GEORGE AFB
CALIFORNIA

ADMINISTRATIVE RECORD
COVER SHEET

AR File Number 475050

Final
Data Gap Investigation Work Plan
Non-CERCLA Site OT071
Former George Air Force Base, California

Prepared For:
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Contract No. FA8903-09-D-8580
Task Order No. 0018
Revision 0
April 2016

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Final Data Gap Investigation Work Plan
Non-CERCLA Site OT071
Former George Air Force Base, California

Contract No. FA8903-09-D-8580
Task Order No. 0018, Revision 0
February 2016

DEPARTMENT OF THE AIR FORCE
AIR FORCE CIVIL ENGINEER CENTER

APR 28 2016

145981-THO-0109-F

MEMORANDUM FOR California RWQCB, Lahontan Region
Attn: Mr. Todd Battey, PG
14440 Civic Drive, Suite 200
Victorville, CA 92392

FROM: AFCEC/CIBW
3411 Olson Street
McClellan, CA 95652-1003

SUBJECT: Final Data Gap (DG) Well Installation Work Plan (WP) Non-CERCLA Site OT071, Former George Air Force Base (AFB), California

Attached is the Final Data Gap Investigation Work Plan Non-CERCLA Site OT071 for your records.

This document has been posted on the George AFB Project Portal:
AFCEE WERC-09 Former George Air Force Base > RegulatorsShaw > Shared Documents >

The document is also uploaded to the GeoTracker.

Thank you for your support of the former George AFB environmental program. If you have any questions or concerns, please do not hesitate to call me at (916) 643-0830, ext. 211.

DONALD GRONSTAL
BRAC Environmental Coordinator

Attachment:
Final DG Well Installation WP Non-CERCLA Site OT071 (CB&I, 2016)

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Final
Data Gap Investigation Work Plan
Non-CERCLA Site OT071
Former George Air Force Base, California

Prepared for Air Force Civil Engineer Center
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AFCEC WERC09, Contract Number FA8903-09-D-8580
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Prepared for Air Force Civil Engineer Center
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Task Order 0018
CB&I Federal Services LLC Project No. 145981

Revision 0

April 2016

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Acronyms and Abbreviations

µg/L	microgram per liter
Air Force	U.S. Air Force
AKA	Also known as
AMR	Annual Monitoring and Operations Report
bgs	below ground surface
CB&I	CB&I Federal Services LLC
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DHS	California Department of Health Services
EPA	U.S. Environmental Protection Agency
FFA	Federal Facilities Agreement
FPA	Flood Plain Aquifer
ft/ft	feet per foot
GAFB	George Air Force Base
MCL	maximum contaminant level
MLU	Middle Lacustrine Unit
msl	mean sea level
MWH	MWH Americas, Inc.
PCAP	Pesticide Corrective Action Plan
PLZ	Permeable Lacustrine Zone
QAPP	Quality Assurance Project Plan
RWQCB	Regional Water Quality Control Board
SBEHS	San Bernardino, Department of Public Health, Environmental Health Services
SCLA	Southern California Logistics Airport
Shaw	Shaw Environmental, Inc.
UFP-QAPP	Uniform Federal Policy Quality Project Plan
VVWRA	Victor Valley Wastewater Reclamation Authority

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1.0 INTRODUCTION

This well installation work plan describes data gap well installations activities to be performed at non-Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Site OT071. Site OT071 is located at the southeastern and east-central portion of the former George Air Force Base (GAFB) in the city of Victorville in San Bernardino County, California (Figure 1-1). Site OT071 encompasses approximately 900 acres and consists of pesticides in groundwater beneath the former housing areas and the Westwinds Golf Course. No formal administrative agreements or decision documents currently govern the ongoing environmental monitoring and reporting actions at Site OT071.

The primary objective of the proposed investigative activities is to fill data gaps identified in the Draft Non-CERCLA OT071 Corrective Action Plan for Pesticides in Groundwater (PCAP) (MWH, 2011) and during discussions between the Air Force (AF) and the Lahontan Region office of the California Regional Water Quality Control Board (RWQCB).

The proposed wells are intended to further characterize the lateral and vertical extent of the dieldrin plume at specific locations identified by the Air Force and the RWQCB. In addition, the wells may be useable at a later date as monitoring wells in a long term monitoring program and/or as future sentinel wells (Lower Aquifer).

Proposed shallow zone soil sampling is intended to provide Dieldrin concentrations for calibration of vadose zone modeling.

The primary proposed field investigative activities include the following:

- Drilling and sampling (for lithology) of five well borings. These borings will be used for installation of five new groundwater wells (two in the Upper Aquifer and three in the Lower Aquifer)
- Groundwater sampling of the five new groundwater wells (stated above)
- Drilling and sampling for both lithology and Dieldrin in five geotechnical borings.

This work plan describes the general scope of work associated with the proposed well installations and geotechnical borings. Details of the methods and procedures to be employed during these field investigative activities are described in the draft Basewide Quality Assurance Project Plan (QAPP) (Shaw Environmental & Infrastructure, Inc. [Shaw] [a CB&I company], 2012), which was prepared using the Uniform Federal Policy QAPP guidelines.

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2.0 BACKGROUND

The former GAFB is located in Victorville, San Bernardino County, California, adjacent to the city of Adelanto. The former GAFB was operational from 1941 to 1992. At present, the former George AFB includes property that has been transferred to civilian ownership under the Base Realignment and Closure (BRAC) process, property that remains under the control of the Air Force Civil Engineer Center (AFCEC) pending transfer, and property transferred to the Federal BOP. The Southern California Logistical Airport (SCLA) has been the largest recipient of property transferred from the Air Force to date. The former GAFB site presently hosts both civilian and Air Force organizations and activities, the majority of which are related to aviation.

During its operational history, GAFB supported a significant training and readiness mission that required military housing and support facilities. The facilities included housing, a golf course, a hospital, and other community-related buildings. Facilities and housing overlayingthe Site OT071 groundwater plume area were used and maintained for military personnel until base closure in 1992, with the exception of the former housing area, which was infrequently used for military training and continued operation, and the Westwinds Golf Course.

The source for pesticides in groundwater appears to be pesticide used for pest control in the former housing area, with subsequent transport to the groundwater by irrigation. As part of the construction and routine maintenance of the housing area, pesticides were applied to the building foundations for pest control, including prevention and treatment in accordance with standard practices of the time. The first housing was built in 1961 and construction continued through the 1970s. Dieldrin was used from approximately 1950 to 1970. The U.S. Environmental Protection Agency (EPA) banned all uses of Dieldrin in 1987.

The former housing area was heavily irrigated to support trees, lawns, and other landscaping. The landscaping in the former housing area is evident in review of the historic aerial photographs. The volume of water used for irrigation was sufficient to create runoff into two drainage culverts near the eastern edge of the northern housing area and to support vegetation year-round (MWH, 2002). The irrigation water was supplied by wells located near the Mojave River and installed in the FPA. The application of pesticide combined with irrigation practices in the housing area resulted in a pesticide impact to the groundwater and the identification of non-CERCLA Site OT071.

The Westwinds Golf Course is a nine-hole course now controlled by the City of Victorville (approximately 100 acres). The Westwinds Golf Course historically used water pumped from

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former GAFB production wells located east of the base for irrigation. In 2003, the irrigation water-supply source changed to effluent water from the VVWRA Wastewater Treatment Plant. This water was piped via a 3 mile-long pipeline to the 600,000-gallon golf course water storage pond, which is now lined but not currently in use. The City of Victorville completed lining this pond in April 2007 at the request of the Air Force and regulatory agencies (MWH, 2008). Infiltration of water from the unlined Westwinds Golf Course pond and irrigation of the golf course created a groundwater mound in the vicinity of well NZ-120 and beneath the golf course. The groundwater mound has persisted despite the lining of the pond, and it is expected to persist for some time, as irrigation of the golf course has continued intermittently.

2.1 OT071 Site Description

Site OT071 encompasses approximately 900 acres in the southeastern and east-central portion of former GAFB and consists of pesticides in groundwater beneath the former housing areas and the Westwinds Golf Course. The site boundary is shown on Figures 2-1 through 2-3. The primary pesticide of concern in groundwater at the site is Dieldrin[1].

City of Adelanto supply well A4 (AKA. Adelanto-4) is the nearest active supply well. A4 is located east of the site, screened in the Lower Aquifer (Figures 2-1 through 2-3), and monitored periodically.

The Federal Bureau of Prisons property has two inactive supply wells (PW-1 and PW-2) that are installed in the Lower Aquifer south of the site. The wells are inactive due to high naturally occurring arsenic levels in groundwater. The locations of the wells are shown on Figures 2-1 through 2-3. In addition, these wells have faulty seals allowing leakage from the Upper Aquifer to the Lower Aquifer.

2.1.1 Hydrogeology

The dieldrin plume at Site OT071 is present in both aquifers beneath the former GAFB. These are the Upper Aquifer and Lower Aquifer. The two aquifers are separated by the Middle Lacustrine Unit (MLU) which grades into a heterogeneous zone named the Permeable Lacustrine Zone (PLZ). The MLU is shown on the site maps (Figures 2-1 through 2-3 underlying the western edge of the site. The PLZ underlies most of the site and provides a route for groundwater to move downward from the Upper Aquifer to Lower Aquifer. The groundwater in the Lower Aquifer is separated from the MLU/PLZ by an upper, unsaturated (dry) zone of the Lower Aquifer. The Mojave River to the east is located on a unit called the Flood Plain Aquifer (FPA). The FPA is younger and more porous and

[1] Dieldrin is a chlorinated hydrocarbon pesticide used from approximately 1950 to 1970. Its use beyond the limited termite control near building foundations was banned in the United States in 1974. The EPA banned all uses of dieldrin in 1987.

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permeable than any of the other aquifers in the area. It is located below and on either side of the Mojave River and next to the Lower Aquifer.

Details of these zones are described below. Figures 2-1 through 2-3 show the aquifer data in plan view and Figures 2-4 through 2-8 show cross sections through OT071.

Upper Aquifer – The Upper Aquifer is composed of fine-grained sand and silt with some clay (Figure 2-4 through 2-8). Groundwater in the Upper Aquifer is present at 40 to 170 feet below the ground surface, and the aquifer is between a few and 40 feet thick. Groundwater moves relatively freely in the Upper Aquifer. The Upper Aquifer is the closest aquifer to the original source of Dieldrin and was the first aquifer to become impacted.

Groundwater in the Upper Aquifer generally flows northeast toward the Mojave River (Figure 2-1) and then downward through the intermixed sand and clay layers that comprise the Permeable Lacustrine Zone. During the time of base operation, it is presumed that there was a large groundwater mound in the Upper Aquifer beneath the heavily irrigated portions of the base. The plume that has resulted from varying points of recharge above the Upper Aquifer is large and dilute.

The Middle Lacustrine Unit and Permeable Lacustrine Zone – The Middle Lacustrine Unit is composed mostly of clay. The Middle Lacustrine Unit is approximately 170 feet deep and approximately 40 feet thick. The Permeable Lacustrine Zone is the eastern edge of the Middle Lacustrine Unit, where thin clay and sand layers overlap in both horizontal and vertical directions and all layers appear to become coarser in grain size. The Permeable Lacustrine Zone is also up to 170 feet deep and approximately 40 feet thick. In the variably saturated Permeable Lacustrine Zone, the groundwater in the Upper Aquifer moves downward to the Lower Aquifer.

Lower (Regional) Aquifer – The Lower Aquifer is primarily sand. The Lower Aquifer lies beneath the Middle Lacustrine Unit. Groundwater flows downward from the Upper Aquifer through the Permeable Lacustrine Zone to the Lower Aquifer. Regional flow in the Lower Aquifer is generally to the northeast. However, flow beneath OT071 is radial, away from the groundwater mound made by the downward percolation of water from the Westwinds Golf Course pond and the golf course (Figure 2-1).

Flood Plain Aquifer – The lithology of the FPA to the east of the study area is primarily fine-grained sand and silty sands. The FPA has an average thickness of about 150 feet and is approximately 1 mile wide beneath the active river channel. Groundwater flow in the FPA is to the north along the river.

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2.1.2 Dieldrin Water Quality Objective

The water quality objective at Site OT071 is 0.002 ug/L, which is the current analytical detection limit and California Department of Public Health (CDPH) advisory level for Dieldrin.

2.1.3 Existing Groundwater Monitoring Wells and Plume

The following network of groundwater monitoring wells is present at Site OT071 (Figures 2-1 through 2-3) and is monitored by the AF semiannually to track potential changes in the dieldrin concentrations in groundwater:

- 15 Upper Aquifer wells: NZ-63, NZ-66, NZ-89, NZ-91, NZ-119 through NZ-125, MW-136, MW-137, MW-144, and MW-146
- Eight Lower Aquifer wells: NZ-64, NZ-65, MW-142, MW-143, MW-145, MW-147, MW-149, and MW-151
- Two PLZ wells (wells screened at Lower Aquifer depths with groundwater elevations higher than the other Lower Aquifer wells): MW-148 and MW-152.

Dieldrin was detected in the Upper Aquifer and Lower Aquifer groundwater above the DHS State action level of 0.002 µg/L at Site OT071. Dieldrin has been consistently detected in samples collected from Upper Aquifer wells NZ-63, NZ-66, NZ-89, NZ-91, and NZ-121 at concentrations of approximately 0.1 µg/L. In the Lower Aquifer, dieldrin has been detected consistently in wells MW-147, MW-151, and MW-143. Dieldrin concentrations throughout the site range from nondetect to 0.15 µg/L. The concentrations in the Upper Aquifer are highest beneath the northern portion of the site and generally decrease in the downgradient directions to the northeast and southeast. Low concentrations in the vicinity of the golf course pond and golf course are likely related to dilution from groundwater mounding caused by irrigation water infiltration. The concentrations in the Lower Aquifer are similar to the concentrations in the Upper Aquifer at the southern portion of the site.

The concentrations of dieldrin and groundwater flow directions in the Upper and Lower Aquifers for the April 2014 monitoring event are shown on Figures 2-1 and 2-2, respectively.

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3.0 DATA GAP INVESTIGATION

The proposed investigative activities are to:

- Fill data gaps identified in the delineation of the dieldrin plume in the Upper and Lower Aquifers, so the appropriate remedial action can be evaluated and selected for pesticides in groundwater at Site OT071. A working session was held on September 22, 2015, to present and discuss in detail the proposed rationale of upcoming OU1 well installations. During the working session, the Air Force presented the well locations and rationales to the RWQCB,

- Provide near-surface Dieldrin concentrations in the vadose zone to aid in the calibration of the vadose zone modeling, and

- Provide geotechnical analyses of vadose zone and aquifer materials for inputs into vadose zone and groundwater models and to update the CSM.

Locations and rationale of individual sampling locations are provided in the following sections.

3.1.1 Groundwater Wells

The location and rational for installing the additional monitoring wells (five total) are summarized in Table 3-1 and by the following:

- MW-159 – Located in the Upper Aquifer southeast of NZ-120 to assess the groundwater mound and possible migration to the Lower Aquifer (Figures 2-1 and 2-3). The well will be screened across the top of the aquifer with between 10 and 15 feet of saturated screened interval to measure dieldrin concentrations near the Upper Aquifer surface (Figure 2-7).

- MW-160 – Located in the Upper Aquifer south of NZ-125 (Figures 2-1 and 2-3) and paired with MW-161 to assess the southeastern extent of the plume where dieldrin has been detected above the notification level. The well will be screened across the top of the aquifer with between 10 and 15 feet of saturated screened interval to measure dieldrin concentrations near the Upper Aquifer surface (Figure 2-6).

- MW-161 – Located in the Lower Aquifer south of MW-147 (Figures 2-2 and 2-3) and paired with MW-152 to assess the southern extent of the plume. MW-161 will be doublecased through the Upper Aquifer and screened across the top of the Lower Aquifer with between 10 and 15 feet of saturated screened interval to measure dieldrin concentrations near the Lower Aquifer surface (Figure 2-6).

- MW-162 – Located in the Lower Aquifer north of MW-147 (Figures 2-2 and 2-3) and paired with MW-152 to assess the southern portion of the plume. The well will be double cased through the Upper Aquifer and screened across the top of the

Lower Aquifer with between 10 and 15 feet of saturated screened interval to measure dieldrin concentrations near the Lower Aquifer surface (Figure 2-7).

- MW-163 – Located in the Lower Aquifer adjacent to MW-149 to assess the groundwater at the top of the water table (Figures 2-2 and 2-3). The well will be screened across the top of the Lower Aquifer with between 10 and 15 feet of saturated screened interval to measure dieldrin concentrations near the Lower Aquifer surface (Figure 2-5). MW-149 is screened in a deeper interval more in line with the nearby A4 supply well

3.1.2 Shallow Vadose Zone Model Calibration Borings

The purpose of the samples to be collected from these five borings will be to provide concentration data for use in calibrating the vadose zone model. The location and rational for installing the additional monitoring wells (five total) are summarized in Table 3-2 and by the following:

- OT071-SB02 - Located where the highest dieldrin concentration was previously detected (SS-37 at 15,000 ug/kg). See Figure 2-1 for location. Samples will be collected directly beneath the slab and at depths of 2, 4, 7, 10, and 15 feet below grade. Samples from depths below two succesive non-detect results will not be analyzed. (Note: The numbering of the new boring was begun at OT071- SB02. OT071-SB01 was drilled and sampled during the 2008 Data Gap Investigation reported by MWH in the Draft Non-CERCLA Site OT071 Corrective Action Plan for Pesticides in Ground Water, June 2011. The numbering of the borings was started with SB02 to avoid confusion in the site database.)

- OT071-SB03 - To be drilled at the location of SS-35 (1710 ug/kg). See Figure 2-1 for location. Samples will be collected at depths of 2, 4, 7, 10, and 15 feet below grade. Samples from depths below two succesive non-detect results will not be analyzed.

- OT071-SB04 - Location to be determined after field survey. To be drilled in an unpaved areas near the locations of former high concentration samples. Samples will be collected at depths of 2, 4, 7, 10, and 15 feet below grade. Samples from depths below two succesive non-detect results will not be analyzed.

- OT071-SB05 - Location to be determined after field survey. To be drilled in an unpaved areas near the locations of former high concentration samples. Samples will be collected at depths of 2, 4, 7, 10, and 15 feet below grade. Samples from depths below two succesive non-detect results will not be analyzed.

- OT071-SB06 - Location to be determined after field survey. To be drilled in a topographic low where runoff may have concentrated Dieldrin Samples will be collected at depths of 2, 4, 7, 10, and 15 feet below grade. Samples from depths below two succesive non-detect results will not be analyzed.

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Sample depths may vary based on the geologist's field observations and the material encountered. An effort will be made to select samples from different soil units if the change is near the designated sample depth. Of the samples collected for Dieldrin analyses, the shallowest samples will be analyzed first. Deeper samples will be analyzed if samples from near the surface detect Dieldrin.

Activities and methods for the installation of the proposed five data gap wells are discussed below. The work will be performed in accordance with the basewide QAPP (Shaw, 2012) and Standard Operating Procedures (SOP) (Appendix A).

3.2 Pre-Field Activities

Wells MW 159 through MW 163 will require Air Force Encroachment Permits. Drilling permits will be obtained for all the wells from the County of San Bernardino, Department of Public Health, Environmental Health Services (SBEHS).

Prior to performance of field activities, the Air Force will coordinate all field activities with the BOP and SCLA and will comply with all security protocols in effect for access to the project locations.

A basewide safety and health plan (HSP) has been prepared for activities to be performed at the former GAFB (CB&I, 2014). All personnel and subcontractors will be trained and certified in compliance with the HSP for the activities they will perform.

The availability of necessary decontamination water and electric power at the project sites as needed for the performance of the proposed activities will be assessed. Water and power will be provided as necessary if not present at the site. Areas for storage of investigation-derived wastes will be established.

Existing site facilities, including underground and aboveground utilities, will be protected by complying with utility avoidance protocols described in the HSP and EIG-HS-308 included in Appendix A. Underground Services Alert will be contacted at least 48 hours prior to the initiation of intrusive field activities. The underground utility avoidance procedure will include hand clearing of each boring location to a depth of 5 feet below ground surface (bgs) prior to the advancement of powered drilling tools and/or a site survey by a subcontracted underground utility locator.

3.3 Field Activities

Data gaps identified in the location of monitoring wells at Site OT071 will be addressed by drilling and sampling (for lithology) five borings and installing groundwater monitoring wells in those borings. The locations and depths of the additional wells are shown on

Figures 2-1 through 2-8, and the rationale for the approach to each additional well is provided in Table 3-1. Table 3-1 also identifies the anticipated depths of the proposed borings. Summaries of each field activity are in the following sections.

3.3.1 Well Borings

Five boring locations for subsequent installation of monitoring wells are proposed, as shown on Figures 2-1 and 2-2 and Table 2-1. All drilling activities will be performed in accordance with the Basewide QAPP (Shaw, 2012) and attached SOPs EID-GS-001, EID-GS-017, EID-GS-018, and EID-GS-019 in Appendix A.

3.3.1.1 Drilling

The proposed borings with depths less than 180 feet will be drilled using hollow-stem auger or air rotary casing hammer (ARCH) (MW-159, MW-160, and MW-163).

The proposed deep borings (MW-161 and MW-162) will be drilled using ARCH drilling or combination of both ARCH and mud rotary, as shown on Table 3-1. The borings will first use ARCH drilling to install surface casing through the MLU to the top of the aquifer. If possible, the wells will be completed using the ARCH drilling method. If site conditions (e.g., heaving sands) cause refusal in the ARCH drilling, mud rotary methods will be used to complete the borings.

From the top of the Upper Aquifer to the total depth, continuous soil samples for lithologic logging will be collected as determined by the field geologist. Borings adjacent to previous borings may not collect core in the interval cored by the adjacent boring. Soils samples will not be collected for chemical analysis because the proposed borings/wells are not near a source.

All downhole drilling equipment will be steam-cleaned prior to drilling and between boring locations. All downhole sampling equipment will be cleaned with an appropriate detergent and potable water rinse prior to each use (SOP EID-FS-014).

3.3.1.2 Geologic Logging

A geologist will supervise the drilling of each borehole and maintain a record of the drilling and soil conditions encountered (SOPs EID-GS-025 and EID-GS-027). The geologist will maintain continuous, detailed subsurface boring logs by examining drill cuttings and core, recording the collection of samples/cores, and noting first-encountered groundwater level for each borehole. The borings will also be logged by a geologist using the Unified Soil Classification System and standard geologic techniques. A boring log will be completed, and any lithologic sample interval selected for geotechnical analysis will be recorded on the log.

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Soil samples will be collected using a continuous sampler or split-barrel sampler (split spoon) (EID-GS-001).

Upon completion of drilling and soil sampling activities, the boreholes will be converted to monitoring wells as described in the following sections.

3.3.2 Well Materials

The well materials proposed for the five data gap wells are described in the following sections and shown on Figures 2-9 and 2-10.

3.3.2.1 Surface Casing

Surface casing, also known as isolation or conductor casing, will be installed in the Lower Aquifer wells (i.e., MW-161 and MW-162), as shown on Figure 2-10. Surface casing will be composed of polyvinyl chloride (PVC) or mild steel. Surface casings will be 8 to 10 inches in diameter to allow a drill string capable of making a boring that will allow at least 2 inches of annular space around the 4-inch well casing installed in the lower borehole.

3.3.2.2 Casing (Well Riser)

The well riser, also known as the casing, will consist of new, threaded, flush-jointed, Schedule 80 PVC, 4-inch inside diameter pipe. All casing will, at a minimum, conform to the requirements of ASTM-D 1785 for PVC pipe, or documentation will be provided that will establish conformance to this requirement. Each will bear markings identifying the material specified. The PVC casing will be National Sanitation Foundation potable water grade and will be so marked, or documentation will be provided that will establish conformance to this requirement.

3.3.2.3 Centralizers

Centralizers will be used during the installation of groundwater monitoring wells in ARCH or mud rotary borings. Well centralizers will be installed at 40 feet spacing on the blank casing and at 20 foot intervals immediately above and below the screen interval. Centralizers will not be required in wells completed using hollow-stem augers.

3.3.2.4 Screen

The well screen will consist of new, threaded, flush joint, 0.020 slot PVC continuous-wrap screen with box and pin ends. If unanticipated conditions are encountered, the well screen slot size will be selected based on the grain size distribution analysis of a sample from the screened interval. Ideally, screen slot size should be selected to retain a minimum of 90 percent of the filter pack material. The well screen will comply with the same requirements as the well casing regarding ASTM and National Sanitation Foundation standards. The screen will be noncontaminating, continuous-wrap design and will be

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constructed with joints 5 or 10 feet in length. The elevations of well screen intervals shown in Table 3-1 are estimated and will be refined based on where groundwater is actually encountered during drilling and the judgment of the field geologist. The screen will be placed such that the screen extends 5 feet above and 15 feet below the water level.

3.3.2.5 Well Caps

The top of the riser will be fitted with a PVC slip cap. The bottom of the deepest screen or casing will be sealed with a threaded PVC end cap or plug.

3.3.2.6 Filter Pack

The filter pack, also known as a sand pack, is installed in the annular space between the well screen and the borehole walls. Monitoring well filter packs extend approximately 1 foot below the bottom of the well. The top of the filter pack should be at least 3 to 5 feet above the top of the screen. Unless unanticipated conditions are encountered, the sand pack will consist of #3 sand.

A filter pack typically consists of washed, rounded to sub-rounded, uniformly-sized sand. This material is placed by gravity, or by pouring the sand slowly through the annulus of hollow-stem augers or through a tremie pipe in borings from other drilling methods. If the observed field conditions suggest that grout intrusion may occur during placement, a secondary filter pack, consisting of fine-grained sand 30/50 size or finer, may be placed atop the primary filter pack. This will prevent grout intrusion into the primary filter pack. If a secondary filter pack is used, it should extend 2 to 3 feet above the primary filter pack.

3.3.2.7 Bentonite Seal

An impermeable seal placed on top of the filter pack and below the annular seal (grout) is usually composed of commercially available bentonite pellets, bentonite chips, or a bentonite and water slurry. The bentonite and water slurry is preferred. Seal material must be a 6:1 to 7:1 ratio of hydrated bentonite powder to fine sand (#40 sand or finer) to be tremied into place.”. The bentonite absorbs water (hydration) and swells to form a seal in the annular space above the filter pack. For this reason, once the bentonite is placed in the borehole and wetted, a period of time must be allowed for the bentonite to absorb the water and swell. The sand is to prevent the propagation of cracks and loss of seal integrity as the seal dries out.

If it is necessary to use bentonite pellet seals, the seal should be 3 to 5 feet thick at the time of placement. The bentonite may be emplaced by free fall into the boring. Bentonite pellets are available as uncoated and coated varieties. Uncoated pellets are the preferred type for this application. Coated pellets may be needed for a well where the seal is to be installed below the water table (e.g., MW-161 and MW-162). If the pellet seal is to be located above the water table, then it will be installed, wetted, and allowed to hydrate for 30 minutes. If the

pellet seal is located below the water table, the entire length of the seal may be installed as one event.

Bentonite chips contain less water and hydrate more slowly than pellets. For this reason, chip seals will only be used in applications where the seal material has to be dropped through a long water column and should not be used above the water table. Chips are an acceptable alternative to coated bentonite pellets.

Bentonite slurry seals may be used, but their use is usually in applications where pellets would not fall through a tall water column without hydrating. The bentonite slurry is a mixture of pure bentonite powder and potable water mixed to a minimum 20 percent solids by weight (30 percent solids is preferred). The slurry should be pumpable with a minimum density of 9.4 pounds per gallon or greater and placed using a side-exiting tremie pipe.

3.3.2.8 Annular Seal

The annular seal (grout) is typically comprised of a slurry of portland cement and bentonite powder. Cement grouts must be mixed using 6.5 to 7 gallons of water per 94-pound bag of portland cement (Type I) and 3 to 4 percent by weight bentonite. A mud balance shall be used to measure the density of the grout slurry, and this will be recorded in the field notes. The grout will be mechanically mixed into a pumpable slurry that is placed in the boring by pumping through a side-exiting tremie pipe. The end of the tremie pipe shall remain submersed in the grout during pumping. If grout is to be emplaced as the hollow-stem augers are removed from the boring, then the level of grout shall be sufficient to leave approximately 10 feet of slurry inside the auger string. Grout will be placed in the boring until undiluted grout is present at the ground surface. Following the initial grout placement, the grout will be allowed to settle (soak into the formation) for at least 8 hours and topped off as necessary.

3.3.2.9 Protective (Above-Ground) Casing

For the data gap monitoring wells, the well will typically be completed above ground. Above the surface, the PVC well riser will be surrounded by a steel protective casing at least 2 inches larger than the riser pipe. The protective casing will be set at least 2 feet into the ground and rise 2 to 3 feet above ground level. A maximum 0.2-foot clearance will be allowed above the top of the PVC well casing and the protective casing cover. The outer protective casing will be of steel construction with a hinged, locking cap. The protective casing will have a minimum of two weep holes for drainage. These weep holes will be a minimum 0.25 inch in diameter and drilled into the protective casing just above the top of the level of concrete inside the protective casing to prevent water from standing inside the protective casing. The protective casing will be secured in the ground with concrete. Locks on the outer protective casing will be keyed the same as other OT071 wells.

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3.3.2.10 Surface Pad

A minimum 3-by-3-foot-square, 6-inch-thick cement pad that is sloped away from the well will be constructed around the well casing. The pad will be flush with the ground around the outer edges of the pad.

3.3.2.11 Protective Posts

Four steel protective posts (bollards) that are 3 inches or larger in diameter will be equally spaced around the well into the ground approximately 8 inches from the concrete pad. The protective posts will be 5 feet in length, set into the ground in concrete to a depth of 2 feet, and filled with concrete. The steel protective casing and posts shall be painted with permanent, high-visibility yellow paint.

3.3.2.12 Flush-Mount Monitoring Well Completions

If necessary, monitoring well completion may be flush with the ground surface. Flush mount completions will be used if site conditions warrant the change (e.g. high traffic areas where an above ground completion might be at risk from or obstruct traffic). The PVC will terminate below the ground surface within a protective watertight vault. The vault will be set into a cement or concrete pad that slopes away from the access port to provide positive drainage. A metal lid, affixed by bolts, will be installed on wells to provide security and a water-tight seal.

3.3.2.13 Well Identification and Survey Markers

A permanent marking or well tag indicating the well identification and completion information will be affixed to each newly installed well. The well identification marker will be an engraved noncorrosive metal tag that will be permanently affixed to the concrete pad at each stick-up well. Flush-mounted monitoring wells will be identified by an aluminum or brass disk at each well with the well identification marked.

3.3.3 Well Installation

Well permits will be obtained from the San Bernardino County Department of Public Health, Environmental Health Services (SBEHS). Well construction inspections will be coordinated with the SBEHS.

The five data gap monitoring wells will be constructed as follows:

- A screen, riser, and threaded end cap will be assembled to complete the well string.
- The well string will be suspended in the borehole.

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- The space between the outside of the well string and the borehole wall will be filled with a sand filter pack,
- The filter pack will extend from 1 to 2 feet below the bottom of the well to at least 3 feet above the top of the screen.
- Following placement of the filter pack but prior to placement of the bentonite seal the water in the well will be surged to settle the sand pack.
- A minimum 3-foot-thick bentonite seal will be placed on top of the filter pack.
- Grout will be placed on top of the bentonite seal.
- Each monitoring well will be completed with a stick-up completion consisting of a steel protective casing, cement pad, and cement-filled steel protective posts that are set in cement.

The on-site geologist will choose the depth for the screened interval that will achieve the objectives of the project and incorporate data from examination of soil samples and determination of static water level at the time of drilling.

3.3.4 Well Development

Well development is the process by which fine-grained sediments, drilling fluids, drilling mud, cuttings, and entrapped gases are removed from the area immediately adjacent to a well and connection with the aquifer is established. Development methods for the data gap monitoring wells at the former GAFB may include mechanical surging, bailing, and pumping.

Mechanical surging is the process that employs a surge block that is pushed and pulled back and forth in the well to force water into the filter pack and formation and pull water and fines from the filter pack and formation. The surge block operates like a piston, in that it fits tightly inside the well casing or screen and moves in an up and down fashion. Drill rods or piping are attached to the surge block and are used to control the movement of the device. Surging results in the mobilization of fine-grained materials into the screened section of the well. Surging will be alternated with periods of water removal (pumping or bailing) to remove these fines. The surging process will initially be performed gently to ensure that no damage is done to the new well.

Pumping is used to remove water and fine-grained solids from the well. A groundwater pump will be assembled, lowered into the screened portion of the well, and operated to remove water from the well, creating lower hydraulic head and a flow of water into the well. Fine-grained materials carried in suspension with the groundwater are evacuated from the well. Pumping is often used in conjunction with surging to mobilize and remove fines from

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the well. Pumping with variable rates may also be used to create a surging effect during the well development.

Bailing is another method for removing groundwater and suspended sediment from a well. A bailer is lowered into the well on a cable, allowed to fill, retrieved from the well, and emptied. This process is repeated. Bailers create a surging effect and mobilize fine-grained material into the well. Bailers can be used alone or in conjunction with a surge block.

Each well will be developed after the well has been constructed and at least 48 after the grout and concrete apron have been placed. During development, the pump inlet will be moved through the entire screened interval or the bailer will be lifted from different depths in the well.

The development procedure will continue until the following conditions are met:

- Water is clear to the unaided eye, free of sand, and free of drilling fluids.
- All measureable sediment has been removed.
- Temperature, pH, turbidity, and specific conductance values have stabilized. Stabilization is defined as three or more readings that are within the tolerances for temperature, pH, and conductance (0.1 units for pH; 1 degree F or less for temperature; and 10 percent or less for conductivity) as described in the Shaw/CBI Standards for Conducting Well Development (No.EID-GS-037 , page 7 of 9) included in Appendix A.
- All water added to the borehole or well during drilling and installation has been removed. At a minimum, 6 well volumes of water will be removed during the well development as described in the Shaw/CBI Standards for Conducting Well Development (No. EID-GS-037, page 7 of 9).
- Drilling fluids have been sufficiently removed from the formation based on measured parameters as described in the Shaw/CB I Standards for Conducting Well Development (No. EID-GS-037, page 7 of 9).

All purged water will be containerized. Water shall not be added to the well once the well has been grouted and sealed. If heavy or caked sediments must be removed by washing, the water will be from a clean, potable water source that has been sampled and analyzed or otherwise approved by the Air Force and Water Board for use.

Well installation diagrams will be included in the final construction report for each site. This diagram will illustrate the depth of the boring, screen location, sand filter pack material, seals, grout, height above or below ground surface of the wellhead, civil survey coordinates, elevation, and other pertinent data.

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3.3.5 Well Development Documentation

Daily field notes will be kept and will include sufficient information to reconstruct the progress of development operations, problems encountered, solutions to the problems, field conditions, and field activities. After completion of site work and report writing, original copies of all field forms and documents will be archived in the project files at the CB&I office in Knoxville, Tennessee and uploaded to the project portal.

The following records will be kept on well development:

- Project name and location
- Well designation and location
- Date and time of well installation
- Date and time of well development
- Static water level from top of well casing both before and 24 hours after well development
- Quantity of fluid in well prior to development, broken down as follows:
  - Fluid standing in well (within PVC casing)
  - Fluid contained in saturated annulus based on an assumed 30 percent porosity
- Field measurement of pH, conductivity, and temperature before, during (several times), and after development
- Depth from top of well casing to bottom of well
- Screen length
- Depth from top of well casing to top of sediment inside well, before and after development
- Physical character of removed water, including changes in clarity, color, suspended particulates, and odor
- Type and size/capacity of pump and/or bailer used
- Description of surge technique used
- Measured height of well casing above ground surface at time of development
- Pumping rates

- Quantity of water/fluid removed during development, recorded both incrementally and cumulatively
- Periodic depth to water measurements during and after development to help determine recovery rates.

3.3.6 Sampling of Groundwater from the Wells

Groundwater sampling from the data gap wells will be performed during the basewide semiannual sampling event and is not described in this work plan. When the groundwater is sampled it will be analyzed for constituents in the existing monitoring for OT071, General Chemistry, and Dieldrin using EPA Method 8270 SIM to reach the lower practical quantitation limits required.

3.3.7 Shallow Vadose Zone Model Calibration Borings

A total of five additional boring locations are proposed to be drilled using a Geoprobe rig or equivalent to depths of 15 feet, as described on Table 3-2. All drilling activities will be performed in accordance with the Basewide QAPP (Shaw, 2012) and attached SOP EID-GS-021 in Appendix A.

3.3.7.1 Drilling

Five proposed shallow vadose zone model calibration borings will be drilled using a Geoprobe rig or equivalent. Continuous soil samples will be collected. The boring locations and rationale are described is Section 2.2.2.

All downhole drilling equipment will be steam-cleaned prior to drilling and between boring locations. All downhole sampling equipment will be cleaned with an appropriate detergent and potable water rinse prior to each use (SOP EID-FS-014).

3.3.7.2 Geologic Logging and Soil Sampling

A geologist will supervise the drilling of each borehole and maintain a record of the drilling and soil conditions encountered (SOPs EID-GS-025 and EID-GS-027). The geologist will maintain continuous, detailed subsurface boring logs by examining the core, recording the collection of samples/cores. The borings will also be logged using the Unified Soil Classification System and standard geologic techniques including dilatancy and plasticity tests. A boring log will be completed, and any lithologic sample interval selected for geotechnical analysis will be recorded on the log.

Soil samples will be collected using a continuous sampler or split-barrel sampler (split spoon) (EID-GS-001). Samples will be selected for chemical analysis from depths of approximately 2, 4, 7, 10, and 15 feet below grade. Sample depths may vary based on the judgment of the onsite geologist and his observations of the material encountered. Of the

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samples collected for Dieldrin analyses, the shallowest samples will be analyzed first and deeper samples will be analyzed if samples from near the surface detect Dieldrin. Samples from depths below two consecutive non-detect results will not be analyzed.

Following selection of the chemistry samples, the core will be cut into lengths that will fit in a sample cooler, capped, and placed on dry ice according to the attached core shipping guidance. The borehole ID, top and bottom, and footage interval for each cut core sample will be labeled on the liner as well as the chain-of-custody.

Sample names will contain the boring designation and the depth interval (e.g. OT071SB-02-5-7 ft).

The core samples not selected for chemical analyses will be shipped to the geotechnical lab. Frozen cores will be slabbed and photographed in white light. Based on the photographs, the intervals for the tests listed in Section 2.4.8.1 will be selected by the geologist (1 per 5-foot core based on lithology).

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3.3.8 Laboratory Analyses of Soil

3.3.8.1 Chemistry

The purpose of the chemical analyses will be to provide concentrations of Dieldrin in near surface soil for calibration of the vadose zone model. Accordingly, selected samples will be sent to the laboratory as described above. The samples will be analyzed for Dieldrin by EPA Method 8081. Samples from depths below at least two non-detect results will not be analyzed.

Of the samples collected for Dieldrin analyses, the shallowest samples will be analyzed first and deeper samples will be analyzed if samples nearer to the surface detect Dieldrin. Samples from depths below non-detect results will not be analyzed.

3.3.8.2 Geotechnical Analyses

The purpose of the geotechnical analyses will be to provide soil property data for use in the vadose zone and groundwater modeling. One sample, per five feet of core from the shallow vadose zone model calibration borings, will be selected by the geologist based on lithology and the results of the white light core photography. Up to two additional samples may be selected from each of the five well borings at the discretion of the geologist. Geotechnical testing will include selected samples for:

- Full-scale digital core photography (white light) by ASTM D5079
- Grain-size analysis by laser by method ASTM D4464 ,

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- Total organic carbon by Walkley-Black method,
- Soil Properties Package (Vadose Zone) - native state permeability to air, total porosity, air-filled porosity, grain and bulk density, moisture content, total pore fluid saturation (reported as water only) by methods API RP40 and ASTM D2216.

Additional geotechnical testing may be added to the work scope once the vadose zone model is selected and the required inputs are known.

3.4 Post-Field and Disposal Activities

After the completion of exploratory boring field activities and monitoring well installation activities, the following waste disposal and surveying activities will be performed.

3.4.1 Waste Handling

All solid and liquid wastes generated during drilling operations will be retained on site in appropriate containment until arrangements can be made for proper disposal. Disposal requirements will be determined by laboratory analytical data generated from waste characterization composite samples in accordance with the basewide QAPP (SOP EID-FS-107).

3.4.2 Surveying

The well and boring locations will be surveyed by a State of California registered professional land surveyor. Horizontal coordinates will be surveyed to the nearest 0.01 foot and referenced to the U.S. State Plane Coordinate System, North American Datum, 1983. Ground surface elevations will be surveyed to the nearest 0.1 foot and referenced to the 1988 North American Vertical Datum.

3.4.3 Data Analysis

The data acquired during these field activities will be used in the HYDRUS model to assess migration through the vadose zone to the groundwater. The HYDRUS model was originally developed by the U.S. Dept. of Agriculture (Šimůnek et al., 1998) for simulating water and contaminant migration in variably saturated soils and has been continuously updated since first developed (Radcliff and Šimůnek, 2010). HYDRUS is a finite-element numerical model code for simulating flow and transport in variably saturated porous media (vadose zone and groundwater). HYDRUS has been selected for contaminant migration simulations involving vadose-zone/groundwater contaminant transport at George AFB for reasons listed below. HYDRUS includes modules for simulating the multi-dimensional movement of water, heat, and multiple solutes in variably saturated media including colloidal transport of contaminants and geochemical reactions between water and soil in the subsurface. The code is supported by an interactive graphics-based interface for data-preprocessing, generation of structured

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and unstructured finite element mesh, internal computational routines to minimize numerical dispersion effects, and graphic presentation and analysis of the results. HYDRUS has been well documented in the peer-reviewed literature and has published record on use at research and real-world sites (Yu and Zheng, 2010). An extensive list of references on HYDRUS use on various projects can be found at http://www.pc-progress.com/en/Default.aspx?h3d-references.

The reasons HYDRUS was selected for remediation modeling at GAFB are:

1. The model in well documented with an extensive user manual, many example projects, and robust vendor support.
2. Compared to other variably saturated model codes, HYDRUS has very robust calculation routines for handling infiltration during and shortly following precipitation events, evapotranspiration from the shallow soils back into the atmosphere following precipitation events, and effects on near-surface contaminant concentration increases in response to evaporation of soil water into the atmosphere.
3. HYDRUS input routines allow for direct use of site-specific hourly or daily climatological data from NOAA or CIMIS monitoring stations with no simplification or averaging. This allows for more realistic calculation of recharge fluxes through the vadose zone than is provided by other model codes. For example, daily (or hourly) data values for precipitation and reference evapotranspiration (calculated from temperatures, wind speed, solar radiation, etc.) are input as a daily meteorological data matrix than is then used in the model to calculate daily water and contaminant fluxes at the soil-atmosphere boundary. These atmospheric boundary fluxes are subsequently included in the water and contaminant migration calculations for underlying parts of the vadose and groundwater zones.
4. The model code incorporates standard contaminant plume hydrodynamic effects including advection, dispersion, retardation, and decay.
5. Using internal computational routines, the solute-transport solution code minimizes numerical dispersion effects by controlling the Peclet (grid spacing) and Courant (time-step increment) numbers during solution of the matrix equations using an othomin solver.
6. The solute transport module allows for a wide-variety of site-specific contaminant transport parameters including the simulation of parent and daughter products with separate sorption and decay characteristics.
7. The solute transport module simulates equilibrium partitioning and transport between water, soil, and vapor and can also simulate non-equilibrium partitioning and transport between the three phases.
8. The solute transport module can simulate colloidal transport of contaminants such as herbicides and pesticides and allows for user-defined colloid-specific transport parameters such as attachment-detachment mechanism for the colloids. There are a number of peer-reviewed publications where the HYDRUS colloidal transport module has been used successfully.
9. The solute transport modules simulate mass transfer between water and vapor using Henry's Law partitioning.

10. Given the large number of iterations (50 million+ iterations are not uncommon) and stability requirements to solve a field-scale variably-saturated solute transport model, the matrix solver is stable and reasonably fast. Processing of the very large output files (many megabytes) into graphical displays is rapid with extensive capabilities for data analysis.
11. HYDRUS was selected over MODFLOW-SURFACT because of better climatological data handling and shallow soil infiltration solution algorithms, flexibility in handling variably-saturated soil characteristics, simulation of colloidal transport of contaminants, and published examples of implementations for variably-saturated contaminant transport problems.

Water Board and Department of Toxic Substances (DTSC) staff are still discussing with the Air Force the applicability of the proposed HYDRUS vadose zone model for colloidal transport of dieldrin through the vadose zone. Once the Water Board, Department of Toxic Substances (DTSC), and CB&I staff have resolved the outstanding issues regarding HYDRUS modeling a technical memorandum describing the modeling and sample analysis methods and procedures will be inserted as Appendix D.

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4.0 REPORT PREPARATION

Upon completion of the well installation described in this work plan, AF will prepare and submit a report documenting the findings. The report will describe all activities performed, including deviations from this work plan. Site maps will indicate boring / monitoring well locations. The report will include boring logs and well construction diagrams. Geotechnical analytical data will be presented. Data resulting from the well installation activities (e.g., survey results and well construction details) will also be uploaded to the AF Environmental Resources Program Information Management System database. The final report will be uploaded to the Water Board's GeoTracker database.

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5.0 REFERENCES

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TABLES

Table 3-1

Well Construction Details
Data Gap Well Installation Work Plan, Non-CERCLA Site OT071
Former George Air Force Base

Well ID	Aquifer	Drilling Method	Estimated Top/Bottom of Screen Elevation (feet amsl)	Estimated Top of Saturated Zone Elevation (feet amsl)	Approximate Ground Surface Elevation (feet amsl)	Approximate Well Depth (feet bgs)	Casing Diameter (inches)	Screen Length! (feet)	Data Gap / Monitoring Purpose
MW-159	Upper	HSA	2750/ 2730	2745	2855	110	4	20	Southeast of NZ-120 to assess the groundwater mound and possible migration to the Lower Aquifer.
MW-160	Upper	HSA	2735/ 2715	2730	2907	177	4	20	South of NZ-125 and paired with MW-161 to assess the southeastern portion of the plume.
MW-161	Lower	ARCH / Mud Rotary *	2605/ 2585	2600	2907	322	4	20	South of MW-147 and paired with MW-160 to assess the southern portion of the plume where dieldrin has been detected above the notification level at MW 147.
MW-162	Lower	ARCH / Mud Rotary *	2605/ 2585	2600	2885	300	4	20	North of MW-147 and paired with NZ-125 to assess the central portion of the plume.
MW-163	Lower	HSA	2615/ 2595	2610	2736	141	4	20	Adjacent to MW-149 to assess the groundwater at the top of the water table.

* If site conditions (e.g., heaving sands) cause refusal in the ARCH drilling, mud rotary methods will be used to complete the boring.

! The proposed depths of the screened interval are designed to allow 5 feet of the screen above the water table with 15 feet below. The elevations of well screen intervals shown above are estimated and will be refined based on where groundwater is actually encountered during drilling and the judgment of the field geologist. The screen will be placed such that the screen extends 5 feet above and 15 feet below the water level.

amsl – Above mean sea level.
ARCH – Air rotary casing hammer.
bgs – Below ground surface.
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act.
HAS – Hollow Stem Auger

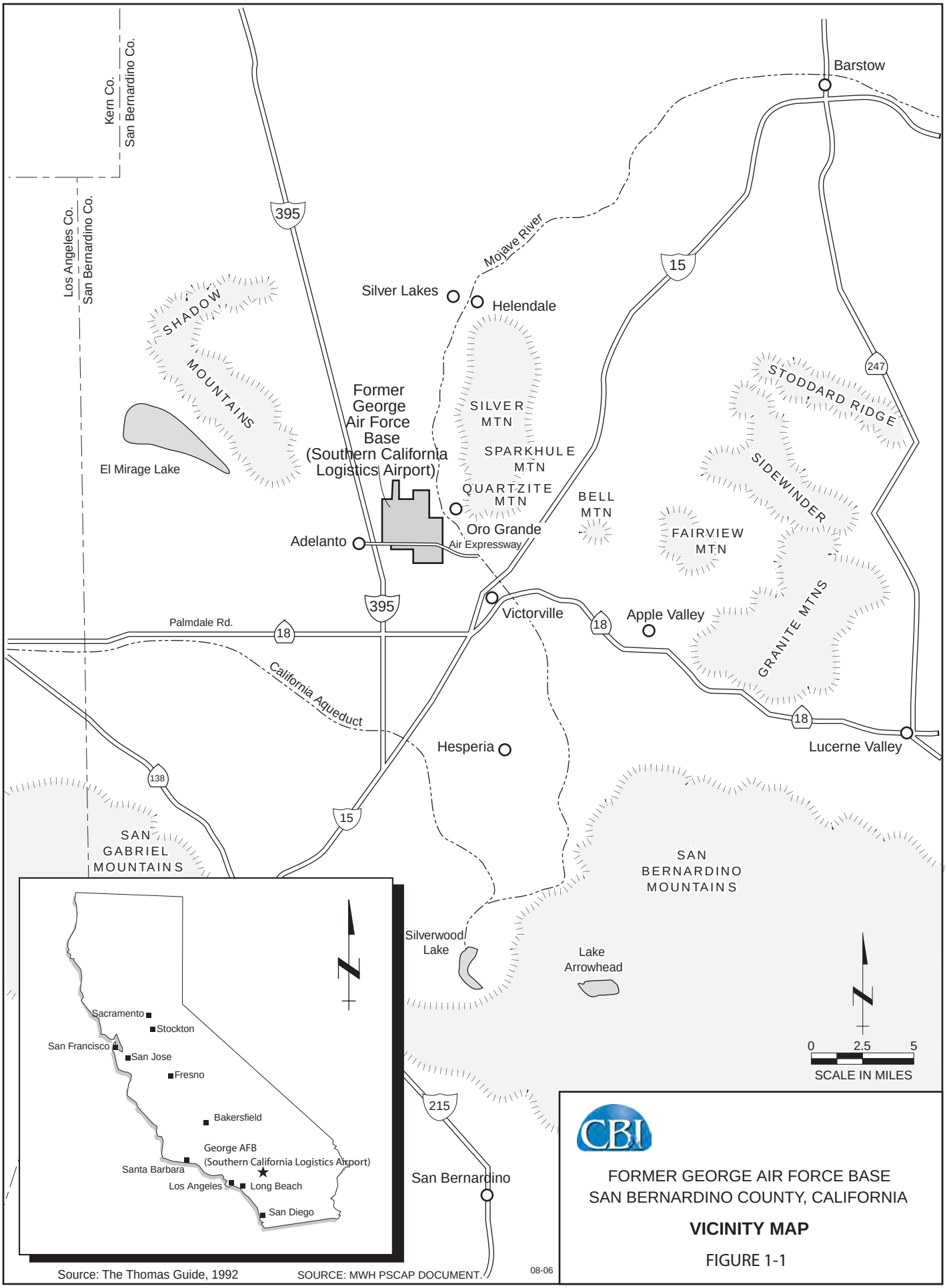
Table 3-2

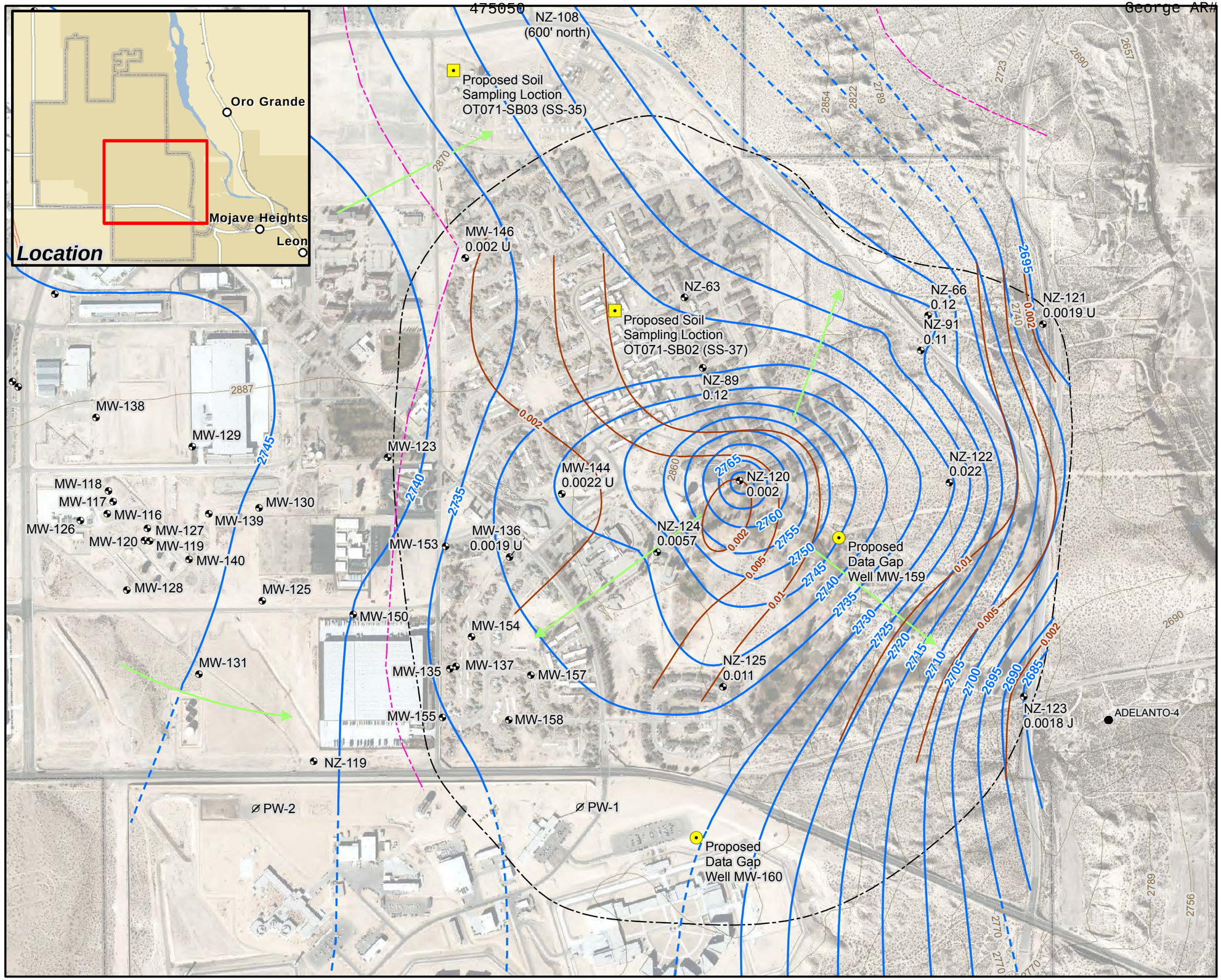
Vadose Zone Model Calibration Borings, Non-CERCLA Site OT071 Former George Air Force Base

Broing ID	Drilling Method	Boring Depth (feet bgs)	Data Gap / Sampling Purpose
OT071-SB02	Geoprobe or equivalent rig	15	Located where the highest dieldrin concentration was previously detected (SS-37 at 15,000 ug/kg). Samples will be collected directly beneath the slab and at depths of 2, 4, 7, 10, and 15 feet below grade.
OT071-SB03	Geoprobe or equivalent rig	15	To be drilled at the location of SS-35 (1710 ug/kg). See Figure 1. Samples will be collected at depths of 2, 4, 7, 10, and 15 feet below grade. See Figure 3-1.
OT071-SB04	Geoprobe or equivalent rig	15	Location to be determined after field survey. To be drilled in an unpaved area near the locations of former high concentration samples. Samples will be collected at depths of 2, 4, 7, 10, and 15 feet below grade.
OT071-SB05	Geoprobe or equivalent rig	15	Location to be determined after field survey. To be drilled in an unpaved area near the locations of former high concentration samples. Samples will be collected at depths of 2, 4, 7, 10, and 15 feet below grade.
OT071-SB06	Geoprobe or equivalent rig	15	Location to be determined after field survey. To be drilled in a topographic low where runoff may have concentrated Dieldrin Samples will be collected at depths of 2, 4, 7, 10, and 15 feet below grade.

Note: Sample depths may vary based on the geologist's field observations and the material encountered. Of the samples collected for Dieldrin analyses, the shallowest samples will be analyzed first and deeper samples will be analyzed if samples from near the surface detect Dieldrin. Samples from depths below consecutive non-detect results will not be analyzed.

FIGURES


Kern Co.
San Bernardino Co.
Los Angeles Co.
San Bernardino Co.
Barstow
395
Mojave River
15
Silver Lakes
Helendale
SHADOW MOUNTAINS
El Mirage Lake
Former George Air Force Base (Southern California Logistics Airport)
SILVER MTN
SPARKHULE MTN
QUARTZITE MTN
Oro Grande
Air Expressway
Adelanto
BELL MTN
247
STODDARD RIDGE
SIDEWINDER
FAIRVIEW MTN
GRANITE MTNS
Victorville
Apple Valley
Palmdale Rd.
18
California Aqueduct
Hesperia
Lucerne Valley
138
SAN GABRIEL MOUNTAINS
SAN BERNARDINO MOUNTAINS
Silverwood Lake
Lake Arrowhead
215
San Bernardino
Sacramento
Stockton
San Francisco
San Jose
Fresno
Bakersfield
George AFB (Southern California Logistics Airport)
Santa Barbara
Los Angeles
Long Beach
San Diego
0 2.5 5
SCALE IN MILES
CBI
FORMER GEORGE AIR FORCE BASE
SAN BERNARDINO COUNTY, CALIFORNIA
VICINITY MAP
FIGURE 1-1
Source: The Thomas Guide, 1992
SOURCE: MWH PSCAP DOCUMENT.
08-06



LEGEND

- Proposed Soil Sampling Location
- Proposed Upper Aquifer
- Groundwater Monitoring Well
- City of Adelanto Production
- Inactive Supply Well
- April/May 2014 Dieldrin Concentration Contour (µg/L)
- April/May 2014 Upper Aquifer Groundwater Contour (ft msl)
- (dashed where estimated)
- Groundwater Flow Direction
- Permeable Lacustrine Zone (PLZ) Boundary
- Topogaphic Contour (ft msl)
- Site OT071 Boundary
- Former George Air Force Base

0.022 April/May 2014 Dieldrin Concentration (µg/L)
J = estimated concentration
U = not detected at concentration shown

Note: Dieldrin concentrations were gridded using IDW with a range of 1800 ft, IDW exponent of 2, and no smoothing. A value of 0.0002 µg/L was used for non-detects. The resulting contours were modified by a hydrogeologist.

N

0 400 800 1,600
Feet
1 inch = 800 feet

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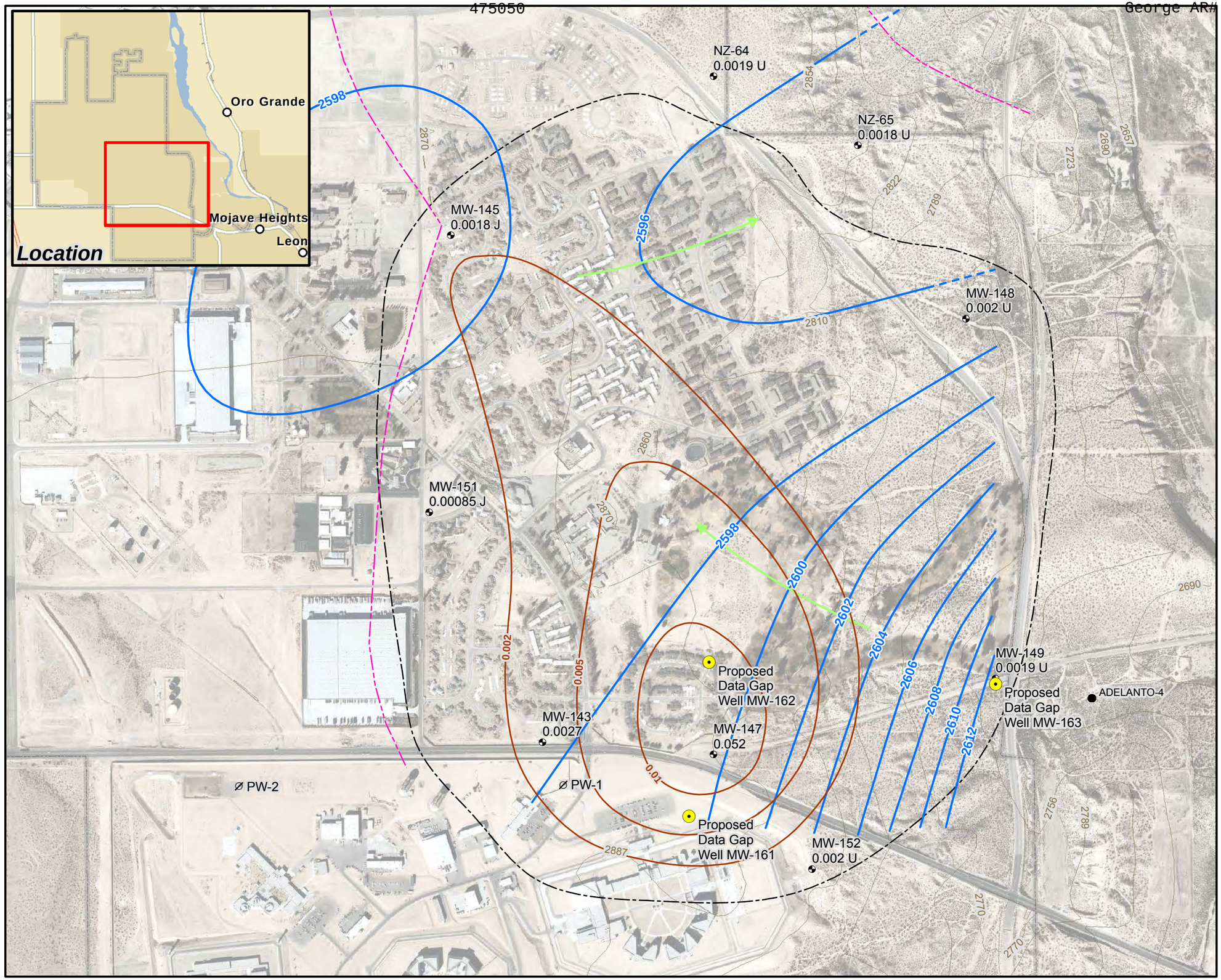
FORMER GEORGE AIR FORCE BASE
VICTORVILLE, CALIFORNIA

FIGURE 2-1

PROPOSED WELLS
UPPER AQUIFER, SITE OT071



LEGEND

- Proposed Lower Aquifer Well
- Groundwater Monitoring Well
- City of Adelanto Production Well
- Inactive Supply Well
- April/May 2014 Dieldrin Concentration Contour (µg/L)
- April/May 2014 Lower Aquifer Groundwater Contour (ft msl)
- (dashed where estimated)
- Groundwater Flow Direction Arrow
- Permeable Lacustrine Zone (PLZ) Boundary
- Topogaphic Contour (ft msl)
- Site OT071 Boundary
- Former George Air Force Base

0.052 April/May 2014 Dieldrin Concentration (µg/L);
J = estimated concentration
U = not detected at concentration shown

Note: Dieldrin concentrations were gridded using IDW with a range of 1800 ft, IDW exponent of 2, and no smoothing. A value of 0.0002 µg/L was used for non-detects. The resulting contours were modified by a hydrogeologist.

N

0 400 800 1,600
Feet
1 inch = 800 feet

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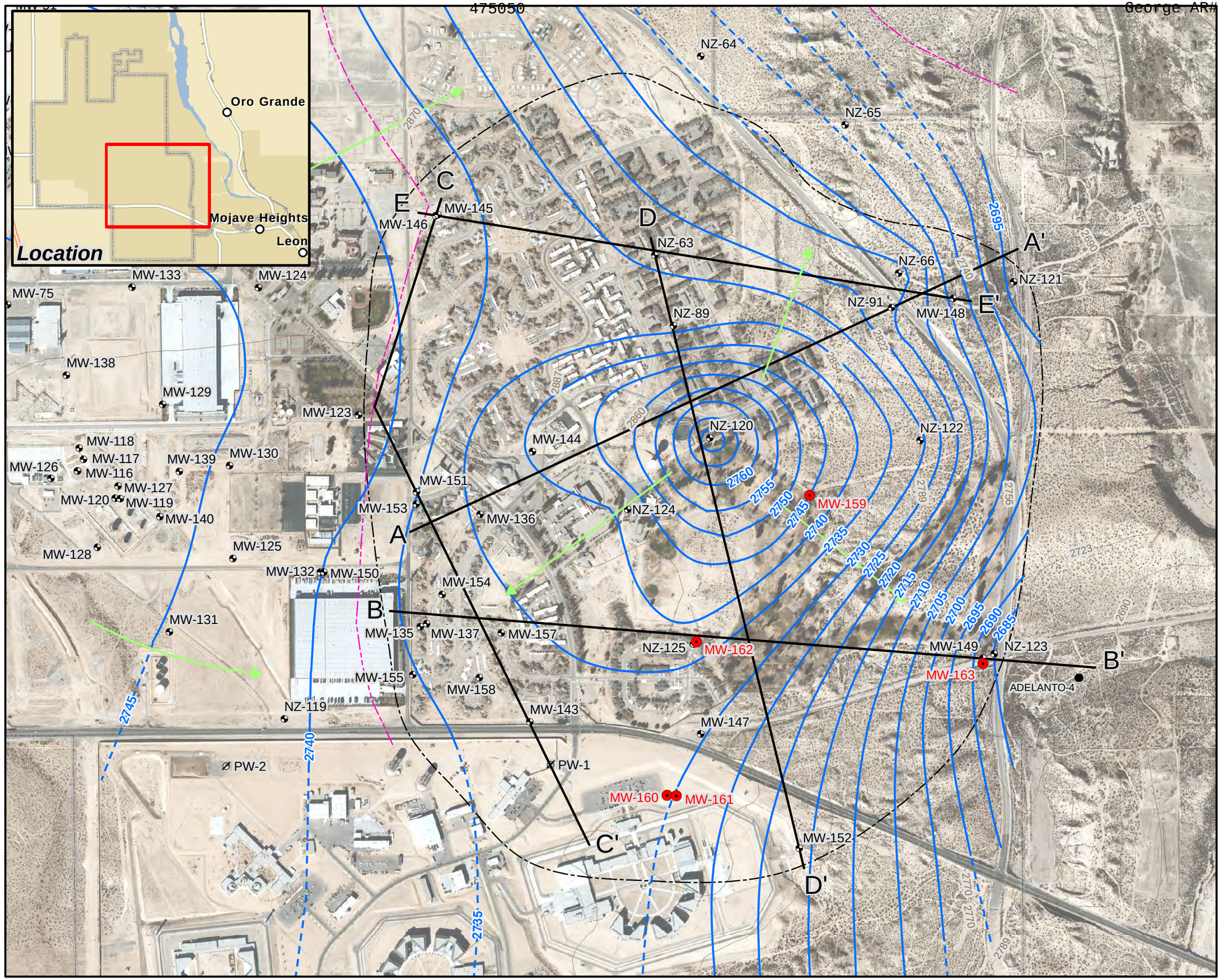
OT071 CAP
FORMER GEORGE AIR FORCE BASE
VICTORVILLE, CALIFORNIA

FIGURE 2-2

PROPOSED WELLS
LOWER AQUIFER, SITE OT071



LEGEND

- Proposed Well Locatoin
- Groundwater Monitoring Well
- City of Adelanto Production Well
- Inactive Supply Well
- April/May 2014 Upper Aquifer Groundwater Contour (ft msl)
- (dashed where estimated)
- Groundwater Flow Direction
- Permeable Lacustrine Zone (PLZ) Boundary
- Topogaphic Contour (ft msl)
- Site OT071 Boundary
- Former George Air Force Base

N

0 400 800 1,600
Feet
1 inch = 800 feet

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VICTORVILLE, CALIFORNIA

FIGURE 2-3

CROSS SECTION LOCATIONS
SITE OT071

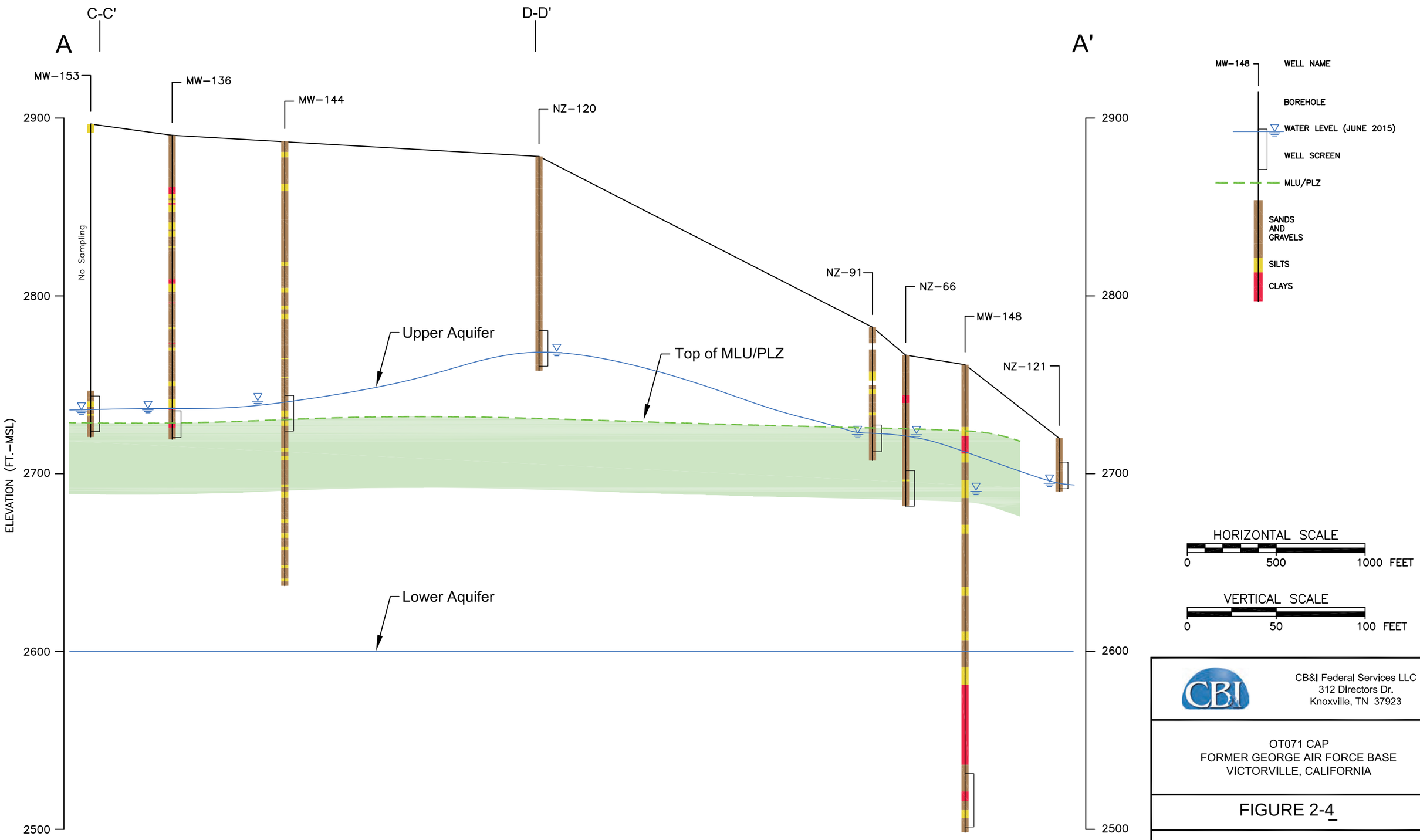

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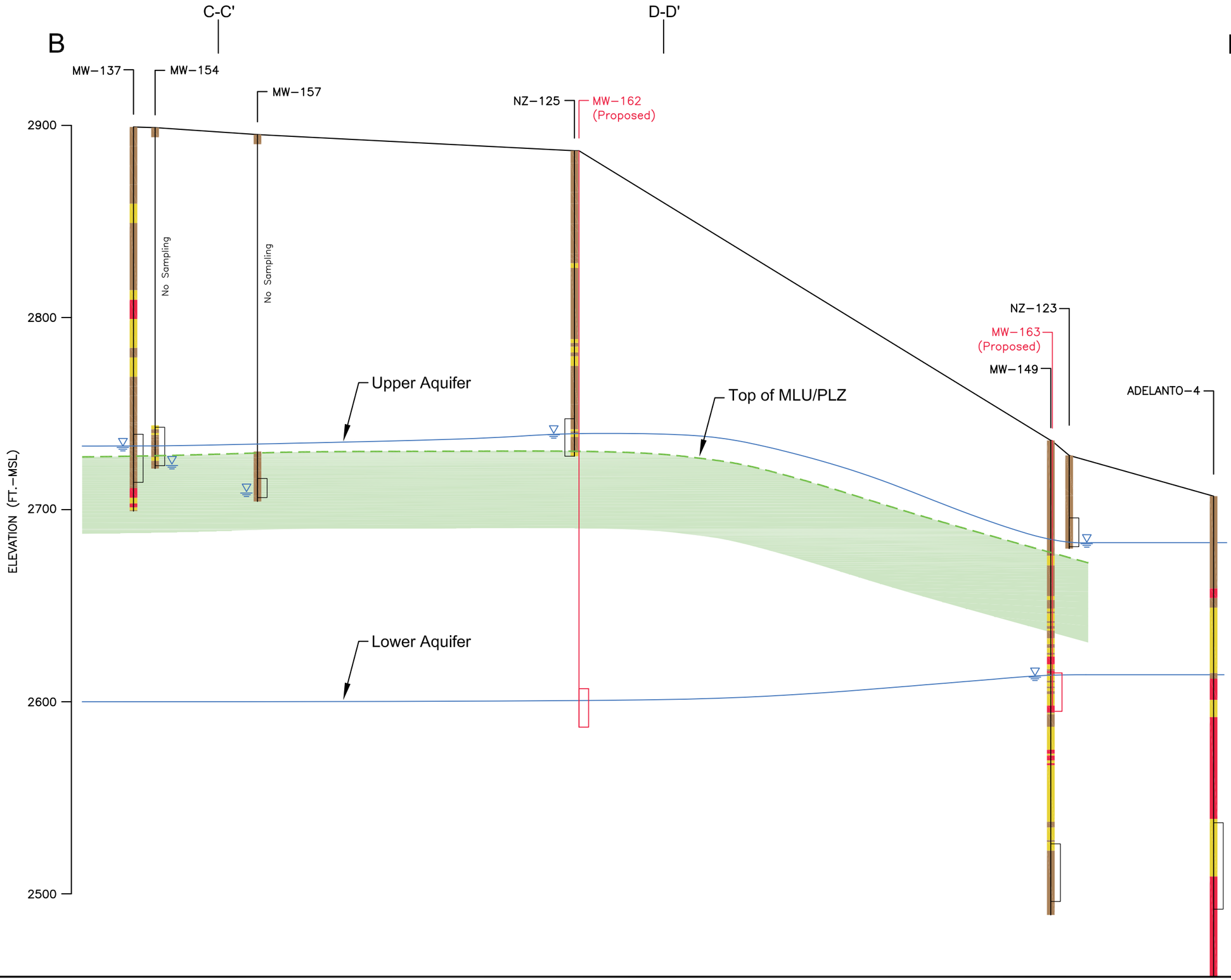
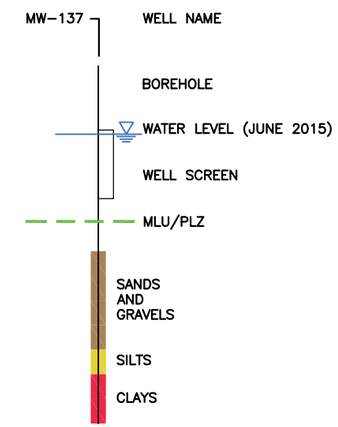
FIGURE 2-4

CROSS SECTION A-A'





HORIZONTAL SCALE

0 500 1000 FEET

VERTICAL SCALE

0 50 100 FEET

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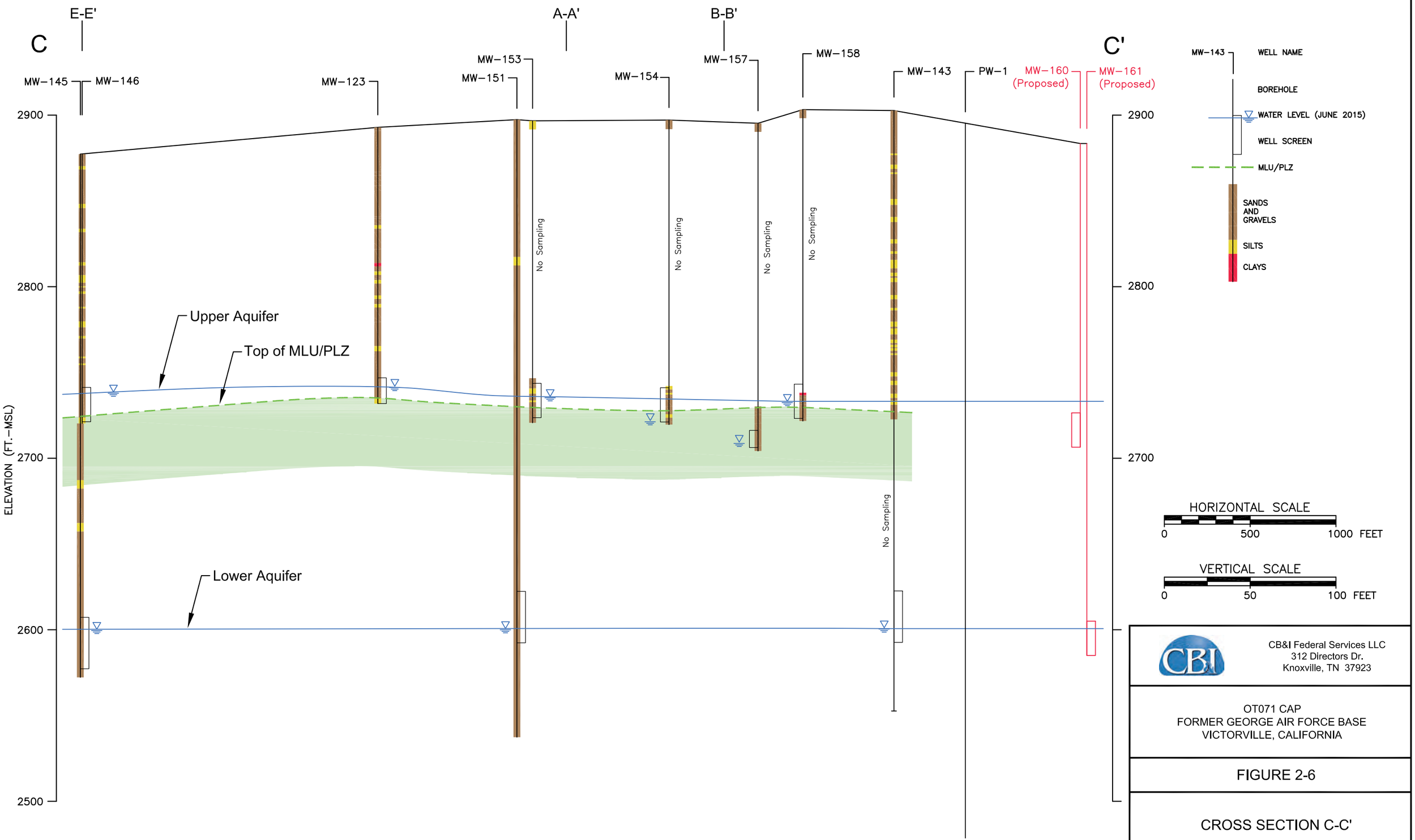
FORMER GEORGE AIR FORCE BASE
VICTORVILLE, CALIFORNIA

FIGURE 2-5

CROSS SECTION B-B'


C
E-E'
A-A'
B-B'
C'
MW-145
MW-146
MW-123
MW-153
MW-151
MW-154
MW-157
MW-158
MW-143
PW-1
MW-160 (Proposed)
MW-161 (Proposed)
No Sampling
2900
2800
2700
2600
2500
ELEVATION (FT.-MSL)
Upper Aquifer
Top of MLU/PLZ
Lower Aquifer
MW-143
WELL NAME
BOREHOLE
WATER LEVEL (JUNE 2015)
WELL SCREEN
MLU/PLZ
SANDS AND GRAVELS
SILTS
CLAYS
HORIZONTAL SCALE
0 500 1000 FEET
VERTICAL SCALE
0 50 100 FEET
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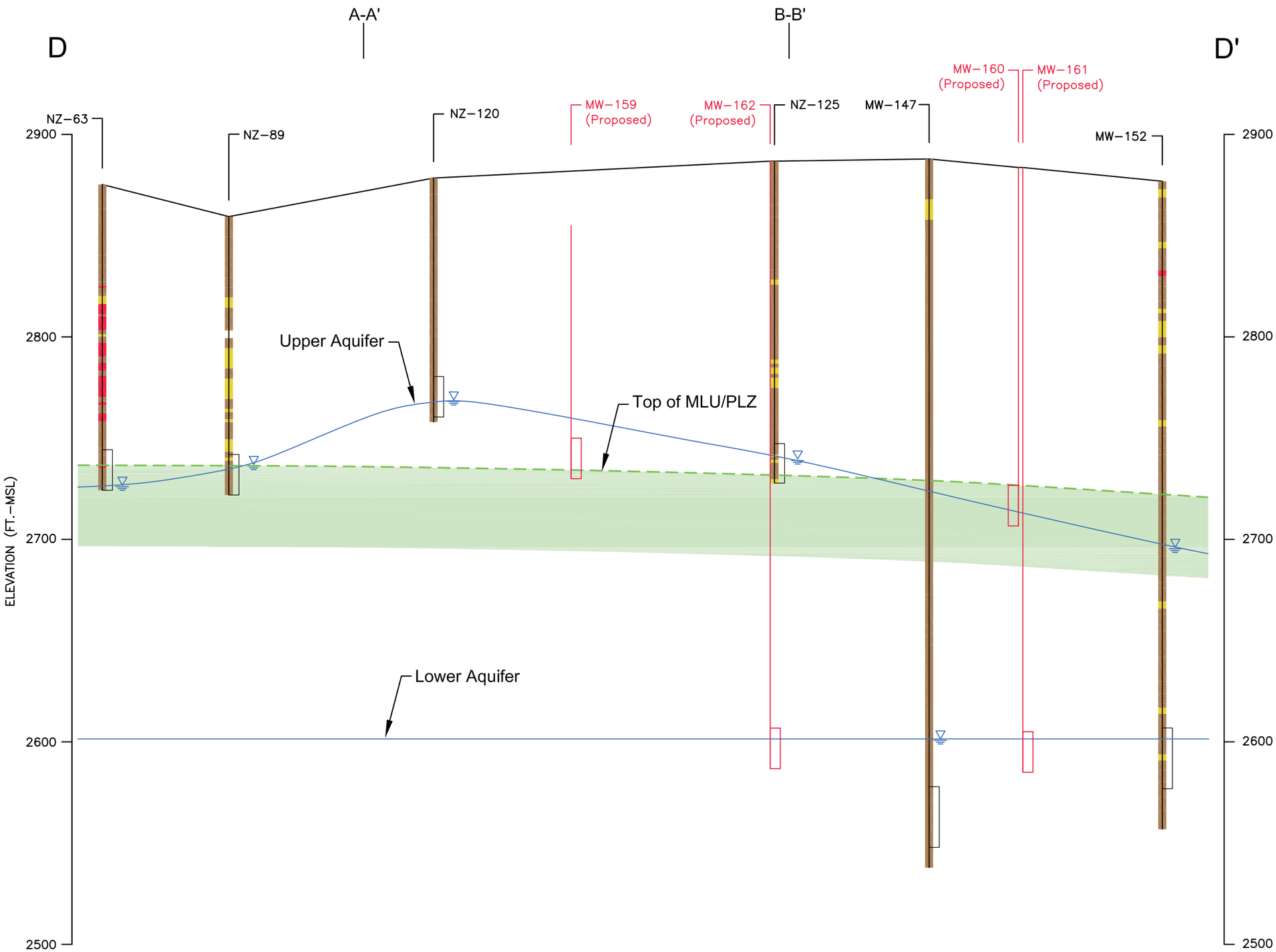
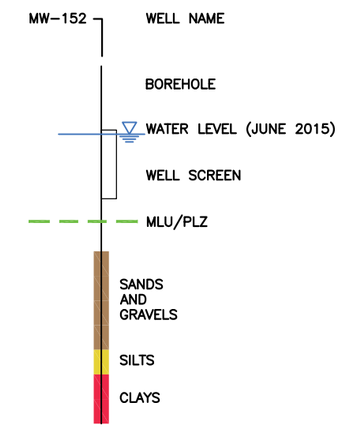
OT071 CAP
FORMER GEORGE AIR FORCE BASE
VICTORVILLE, CALIFORNIA
FIGURE 2-6
CROSS SECTION C-C'





HORIZONTAL SCALE

0 500 1000 FEET

VERTICAL SCALE

0 50 100 FEET

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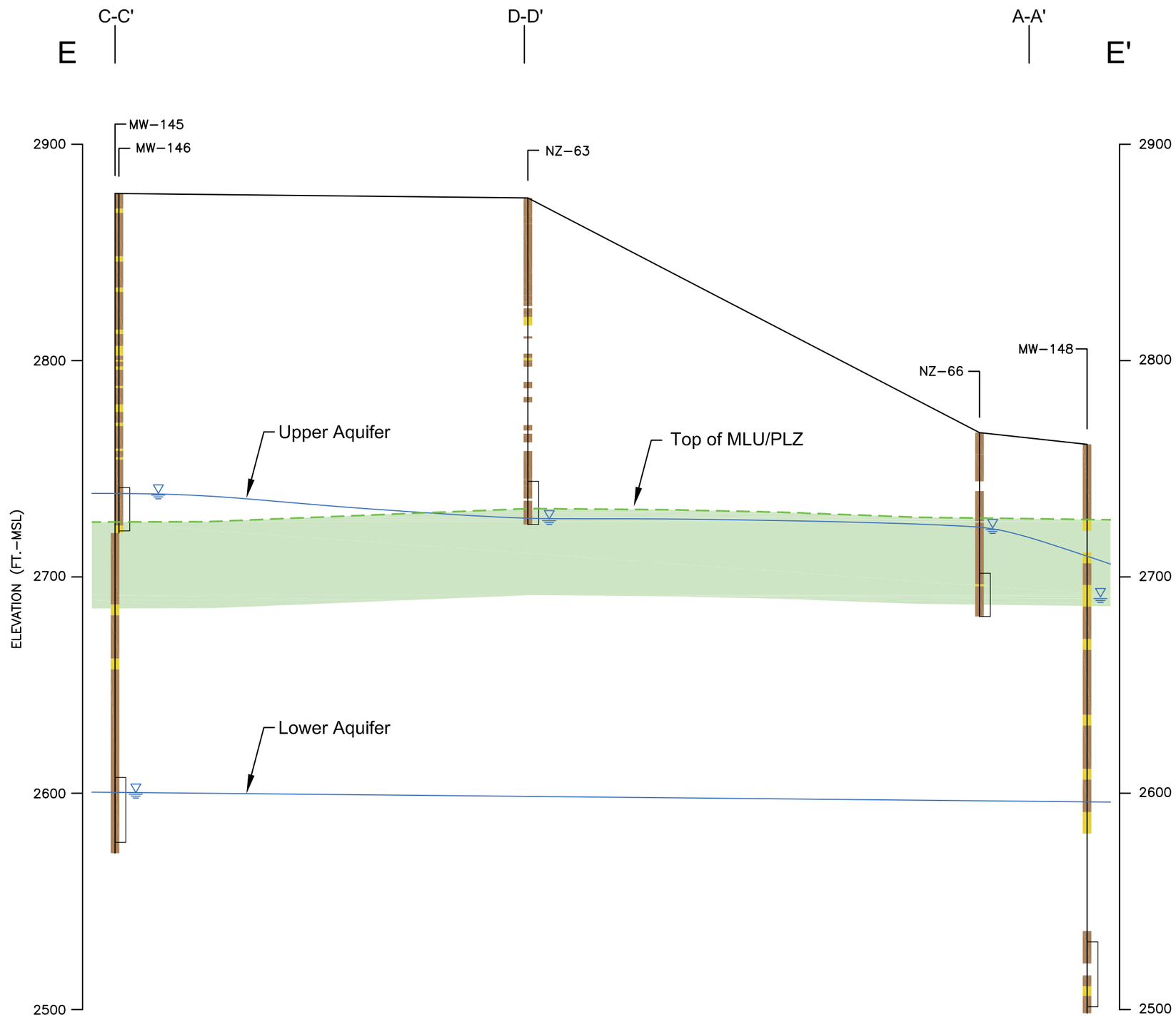
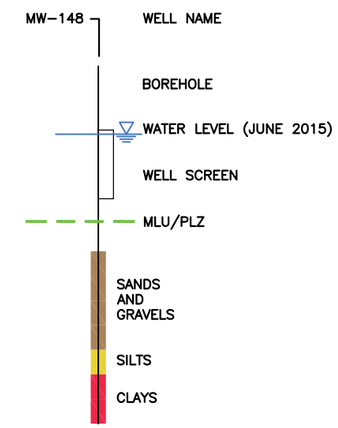
VICTORVILLE, CALIFORNIA

FIGURE 2-7

CROSS SECTION D-D'





HORIZONTAL SCALE

0 500 1000 FEET

VERTICAL SCALE

0 50 100 FEET

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FORMER GEORGE AIR FORCE BASE
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FIGURE 2-8

CROSS SECTION E-E'

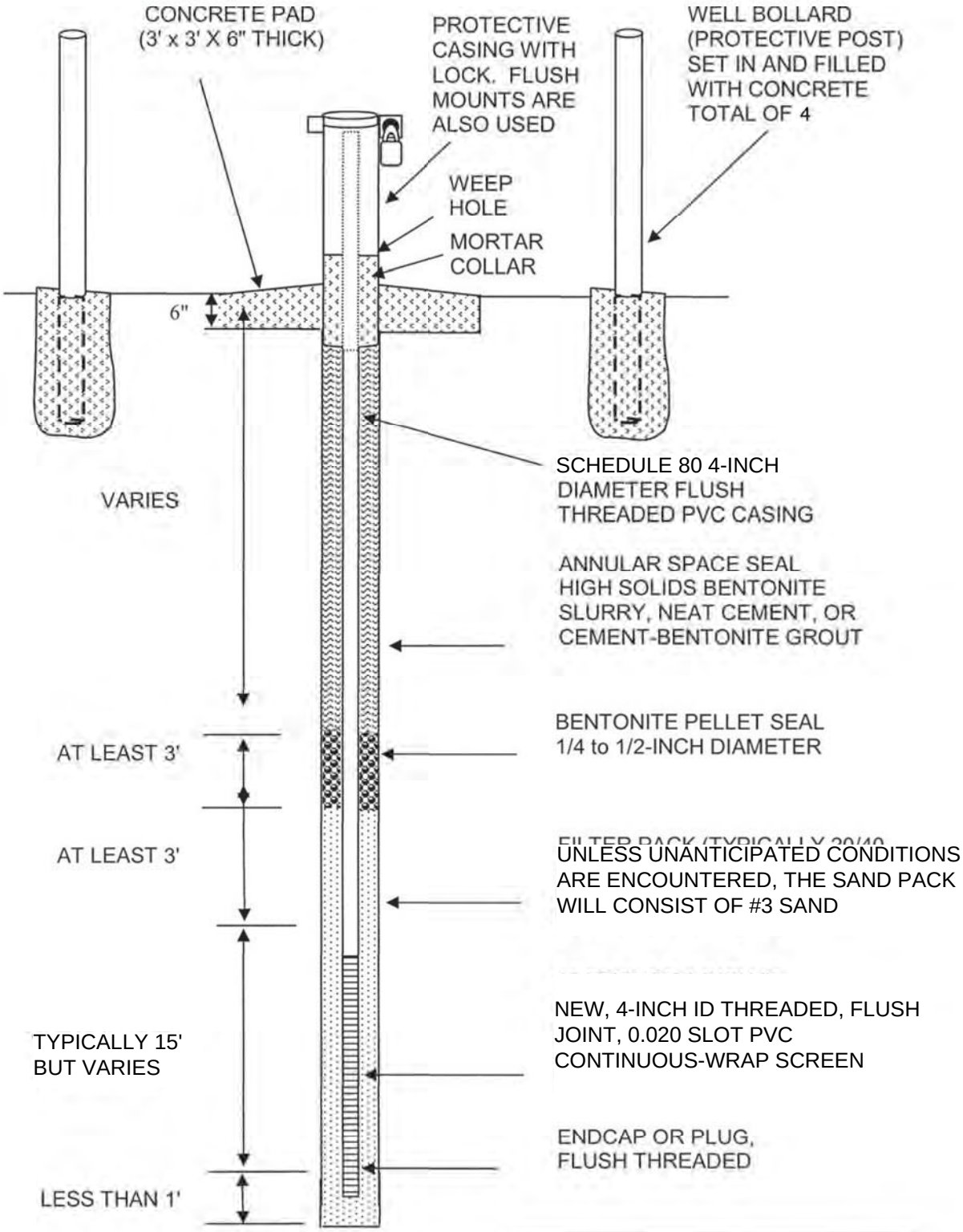

FIGURE 2-9
TYPICAL SINGLE-CASED MONITORING WELL

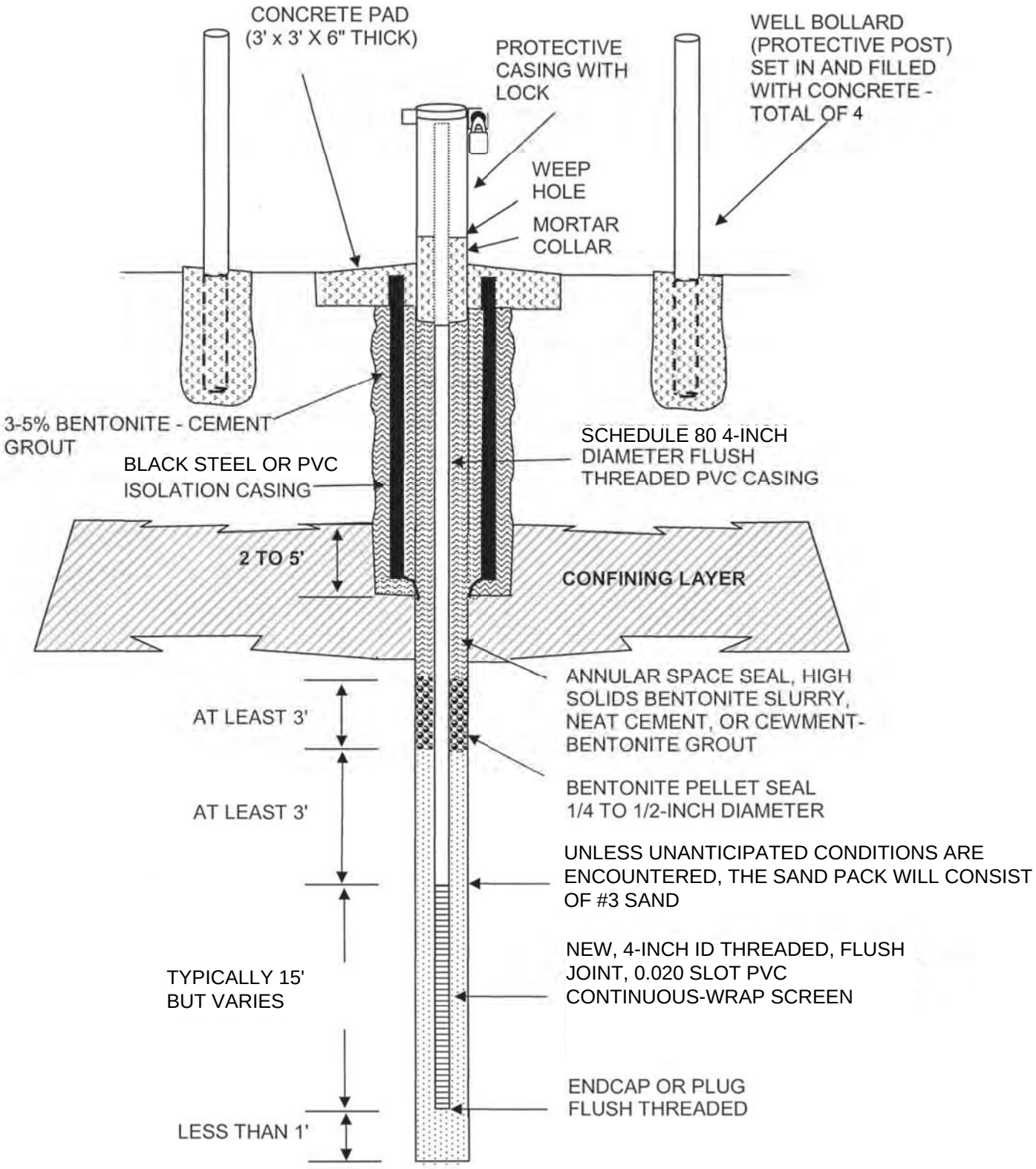

FIGURE 2-10
TYPICAL DOUBLE-CASED
MONITORING WELL

Contract Number FA8903-09-D-8580, Task Order 0018• Final • Revision 0 • April 2016

Appendix A
Standard Operating Procedures

- EID-FS-F001, Field Logbook
- EID-FS-002, Field Logsheet
- EID-FS-003, Chain of Custody Documentation – Paper
- EID-FS-006, Sample Labeling
- EID-FS-012, Shipping and Packaging of Non-Hazardous Samples
- EIG-HS-308, Underground/Overhead Utility Contact Prevention
- EID-GS-001, Standards for Conducting Subsurface SoilSampling While Drilling
- EID-GS-017, Standards for Conducting Hollow Stem Auger Drilling
- EID-GS-018, Standards for Conducting Mud Rotary Drilling
- EID-GS-019, Standards for Conducting Air Rotary Drilling
- EID-GS-021, Standards for Conducting Direct Push Drilling and Soil Sampling
- EID-GS-025, Standards for Soils Logging
- EID-GS-027, Standards for Generation of Boring Logs
- EID-GS-031, Standards for Design and Installation of Groundwater Monitoring Wells
- EID-GS-037, Standards for Conducting Well Development
- EID-FS-014, Decontamination of Contact Sampling Equipment
- EID-FS-107, Roll-Off Sampling
- EIP-G-005, Field Activities Documentation
- EIG-Q-007, Nonconformance Reporting
- CMS-830-03-GL-00002, Checking of Specifications, Calculations, and Drawings

Shaw a world of Solutions	Document Type: **Discipline-Specific Procedure**	Level: 3 Owner: Applied Science & Engineering Origination Date: 6/5/2003 Revision Date: 8/25/2011
Group: E&I	Title: Field Logbook	No: EID-FS-001 Revision No.: 2 Page 1 of 5

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1. PURPOSE

This procedure is intended to communicate the requirements for selection, use, and maintenance of all field logbooks. Field logbooks are often used to document observations, sampling information, and other pertinent information on project sites. They are considered legal documents and should be maintained and documented accordingly as part of the project file.

2. SCOPE

This procedure is applicable to all Shaw E & I site operations where field logbooks are utilized to document all site activities and pertinent information.

3. REFERENCES

- Nielsen Environmental Field School, 1997, *Field Notebook Guidelines*

4. DEFINITIONS

- **Significant detail**—Any piece and/or pieces of information or an observation that can be considered pertinent to the legal reconstruction of events, description of conditions, or documentation of samples and/or sampling procedures.
- **Significant event**—Any event or events that could influence or be considered pertinent to a specific task or function and therefore require documentation in the Field Logbook.
- **Field Logbook**—Logbooks used at field sites that contain detailed information regarding site activities that must include dates, times, personnel names, activities conducted, equipment used, weather conditions, etc. Field logbooks can be used by a variety of different field personnel and are part of the project file.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be directed to the Field Sampling Discipline Lead.

5.2 Project Responsibility

Shaw employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

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6. PROCEDURE

6.1 General

Each site or operation, as applicable, will have one current Logbook, which will serve as an index of all activities performed at the site or in the task performance. The Logbook is initiated at the start of the first applicable activity. Summary entries are made for every day that covered activities take place. Multiple field logbooks may be used depending upon the number of different types of field personnel conducting work and the various activities at the site. These field logbooks and the site logbooks shall be made part of the project files.

Information recorded in field logbooks includes observations (significant events and details), data, calculations, time, weather, and descriptions of the data collection activity, methods, instruments, and results. Additionally, the field logbook may contain descriptions of wastes, biota, geologic material, and site features including sketches, maps, or drawings as appropriate.

6.2 Equipment and Materials

- Logbook(s), bound with numbered pages, hard-covered, waterproof preferred. One per project or separate significant task (example-treatment residual composite collection).
- Indelible black or dark blue ink pen
- Other items needed to perform required tasks: compass, ruler, calculator, etc.

6.3 Preparation

Site personnel responsible for maintaining field logbooks must be familiar with the SOPs for all tasks to be performed.

Field logbooks are project files and should remain with project documentation when not in use. *Personnel should not keep Field logbooks in their possession when not in use. Field logbooks should only leave the project site for limited periods, and they should always be returned to the site files or the designated on-site location (Sampler's Trailer, etc.)*.

Field logbooks shall be bound with lined, consecutively numbered pages. All pages must be numbered prior to initial use of the field logbook.

The front cover shall include the following information:

- Project Number
- Project Name and Task(s) included in logbook
- Dates covered by logbook—the starting date must be entered on the first day of use
- Logbook number—if more than one logbook will be needed to cover project/task(s)

The inside front cover shall contain a listing and sign-off of each person authorized to make entries and/or review the logbook. All persons who make entries or review/approve such entries must signify their authority to enter into the logbook via their signature and the date of their signing on the inside front cover. If initials are used for entries instead of full names, the initials must be entered beside the full name on the inside cover.

6.4 Operation

The following requirements must be met when using a field logbook:

- Record significant details and/or events, work, observations, material quantities, calculations, drawings, and related information directly in the field logbook. If data-collection forms are in

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use, the information on the form need not be duplicated in the field logbook. However, any forms used to record site information *must be referenced* in the field logbook.

- Information must be factual and unbiased.
- Do not start a new page until the previous one is full or has been marked with a single diagonal line so that additional entries cannot be made. Use both sides of each page.
- Write in black or dark blue indelible ink.
- Do not erase, scribble over, or blot out any entry. Do not use White-Out or like correction items. Before an entry has been signed and dated, changes may be made; however, care must be taken not to obliterate what was written originally. Indicate any deletion by a single line through the material to be deleted. Any change shall be initialed and dated. Error codes (Attachment 1) should be added to the end of the deleted entry. All error codes should be circled.
- Do not remove any pages from the book.
- Do not use loose paper and copy into the field logbook later.
- Record sufficient information to completely document field activities and all significant details/events applicable to the project/task(s) covered by the logbook.
- All entries should be neat and legible.

Specific requirements for field logbook entries include the following:

- Initial and date each page.
- Sign and date the final page of entries for each day.
- Initial, date, and if used, code all changes properly.
- Draw a diagonal line through the remainder of the final page at the end of the day.
- Record the following information on a daily basis:

  a) Date and time

  b) Name of individual making entry

  c) Detailed description of activity being conducted including well, boring, sampling, location number as appropriate

  d) Unusual site conditions

  e) Weather conditions (i.e., temperature, cloud cover, precipitation, wind direction and speed) and other pertinent data

  f) Sample pickup (chain-of-custody form numbers, carrier, time)

  g) Sampling activities/sample log sheet numbers

  h) Start and completion of borehole/trench/monitoring well installation or sampling activity

  i) Health and Safety issues, such as PPE upgrades, monitoring results, near-misses, and incidents associated with the logbook areas

  j) Instrumentation calibration details

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Entries into the field logbook shall be preceded with the time of the observation. The time should be recorded frequently and at the point of events or measurements that are critical to the activity being logged. All measurements made and samples collected must be recorded unless they are documented by automatic methods (e.g., data logger) or on a separate form required by an operating procedure. In such cases, the field logbook must reference the automatic data record or form.

While sampling, make sure to record observations such as color and odor. Indicate the locations from which samples are being taken, sample identification numbers, the order of filling bottles, sample volumes, and parameters to be analyzed. If field duplicate samples are being collected, note the duplicate pair sample identification numbers. If samples are collected that will be used for matrix spike and/or matrix spike/matrix spike duplicate analysis, record that information in the field logbook.

A sketch of the station location may be warranted. All maps or sketches made in the field logbook should have descriptions of the features shown and a direction indicator. There must be at least one fixed point with measurements on any map drawn. Maps and sketches should be oriented so that north is towards the top of the page.

Other events and observations that should be recorded include (but are not limited to) the following:

- Changes in weather that impact field activities
- Visitors to the site associated with the covered task(s). Note their time of arrival and departure and provide a brief summary of their purpose on site.
- Subcontractor activities applicable to the covered task(s)
- Deviations from procedures outlined in any governing documents, including the reason for the deviation. Deviations from procedures must be accompanied with the proper authorization.
- Significant events that may influence data, such as vehicles in the vicinity of VOC sampling efforts
- Problems, downtime, or delays
- Upgrade or downgrade of personal protective equipment

6.5 Post-Operation

To guard against loss of data due to damage or disappearance of field logbooks, all original completed logbooks shall be securely stored by the project. All field logbooks will be copied at the end of each work shift and attached to the daily reports.

At the conclusion of each activity or phase of site work, the individual responsible for the field logbook will ensure that all entries have been appropriately signed and dated and that corrections were made properly (single lines drawn through incorrect information, initialed, coded, and dated). The completed field logbook shall be submitted to the project records file.

6.6 Restrictions/Limitations

Field logbooks constitute the official record of on-site technical work, investigations, and data collection activities. Their use, control, and ownership are restricted to activities pertaining to specific field operations carried out by Shaw personnel and their subcontractors. They are documents that may be used in court to indicate and defend dates, personnel, procedures, and techniques employed during site activities. Entries made in these notebooks should be factual,

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clear, precise, and as non-subjective as possible. Field logbooks, and entries within, are not to be utilized for personal use.

7. ATTACHMENTS

- Attachment 1, Common Data Error Codes

8. FORMS

None

9. RECORDS

- Field Logbook

10. REVISION HISTORY AND APPROVAL

Revision Level Revision Date	Revision Description	Responsible Manager
00 6/5/2003	Initial Issue	N/A
01 9/8/2006	New template, new numbering of procedure, Section 1 Purpose- content added, Section 2 edited, Section 4-Definitions edited. Sections 6.2, 6.3, 6.4, 6.5 and 6.6 were all edited.	Guy Gallello
02 8/25/2011	Modified format only to align with Governance Management framework	Scott Logan

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Attachment 1
Common Data Error Codes

COMMON DATA ERROR CODES

RE Recording Error

CE Calculation Error

TE Transcription Error

SE Spelling Error

CL Changed for Clarity

DC Original Sample Description Changed After Further Evaluation

WO Write Over

NI Not Initialed and Dated at Time of Entry

OB Not Recorded at the Time of Initial Observation

All Error Codes should be circled.

Shaw a world of Solutions	Document Type: **Discipline-Specific Procedure**	Level: 3 Owner: Applied Science & Engineering Origination Date: 6/5/2003 Revision Date: 1/23/2012
Group: E&I	Title: Field Logsheet	No: EID-FS-002 Revision No.: 2 Page 1 of 3

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1. PURPOSE

This procedure is intended to communicate the requirements for proper use and completion of Field Logsheets to document sample collection and data gathering activities. Field Logsheets are often utilized to document single location/event information. Examples include boring logs and drum/container logs. This procedure also provides several templates that *may* be utilized or modified to a particular need.

2. SCOPE

This procedure is applicable to all Shaw E & I projects where Field Logsheets are utilized to document data and/or sample collection information. This procedure does **not** mandate the use of Field Logsheets on all Shaw E & I data/sample collection efforts, and projects/programs are free to utilize other means (Field Logbooks, direct data entry, etc.) to document sample collection and other pertinent data gathering activities.

3. REFERENCES

- U.S. Environmental Protection Agency, 1998, *EPA Guidance for Quality Assurance Project Plans*, EPA/600/R-98/018, Washington, D.C.
- U.S. Army Corps of Engineers, 2001, *Requirements for the Preparation of Sampling and Analysis Plans*, EM200-1-3, Washington, D.C.

4. DEFINITIONS

None

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this SOP should be directed to the Field Sampling Discipline Lead.

5.2 Project Responsibility

Shaw employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

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6. PROCEDURE

Field Logsheets can be prepared to address the specific needs of each project and they can even be converted to laptop data entry forms. Field Logsheets are considered legally defensible, and all appropriate requirements must be observed.

6.1 Required Information

All Field Logsheets must contain entry lines for the following in addition to whatever sample/data gathering-specific information is desired:

- Site/Project Name
- Project Number
- Date (including time if required to properly document)
- Comments or Issues area to record any non-specified information pertinent to the sample/data collection effort
- Initial or signature line for person responsible for completion

6.2 Proper Completion/Use

Whenever Field Logsheets are utilized, the following requirements must be strictly followed and enforced:

- Field Logsheets are to be completed in **real-time.** They should not be filled out by transcription from another source.
- All corrections **must** be single-line cross-out with the initials of the person making the correction.
- All data/information areas **must** be completed. If an entry line/block is not applicable to a particular sample/data gathering effort, this must be indicated on the form by either a single line cross-out or the letters “NA” being written in the data line/block.

7. ATTACHMENTS

None

8. FORMS

- EID-FS-002.01, Waste Container Field Logsheet
- EID-FS-002.02, Soil/Sediment Field Logsheet
- EID-FS-002.03, Surface Water Field Logsheet
- EID-FS-002.04, Air Field Logsheet

9. RECORDS

- Field Logsheet

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10. REVISION HISTORY AND APPROVAL

Revision Level / Revision Date	Revision Description	Responsible Manager
00 6/5/2003	Initial issue	Guy Gallello
01 9/8/2006	Revised Section1 Purpose and Section 2 Scope. Revised section 6.1 Site Information. Changed Section 6.2 Sample Information, 6.3 Equipment Information, 6.4 Analytical to Section 6.2 being Proper Completion/Use.	Guy Gallello
02 1/23/2012	Modified format only to align with Governance Management framework.	Scott Logan

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	Title: Field Logsheet	Form No: EID-FS-002.01_2

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Waste Container Field Logsheet

Date: Time: Site:

Container Number: Project #:

Container Size: Weather:

Container Location: Photograph:

Container material of construction:	plastic	glass	metal	fiberboard
Container condition:	intact	bulging	leaking	
Lid type:	screw	bung	ring	
Lid material of construction:	plastic	glass	metal	fiberboard
Labels:	manufacturer:			
	address:			
	content name:			
	chemical name:			
	chemical formula:			
	other:			
Hazard Label:	flammability:			
	reactivity:			
	health:			
	other:			
PID:	Calibration Date:			
O2/LEL:	Calibration Date:			
Sampling Device:	Decontamination technique:			
Contents Description:				
Amount:	1/4	1/2	3/4	full
Color:				
State:	solid	liquid	paste	other:
Sample Number:	Preservative:			
QC Samples:				
Analyses requested:				
Analytical Laboratory:				
Field Technician (Print):				
Comments:				

Shaw	Title: Field Logsheet	Form No: EID-FS-002.02_2

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Soil / Sediment Field Logsheet

Site Name: Project #:

Sample ID:	Sample Location Sketch:
Sample Type*:	
*: SED=Sediment; SUR=Surface soil; SUB=Subsurface Soil; OTH=Other. grab=Grab, comp=Composite	
Date Sampled:	
Time Sampled:	
Depth (ft bgs):	
Physical description:	
Analyses requested:	
	Photograph Log #:
PID:	Calibration Date:
O2/LEL:	Calibration Date:
Weather:	
Temperature: ° F	
Sampling Equipment:	
Equipment Decontamination Technique:	
QC Samples:	
Analytical Laboratory:	
Comments:	
Field Technician: (Print)	Date:

	Title: Field Logsheet	Form No: EID-FS-002.03_2

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Surface Water Field Logsheet

Site Name: Project #:

Sample ID:	Sample Location Sketch:
Date Sampled:	
Time Sampled:	
Depth (ft below surface):	

Analysis	Preservative

Field Reading	Calibration Date
Sp cond:	
pH:	
Temp:	
D.O.:	
Turbidity:	

Photograph Log #:	
Weather:	
Temperature:	° F
Sampling Equipment:	
Equipment Decon Technique:	

QC Samples:	
Analytical Laboratory:	
Comments:	
Field Technician: (Print)	Date:

	Title: Field Logsheet	Form No: EID-FS-002.04_2

Uncontrolled when printed: Verify latest version on ShawNet/Governance

Air Field Logsheet

Site Name: Project #:

Sample ID:		Sample Location Sketch:
Date Sampled:		
Time Sampled:		
Sampling Technique:		
Analyses:		
Field Reading	Calibration Date	
		Photograph Log #:

Weather:
Temperature: ° F
Sampling Equipment:
Equipment Decon Technique:
QC Samples:
Analytical Laboratory:
Comments:
Field Technician: (Print) Date:

Shaw a world of Solutions	Document Type: **Discipline-Specific Procedure**	Level: 3 Owner: Applied Science & Engineering Origination Date: 7/2/2003 Revision Date: 8/25/2011
Group: E&I	Title: Chain of Custody Documentation - Paper	No: EID-FS-003 Revision No.: 2 Page 1 of 4

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1. PURPOSE

The purpose of this procedure is to provide the requirements for completion of written Chain of Custody (COC) documentation and to provide a suggested Chain of Custody Form for project use.

2. SCOPE

This procedure is applicable to all Shaw E & I efforts where samples are transferred among parties, including to off-site testing facilities. Adherence to this procedure is not required whenever the same individual/team is performing the sampling and testing within the same workday, and transfer to the testing process is being documented by other means, e.g. sampling and then field-screening in a mobile laboratory.

3. REFERENCES

- U.S. Environmental Protection Agency, 1986, *Test Methods for Evaluating Solid Waste; Physical/Chemical Methods, SW-846*, Third Edition.
- U.S. Army Corps of Engineers, *Requirements for the Preparation of Sampling and Analysis Plans*, EM200-1-3.
- Shaw E & I, 2002, *Sampler's Training Course Handout*.

4. DEFINITIONS

- **Custody**—The legal term used to define the control and evidence traceability of an environmental sample. A sample is considered to be in an individual's custody when it is in actual physical possession of the person, is in view of the person, is locked in a container controlled by the person, or has been placed into a designated secure area by the person.
- **Chain of Custody Form**—A form used to document and track the custody and transfers of a sample from collection to analysis or placement in a designated secure area within the testing facility.
- **COC Continuation Page**—Additional page(s) that may be included with a Chain of Custody form. The continuation page(s) contain the information on additional samples contained within the *same* cooler/shipping container associated with the cooler/shipping container Chain of Custody form.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be directed to the Field Sampling Discipline Lead.

5.2 Project Responsibility

Shaw E & I employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

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For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURE

6.1 Documentation

All Chain of Custody documentation must be completed in indelible ink. All corrections must be performed using standard single-line cross-out methods, and the initials of the individual making the change must be included beside the corrected entry.

6.2 Continuation Pages

Continuation pages may be utilized for shipping containers/coolers with sufficient samples/sample containers that all of the lines of the Chain of Custody form are used before the documentation of the cooler/shipping container is complete. The number of pages in total must be filled out. *All samples entered onto a Continuation Page must be included in the same cooler/shipping container as those on the Chain of Custody form itself.*

6.3 Header Information

- Each Chain of Custody form must be assigned a unique Reference Document Number–use the Project/proposal number followed by a unique numeric sequence or current date (if only one cooler sent per day). Continuation Pages should contain the same Document Reference Number as the Chain of Custody form that they are associated with. The project team should maintain a log of Chain of Custody Reference Document Numbers.
- The page identifier and total page count section must be completed. Total pages include the Chain of Custody form and any attached Continuation Pages.
- Project number, name, and location information must be completed for all forms.
- If available, the laboratory Purchase Order Number should be included on the appropriate line.
- The name and phone number of the *Project Contact* should be included; the Project Contact should be a responsible individual that the laboratory may access to address analytical issues. This person is usually the analytical lead for the project.
- The *Shipment Date* should be provided on the applicable lines.
- If shipping by carrier, the *Waybill/Airbill Number* must be included. Note: couriers will not sign custody documents. Therefore, inclusion of the waybill/airbill number on the Chain of Custody is the *only* means of documenting the transfer to the carrier.
- Laboratory Destination and Contact information should be provided.
- The Sampler(s) names should be provided on the appropriate line. This line should include all persons whose initials appear on any of the sample containers, to provide the laboratory a means of cross-referencing containers.
- The “Send Report To” information should be completed. If multiple reports/locations are needed, the information should be provided on a separate page included with the Chain of Custody documents.

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6.4 Sample Information Section–Including on Continuation Page(s)

During actual sampling, each sample must be entered on the COC form at the time of collection in order to document possession. The sampler must not wait until sampling is completed before entering samples on the COC.

- Complete the *Sample ID Number* for each line. If there are multiple container types for a sample, use additional lines to indicate the needed information.
- Ensure that the *Sample Description* matches the description on the sample label–the laboratory will use this information for cross-referencing.
- Provide the *Collection Date* and *Time*. These must match those on the sample label and Field Logbook/Logsheets.
- Indicate whether the sample is a Grab or Composite sample.
- Indicate the *Matrix* of the sample. Use the Matrix Codes listed on the Chain of Custody form.
- Indicate the *Number of Containers* and the *Container Type*. If a sample has multiple container types, use multiple lines and cross-out the information spaces to the left of the container blocks. *Failure to do this may cause the laboratory to log-in each container type as a separate sample/lab-ID, resulting in a confused report and invoice.*
  - Alternatively, if each sample has the same number/type container types, use “various” in the *Container Type* block and provide detail in the *Special Instructions* section, e.g., “Each sample consists of one 16-oz jar, two pre-weighed VOC w/DI water, and one pre-weighed VOC w/Methanol.”
- Check the appropriate *Preservative* box for each line/container type.
- Write in and check the *Analyses Requested* boxes for each line/container type. The appropriate method number (e.g., EPA Method 8260C) must be written as well as the method name.
- Indicate the *Turn-around Time Requested* for each sample.
- Use the *Special Instructions* section to provide important information to the laboratory, e.g., samples that may require dilution or samples that will need to be composited by the laboratory. This section may also be used to inform the laboratory of additional information contained in attachments to the Chain of Custody package.
- Circle the appropriate *QC/Data Package Level* requested.

6.5 Custody Transfer Section

- The first *Relinquished By* space must be completed by the individual who will either transfer the samples or seal the shipping container.
- If the samples will be transferred to a courier, write the courier/carrier company in the *Received By* box and enter the Date and Time that the shipping container was closed.
- All other transfers must be performed in person, and the Relinquisher must witness the signing by the Receiver.
- A copy of the Chain of Custody form and all associated Continuation Pages should be maintained in the project files.

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7. ATTACHMENTS

None

8. FORMS

- EID-FS-003.01, Shaw E & I Chain of Custody Form
- EID-FS-003.02, Shaw E & I COC Continuation Page

9. RECORDS

- EID-FS-003.01, Chain of Custody Form
- EID-FS-003.02, Chain of Custody Continuation Page(s)

10. REVISION HISTORY AND APPROVAL

Revision Level / Revision Date	Revision Description	Responsible Manager
00 / 07/22/2003	Initial Issue	N/A
01 / 09/08/2006	New template, new numbering of procedure, Section 6.3 was edited, content was added in Section 6.4	Guy Gallello
02 / 08/25/2011	Modified format only to align with Governance Management framework	Scott Logan

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Shaw a world of Solutions	Document Type: **Discipline-Specific Procedure**	Level: 3 Owner: Applied Science & Engineering Origination Date: 8/17/2003 Revision Date: 8/25/2011
Group: E&I	Title: Sample Labeling	No: EID-FS-006 Revision No.: 2 Page 1 of 2

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1. PURPOSE

The purpose of this procedure is to provide the requirements for completion and attachment of sample labels on environmental sample containers.

2. SCOPE

This procedure is applicable to all Shaw E & I projects/proposals where samples will be collected.

3. REFERENCES

- U.S. Environmental Protection Agency, 1986, *Test Methods for Evaluating Solid Waste; Physical/Chemical Methods*, SW-846, Third Edition.
- U.S. Army Corps of Engineers, *Requirements for the Preparation of Sampling and Analysis Plans*, EM200-1-3
- Shaw E & I, 2002, Sampler's Training Course Handout.

4. DEFINITIONS

- **Sample Label**—Any writing surface with an adhesive backing that can be used to document sample identification information. The sample label is attached to the sample container as a means of identification and, in some commercially available or laboratory-supplied containers, may be pre-attached. All Shaw E & I strategic alliance laboratories provide sample labels or pre-labeled containers in their sample container supply kits.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be directed to the Field Sampling Discipline Lead.

5.2 Project Responsibility

Shaw E & I employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw E & I employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURE

- All sample labels must be completed in indelible ink. All corrections must be performed using standard single-line cross-out methods, and the initials of the individual making the change must be included beside the corrected entry.

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- Sample labels should be completed and attached as samples are collected. Do not wait until final packaging to attach and/or complete the sample labels.
- Sample labels must be attached to the non-sealing portion of the container. Do not place labels on or across sample container caps.
- If the laboratory has provided pre-labeled containers, make sure to fill one for each parameter set needed. Laboratory pre-labeled containers are often bar-coded and it is important to provide a complete container set for each sample.
- The following information must be recorded on the Sample Label:
  - Sample Identification Number
  - Date and Time collected
  - Initials of person(s) responsible for collection
- If a space is provided, the *Analysis Requested* should also be added.
- If a *Description* is provided, remember it must match that on the Chain of Custody form for cross-referencing purposes.
- Cover the completed and attached label with clear plastic tape to prevent bleeding of the ink if it becomes wetted. *Do **not** perform this step for pre-weighed VOC vials, as the final weight values will be influenced by the mass of the tape. Protect these containers by enclosing the rack/holder in a plastic bag within the cooler.*

7. ATTACHMENTS

None

8. FORMS

None

9. RECORDS

None

10. REVISION HISTORY AND APPROVAL

Revision Level Revision Date	Revision Description	Responsible Manager
00 09/08/2006	Initial issue	N/A
01 09/08/2006	Updated template, procedure numbering change, updated Section 2- Scope, Edited content in section 6.	Guy Gallello
02 08/28/2011	Modified format only to align with Governance Management framework	Scott Logan

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Shaw a world of Solutions	Document Type: **Discipline-Specific Procedure**	Level: 3 Owner: Applied Science & Engineering Origination Date: 6/5/2003 Revision Date: 8/25/2011
Group: E&I	Title: Shipping and Packaging of Non Hazardous Samples	No: EID-FS-012 Revision No.: 2 Page 1 of 3

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1. PURPOSE

The purpose of this procedure is to provide general instructions in the packaging and shipping of non-hazardous samples. The primary use of this procedure is for the transportation of samples collected on site to be sent off site for physical, chemical, and/or radiological analysis.

2. SCOPE

This procedure applies to the shipping and packaging of all non-hazardous samples. Non-hazardous samples are those that do not meet any hazard class definitions found in 49 CFR 107-178, including materials designated as Class 9 materials and materials that represent Reportable Quantities (hazardous substances) and/or materials that are not classified as *Dangerous Goods* under current IATA regulations.

In general most soil, air, and aqueous samples, including those that are acid or caustic preserved do **not** qualify as *hazardous materials* or *dangerous goods*. An exception is methanolic soil VOC vials: these containers are flammable in any quantity and **must** be packaged, shipped, and declared as *Dangerous Goods* whenever transported by air.

The Class 9 "Environmentally Hazardous" designation should only be applied to samples if they are known or suspected (via screening) to contain a sufficient concentration of contaminant to pose a health and/ or environmental risk if spilled in transport. Samples for which screening has shown a potential hazard (i.e. flammability) or those that are derived from a known hazard, including a site/facility with confirmed contamination by an *infectious substance* must also be shipped in accordance with the applicable DOT/IATA requirements. Refer to Shaw E & I SOP FS013.

Improper shipment of hazardous materials, especially willful misrepresentation and shipment as non-hazardous materials, is a violation of federal law and is punishable by fines and possible imprisonment of the guilty parties. It is also a violation of Shaw E & I policy and can result in disciplinary action up to and including termination of employment.

3. REFERENCES

- U.S. Army Corps of Engineers, 2001, *Requirements for the Preparation of Sampling and Analysis Plans*, EM200-1-3, Washington, D.C.
- U.S. Department of Transportation Regulations, 49 CFR Parts 108-178
- International Air Transport Association (IATA), *Dangerous Goods Regulations*, current edition.

4. DEFINITIONS

- **Cooler/Shipping Container**—Any hard-sided insulated container meeting DOT's or IATA's general packaging requirements.
- **Bubble Wrap**—Plastic sheeting with entrained air bubbles for protective packaging purposes.

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5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be sent to the Field Sampling Discipline Lead.

5.2 Project Responsibility

Shaw employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURE

6.1 Packaging

- Use tape and seal off the cooler drain on the inside and outside to prevent leakage.
- Place packing material on the bottom on the shipping container (cooler) to provide a soft impact surface.
- Place a large (30-55 gallon or equivