboratory Supervisor and Data Reviewer	Accuracy / Bias	Same as Method/SOP QC Acceptance Limits.

Matrix	Groundwater
Analytical Group	VOCs
Analytical Method/ SOP Reference	SW-846 8260B Accutest MS 005.6

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria (MPCs)
Matrix Spike/Matrix Spike Duplicate (MS/MSD)	One per batch of 20 samples or less.	Laboratory specific limits provided in Appendix D. MS/MSD RPD should be ≤ 30%.	Check for errors in calculations and spike preparation. Check un-spiked sample results and surrogate recoveries for possible matrix effects. If no errors are found and the associated LCS in control, matrix effects are the likely cause. Qualify failing analytes as estimated.	Analyst, Laboratory Supervisor and Data Reviewer	Precision / Accuracy / Bias	Same as Method/SOP QC Acceptance Limits.

Matrix	Groundwater
Analytical Group	SVOCs
Analytical Method/ SOP Reference	SW-846 8270D Accutest MS 006.7

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria (MPCs)
Method Blank	One per batch of 20 samples or less.	No target compounds > ½ the QL, except common lab contaminants which must be < LOQ.	Re-prepare and reanalyze all samples with positive results. If insufficient amount of sample is available, apply B flag to all affected sample results.	Analyst, Laboratory Supervisor and Data Reviewer	Bias / Contamination	Same as Method/SOP QC Acceptance Limits.
SMCs	6 per sample: Nitrobenzene-d5 2-Fluorobiphenyl p-Terphenyl Phenol-d5 2-Fluorophenol 2,4,6-Tribromophenol	Laboratory specific limits are provided in Appendix D.	Check for possible matrix effects. If none found, reanalyze affected sample if sufficient sample is available. Qualify data as needed.	Analyst, Laboratory Supervisor and Data Reviewer	Accuracy / Bias	Same as Method/SOP QC Acceptance Limits.
LCS	One per batch of 20 samples or less.	Laboratory specific limits are provided in Appendix D.	Re-prepare and reanalyze all samples with positive results. If insufficient amount of sample is available, apply qualifier to all affected sample results.	Analyst, Laboratory Supervisor and Data Reviewer	Accuracy / Bias	Same as Method/SOP QC Acceptance Limits.
IS	6 per sample: 1,4-Dichlorobenzene-d4 Naphthalene-d8 Acenaphthene-d10 Phenanthrene-d10 Chrysene-d12 Perylene-d12	Retention time +/- 30 seconds from RT of the ICAL midpoint standard, and the EICP area within -50% to +100 % of ICAL midpoint standard.	Inspect instrument for malfunctions. Check for possible matrix effects. If none found, reanalyze affected sample if sufficient sample is available. Qualify data as needed.	Analyst, Laboratory Supervisor and Data Reviewer	Accuracy / Bias	Same as Method/SOP QC Acceptance Limits.
MS/MSD	One per sample delivery group (SDG) or every 20 samples.	Laboratory specific limits are provided in Appendix D. MS/MSD RPD should be ≤ 30%.	Check for errors in calculations and spike preparation. Check un-spiked sample results and surrogate recoveries for possible matrix effects. If no errors are found and the associated LCS in control, matrix effects are the likely cause. Qualify failing analytes as estimated.	Analyst, Laboratory Supervisor and Data Reviewer	Precision / Accuracy / Bias	Same as Method/SOP QC Acceptance Limits.

Matrix	Groundwater
Analytical Group	Metals
Analytical Method/ SOP Reference	SW-846 6010B Accutest MET 100.10

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria (MPC)
Method Blank	One per preparation batch of 20 or fewer samples of similar matrix.	Contaminants in the method blank must be < ½ LOQ.	Re-prepare and analyze all associated samples.	Analyst, Laboratory Supervisor and Data Reviewer	Accuracy / Bias	Same as Method/SOP QC Acceptance Limits.
LCS	One per preparation batch of 20 or fewer samples of similar matrix.	%R must be within 80-120% of the true value.	Corrective actions are: High bias, samples ND – report without qualification. Low bias – re-extract and reanalyze.	Analyst, Laboratory Supervisor and Data Reviewer	Accuracy / Bias	Same as Method/SOP QC Acceptance Limits.
MS/Laboratory Duplicate	One per preparation batch of 20 or fewer samples of similar matrix.	Recovery ± 25 % of true value if sample < 4x spike value RPD ≤ 20 %	If both the LCS and MS/lab duplicate are unacceptable, re-prepare and analyze the associated samples and QC.	Analyst, Laboratory Supervisor and Data Reviewer	Accuracy / Bias / Precision	Same as Method/SOP QC Acceptance Limits.
ICP Serial Dilution	One per preparation batch of 20 or fewer samples of similar matrix.	If original sample result is at least 50x instrument detection limit, then serial dilution must agree within ± 10% of the original result.	Sample must be post digestion spiked at a level no less than 10x but no greater than 100x the DL concentration or flagged as interference.	Analyst, Laboratory Supervisor and Data Reviewer	Accuracy / Bias / Precision	Same as Method/SOP QC Acceptance Limits
Post-Digestion Spike	For any element that fails in the matrix spike where the native sample concentration was <4x the spike amount.	%R must be + 25% of the true value.	Narrate.	Analyst, Laboratory Supervisor, Data Validator	Accuracy/ Bias	Same as Method/SOP QC Acceptance Limits.

SAP Worksheet # 30 -- Analytical Services Table

(UFP-QAPP Manual Section 3.5.2.3)

Matrix	Analytical Group	Sample Locations/ID Number	Analytical Method	Data Package Turnaround Time	Laboratory / Organization[1] (name and address, contact person and telephone number)	Backup Laboratory / Organization[1] (name and address, contact person and telephone number)
Groundwater	VOC	See Worksheet #18	SW-846 8260B SOP MS 500.6	21 days	Ms. Jean Dent-Smith jeans@accutest.com Accutest SE 4405 Vineland Road Suite C-15 Orlando, FL 32811 407-425-6700 407-425-0707	NA
Groundwater	SVOC		SW-846 8270C SOP MS 006.7			
Groundwater	Metals		SW-846 6010B SOP MET 100.10			

ATTACHMENT 3

Tetra Tech Standard Operating Procedures

TETRA TECH	STANDARD OPERATING PROCEDURES	Number SA-2.5	Page 1 of 6
		Effective Date 01/2012	Revision 4
		Applicability Tetra Tech, Inc.	
		Prepared Earth Sciences Department	
Subject DIRECT PUSH TECHNOLOGY (GEOPROBE®/HYDROPUNCH™)		Approved J. Zimmerly	

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ATTACHMENTS

1.0 PURPOSE

The purpose of this procedure is to provide general reference information on Direct Push Technology (DPT). DPT is designed to collect soil, groundwater, and soil gas samples without using conventional drilling techniques. The advantage of using DPT over conventional drilling includes the generation of little or no drill cuttings, sampling in locations with difficult accessibility, reduced overhead clearance requirements, no fluid introduction during probing, and typical lower costs per sample than with conventional techniques. Disadvantages include a maximum penetration depth of approximately 15 to 40 feet in dense soils (although it may be as much as 60 to 80 feet in certain types of geological environments), reduced capability of obtaining accurate water-level measurements, and the inability to install permanent groundwater monitoring wells. The methods and equipment described herein are for collection of surface and subsurface soil samples and groundwater samples. Soil gas sampling is discussed in SOP SA-2.4.

2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for DPT. 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 adjustments in methodology.

3.0 GLOSSARY

Direct Push Technology (DPT) - DPT refers to sampling tools and sensors that are driven directly into the ground without the use of conventional drilling equipment. DPT typically utilizes hydraulic pressure and/or percussion hammers to advance the sampling tools. A primary advantage of DPT over conventional drilling techniques is that DPT results in the generation of little or no investigation derived waste.

Geoprobe7 - Geoprobe7 is a manufacturer of a hydraulically-powered, percussion/probing machines utilizing DPT to collect subsurface environmental samples. Geoprobe7 relies on a relatively small amount of static weight (vehicle) combined with percussion as the energy for advancement of a tool string. The Geoprobe7 equipment can be mounted in a multitude of vehicles for access to all types of environmental sites.

HydroPunchϑ - HydroPunchϑ is a manufacturer of stainless steel and Teflon7 sampling tools that are capable of collecting representative groundwater and/or soil samples without requiring the installation of a groundwater monitoring well or conventional soil boring. HydroPunchϑ is an example of DPT sampling equipment.

Flame Ionization Detector (FID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing a flame as the energizing source.

Photo Ionization Detector (PID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing ultraviolet radiation as the energizing source.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for selecting and/or reviewing the appropriate DPT drilling procedure required to support the project objectives.

Field Operations Leader (FOL)- The FOL is primarily responsible for performing the DPT in accordance with the project-specific plan.

5.0 SOIL SAMPLING PROCEDURES

5.1 General

The common methodology for the investigation of the vadose zone is soil boring drilling and soil sampling. However, drilling soil borings can be very expensive. Generally the advantage of DPT for subsurface soil sampling is the reduced cost of disposal of drilling cuttings and shorter sampling times.

5.2 Sampling Equipment

Equipment needed for conducting DPT drilling for subsurface soil sampling includes, but is not limited to, the following:

- Geoprobe® Sampling Kit
- Cut-resistant gloves
- 4-foot x 1.5-inch diameter macrocore sampler
- Probe sampling adapters
- Roto-hammer with 1.5-inch bit
- Disposable acetate liners for soil macrocore sampler
- Cast aluminum or steel drive points
- Geoprobe® AT-660 Series Large Bore Soil Sampler, or equivalent
- Standard decontamination equipment and solutions

For health and safety equipment and procedures, follow the direction provided in the Safe Work Permit in Attachment 1, or the more detailed directions provided in the project's Health and Safety Plan.

5.3 DPT Sampling Methodology

There are several methods for the collection of soil samples using DPT drilling. The most common method is discussed in the following section. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project-specific plan.

- Macrocore samplers fitted with detachable aluminum or steel drive points are driven into the ground using hydraulic pressure. If there is concrete or pavement over a sampling location, a Roto-hammer is used to drill a minimum 1.5-inch diameter hole through the surface material. A Roto-hammer may also be used if very dense soils are encountered.

- The sampler is advanced continuously in 4-foot intervals or less if desired. No soil cuttings are generated because the soil which is not collected in the sampler is displaced within the formation.

- The sampler is retracted from the hole, and the 4-foot continuous sample is removed from the outer coring tube. The sample is contained within an inner acetate liner.

- Attach the metal trough from the Geoprobe® Sampling Kit firmly to the tail gate of a vehicle. If a vehicle with a tail gate is not available, secure the trough on another suitable surface.

- Place the acetate liner containing the soils in the trough.

- While wearing cut-resistant gloves (constructed of leather or other suitable material), cut the acetate liner through its entire length using the double-bladed knife that accompanies the Geoprobe® Sampling Kit. Then remove the strip of acetate from the trough to gain access to the collected soils. Do not attempt to cut the acetate liner while holding it in your hand.

- Field screen the sample with an FID or PID, and observe/examine the sample (according to SOP GH-1.3). If appropriate, transfer the sample to sample bottles for laboratory analysis. If additional volume is required, push an additional boring adjacent to the first and composite/mix the same interval. Field compositing is usually not acceptable for sample requiring volatile organics analysis.

- Once sampling has been completed, the hole is backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch is used to cap holes through paved or concrete areas. All holes should be finished smooth to existing grade.

- In the event the direct push van/truck cannot be driven to a remote location or a sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric operated equipment (e.g., jack hammer).

- Sampling equipment is decontaminated prior to collecting the next sample.

6.0 GROUNDWATER SAMPLING PROCEDURES

6.1 General

The most common methodology for the investigation of groundwater is the installation and sampling of permanent monitoring wells. If only groundwater screening is required, the installation and sampling of temporary well points may be performed. The advantage of temporary well point installation using DPT is reduced cost due to no or minimal disposal of drilling cuttings and well construction materials, and shorter installation/times sampling.

Two disadvantages of DPT drilling for well point installation are:

- In aquifers with low yields, well points may have to be sampled without purging or development.
- If volume requirements are high, this method can be time consuming for low yield aquifers.

6.2 Sampling Equipment

Equipment needed for temporary well installation and sampling using DPT includes, but is not limited, to the following:

- 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point
- Connecting rods
- Roto-hammer with 1.5-inch bit
- Mechanical jack
- 1/4-inch OD polyethylene tubing
- 3/8-inch OD polyethylene tubing
- Peristaltic pump
- Standard decontamination equipment and solutions

6.3 DPT Temporary Well Point Installation and Sampling Methodology

There are several methods for the installation and sampling of temporary well points using DPT. The most common methodology is discussed below. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project specific plan.

- A 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point attached to connecting rods is driven into the ground to the desired depth using a rotary electric hammer or other direct push drill rig. If there is concrete or pavement over a sampling location, a Roto-hammer or electric coring machine is used to drill a hole through the surface material.

- The well point will be allowed to equilibrate for at least 15 minutes, after which a measurement of the static water level will be taken. The initial measurement of the water level will be used to assess the amount of water which is present in the well point and to determine the amount of silt and sand infiltration that may have occurred.

- The well point will be developed using a peristaltic pump and polyethylene tubing to remove silt and sand which may have entered the well point. The well point is developed by inserting polyethylene tubing to the bottom of the well point and lifting and lowering the tubing slightly while the pump is operating. The pump will be operated at a maximum rate of approximately 2 liters per minute. After removal of sediment from the bottom of the well point, the well point will be vigorously pumped at maximum capacity until discharge water is visibly clear and no further sediments are being generated. Measurements of pH, specific conductance, temperature, and turbidity shall be recorded every 5 to 10 minutes during the purging process. After two consistent readings of pH, specific conductance, temperature and turbidity (∀10 percent), the well may be sampled.

- A sample will be collected using the peristaltic pump set at the same or reduced speed as during well development. Samples (with the exception of the samples to be analyzed for volatile organic compounds, VOCs) will be collected directly from the pump discharge. Sample containers for VOCs will be filled by (first shutting off the pump) crimping the discharge end of the sample tubing when filled, removing the inlet end of the sample tubing from the well, suspending the inlet tubing above the vial, and allowing water to fill each vial by gravity flow.

- Once the groundwater sample has been collected, the connecting rods and well point will be removed from the hole with the direct push rig hydraulics. The hole will be backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch will be used to cap holes through paved or concrete areas. All holes will be finished smooth to existing grade.

- In the event the direct push van/truck cannot be driven to a remote location or sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric-operated equipment (e.g., jack hammer).

- Decontaminate the equipment before moving to the next location.

7.0 RECORDS

A record of all field procedures, tests, and observations must be recorded in the field logbook, boring logs, and sample log sheets, as needed. Entries should include all pertinent data regarding the investigation. The use of sketches and field landmarks will help to supplement the investigation and evaluation.

ATTACHMENT 1
SAFE WORK PERMIT FOR DPT OPERATIONS

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

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): **Monitoring well drilling and installation through direct push technology**

II. Required Monitoring Instruments: ____________________

III. Field Crew: ____________________

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector ____________ ____________ Tetra Tech

SECTION II: General Safety Requirements (To be filled in by permit issuer)

V. Protective equipment required

Level D ☒ Level B ☐
Level C ☐ Level A ☐
Detailed on Reverse

Respiratory equipment required

Full face APR	☐	Escape Pack	☐
Half face APR	☐	SCBA	☐
SKA-PAC SAR	☐	Bottle Trailer	☐
Skid Rig	☐	None	☒

Level D Minimum Requirements: Sleeved shirt and long pants, safety footwear, and work gloves. Safety glasses, hard hats, and hearing protection will be worn when working near or sampling in the vicinity of the DPT rig.

Modifications/Exceptions.

VI. Chemicals of Concern | Action Level(s) | Response Measures

VII. Additional Safety Equipment/Procedures

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	☐ Yes	☒ No
Splash Shield	☐ Yes ☒ No	Barricades	☒ Yes	☐ No
Splash suits/coveralls	☐ Yes ☐ No	Gloves (Type - ____________)	☐ Yes	☐ No
Steel toe Work shoes or boots	☒ Yes ☐ No	Work/warming regimen	☐ Yes	☐ No

Modifications/Exceptions: Reflective vests for high traffic areas.

VIII. Procedure review with permit acceptors

	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)	☐	☒	Emergency alarms	☐	☐
Daily tail gate meetings	☒	☐	Evacuation routes	☐	☐
Contractor tools/equipment/PPE inspected	☐	☐	Assembly points	☐	☐

IX. Site Preparation

Utility Clearances obtained for areas of subsurface investigation	☐ Yes	☐ No
Physical hazards removed or blockaded	☐ Yes	☐ No
Site control boundaries demarcated/signage	☐ Yes	☐ No

X. Equipment Preparation

	Yes	NA
Equipment drained/depressurized	☐	☒
Equipment purged/cleaned	☐	☒
Isolation checklist completed	☐	☒
Electrical lockout required/field switch tested	☐	☒
Blinds/misalignments/blocks & bleeds in place	☐	☒
Hazardous materials on walls/behind liners considered	☐	☒

XI. Additional Permits required (Hot work, confined space entry). ☐ Yes ☐ No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

XII. Special instructions, precautions:

Permit Issued by: ____________________ Permit Accepted by: ____________________

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		Effective Date 01/2012	Revision 4
		Applicability Tetra Tech, Inc.	
		Prepared Earth Sciences Department	
Subject GROUNDWATER MONITORING WELL INSTALLATION		Approved J. Zimmerly	

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 <u>Well Development Methods</u>

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.

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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[7]
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[7]*	Silicone	Neoprene	Teflon[7]*
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[7]
2 Polypropylene (PP)
3. PVC Flexible/PE Linear
4 Viton[7]
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.

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		Effective Date 01/2012	Revision 3
		Applicability Tetra Tech, Inc.	
		Prepared Earth Sciences Department	
Subject WELL ABANDONMENT		Approved J. Zimmerly	

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1.0 PURPOSE

Well abandonment is that procedure by which any monitoring well is permanently closed. Abandonment procedures are designed to prevent fluids from entering or migrating within the monitoring well. Therefore, an abandoned monitoring well must be sealed in such a manner that it can not act as a conduit for migration of contaminants from the ground surface to the water table or between aquifers.

It is important that the appropriate state or local agency be notified of monitoring well abandonment. The application of and adherence to this SOP must be tailored to applicable state, local, and Federal regulatory requirements.

2.0 SCOPE

The methods described in this procedure shall be used for all projects requiring well abandonment where specific state, local, or Federal regulations are unavailable. An abandoned well shall be filled and sealed so that it will not act as a pathway for the interchange of water between the surface and subsurface or present a hazard to the environment.

3.0 GLOSSARY

Well - Any constructed access point to an aquifer, confined or unconfined, including, but not limited to, test borings, hydropunch holes, monitoring points, and production wells.

Abandon - To permanently discontinue the use of a well. Any well shall require abandonment when it is no longer serving as a monitoring point or is in such a state of disrepair that continued use for the purpose of obtaining groundwater is impracticable, or when it has been permanently disconnected from any water supply system or irrigation system.

4.0 RESPONSIBILITIES

Project Manager - It shall be the responsibility of the Project Manager and/or Project Hydrogeologist to determine the applicability of well abandonment, based on the established scope and objective of the project and program-specific requirements. It shall be the responsibility of the Project Manager (or designee) to ensure that the procedures established for well abandonment are thoroughly specified and/or referenced in the relevant project planning documents. It shall be the responsibility of the Project Manager to ensure that the Field Operations Leader is familiar with the proper procedures for well abandonment and confirm the supervising project geologist or the subcontractor performing the well abandonment are qualified to perform such activities.

Field Operations Leader (FOL) - It shall be the responsibility of the Field Operations Leader to ensure that all field technicians and/or drilling personnel are thoroughly familiar with this Standard Operating Procedure. It shall be the responsibility of the FOL to ensure that the procedures identified in this SOP are used during well abandonment.

5.0 PROCEDURES

5.1 General

Well abandonment is warranted when the project team has reason to believe, on the basis of local conditions, that the well is causing or is a potential source of pollution to an aquifer; is a production well that is producing water that is polluted; or does not have a certificate of potability, if required. Wells may also be abandoned once their designed purposes have been fulfilled and are determined to no longer be of use.

Well abandonment is conducted to eliminate physical hazards, prevent groundwater contamination, prevent intermixing of aquifer waters, and conserve aquifer yield and hydrostatic head.

Please note Federal, state, and local regulations concerning this activity may vary. Therefore, applicable regulatory requirements should be reviewed to determine the need for Licensed/Certified Well Drillers to complete/oversight this activity.

5.2 Material for Sealing

Acceptable sealing materials include concrete, portland cement grout, sodium-base bentonite clay, or combinations of these materials. These materials are defined as follows:

- Concrete may be used for filling the upper part of a well or water bearing formation, or plugging short sections of casing and filling large diameter wells.

- Portland cement grout is superior for sealing small openings, penetrating any annular space outside the casing, and for filling voids in the surrounding formation. Portland cement grout shall be composed of one bag of Type I cement per 6 to 8 gallons of water. Two parts sand to one part cement may be added.

- Bentonite clay, when applied as a heavy mud-laden fluid under pressure, has most of the advantages of cement grout, but under some conditions may be carried away into the surrounding formation. A bentonite clay mixture shall be composed of not less than 2 pounds of clay per gallon of water. Bentonite clay may not be used where it will come in contact with water of a pH below 5.0 or total dissolved solids (TDS) content greater than 1,000 mg/L or both. Bentonite may also be added to cement grout to add flexibility.

Fill materials include clay, silt, sand, gravel, crushed stone, or a mixtures of these materials may be used as a filler in sealing a well when used in conjunction with the sealing materials described above. Organic material may not be used and fill material may be required to be disinfected or certified clean prior to use. Spent drilling muds or drill cuttings are not to be used to seal a well.

5.3 Procedures for Sealing Wells

5.3.1 Preliminary Considerations

Several factors should be considered to determine the appropriate well abandonment method. These factors include:

- Conditions of the well.
- Details of well construction, including casing material, diameter of casing, depth of well, and well plumbness.
- Obstructions within the well that may interfere with filling or sealing.
- Hydrogeologic setting.
- Level of contamination and the zone or zones where it occurs.
- Regulatory requirements.

Degraded wells may not permit casing removal by pulling. Also, the casing material may dictate whether a casing can be removed intact. Stainless steel will have a higher tensile strength than PVC and may hold together while pulling the casing; PVC well casing may break under pulling and may need to be overdrilled to remove it. The depth of the well and well plumbness may limit casing removal depending on whether a casing is pulled or overdrilled. In some cases, casings can be left in-place if they are properly filled with appropriate backfill.

The formation lithology influences the selection of casing removal. Unconsolidated materials can be drilled with hollow-stem augering techniques whereas consolidated materials cannot. Unconsolidated materials may also cave-in during well casing removal.

5.3.2 Filling and Sealing Procedures

Drilled wells (all wells not dug) shall be filled with sealing material or a combination of sealing material and fill material.

In some cases, well casing removal is necessary for well abandonment. If the borehole is unstable and may cave-in, sealing material will be emplaced simultaneously during casing removal. If the well is not grouted, casing may be pulled with hydraulic jacks or a drilling rig. It may also be pulled by sandlocking. Sandlocking consists of lowering a pipe wrapped with burlap approximately 2/3 of the well depth and filling the burlap wrap with sand. The pipe is slowly lifted and locks the sand, pulling the casing. Well casings can also be removed by overdrilling. Wells can be overdrilled with larger diameter hollow steam or solid stem augers or direct rotary techniques, using air or mud. Augers used for overdrilling should be at least 2 inches larger in diameter than the diameter of the well casing.

If well casing is in poor condition or is grouted in place, the casing may be ripped or perforated and filled and pressure grouted in place.

Abandoned wells shall be filled with the appropriate filling and sealing material placed from the bottom of the well upward. When Portland cement grout or concrete is used, it shall be placed in continuous operation using a tremie pipe. Sealing material shall be placed in the interval or intervals to be sealed by methods that prevent free fall, dilution, and/or separation of aggregates from cementing material.

A well constructed in unconsolidated material in an unconfined groundwater zone shall be filled and sealed by placing fill material in the well to the level of the water table, and filling the remainder of the well with sealing material. If the water table is at a depth greater than 40 feet, a minimum of 40 feet of sealing material shall be required.

A well which penetrates several aquifers or formations shall be filled and sealed in such a way as to prevent the vertical movement of water from one aquifer or formation to another. If the casing has been removed, sealing material shall be placed opposite the confining formations and from the surface down to the first confining formation. Sand and other suitable fill material may be placed opposite the producing aquifer. Ideally, the entire well can be filled with sealing material. If the casing has not been removed, the entire well shall be fill with sealing material.

A well penetrating creviced or cavernous rock shall be filled using coarse fill material opposite the cavernous or creviced rock portions of the well. Sealing material shall extend from the top of the unfractured rock portion of the well or base of the casing, whichever is deeper, to the surface. The minimum depth of sealing material may not be less than 10 feet.

In the case where wells penetrate specific aquifers where conditions necessitate the sealing of specific aquifers or formations, the annular space in the area of the specific aquifer or formation shall be sealed during the abandonment of the well.

A dug well exceeding 24 inches in diameter shall be filled and sealed by placing fill material (excluding clay or silt) in the well to a level approximately 5 feet below the land surface, and placing a 3 foot plug of sealing material above the fill. The remainder of the well shall be back filled with soil material.

6.0 REFERENCES

Maryland Department of the Environment (MDE Regulations); Title 26, Subtitle 04; Regulation of Water Supply, Sewage Disposal, and Solid Waste; Chapter 4--Well Construction.

U.S. EPA, February 1990. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells.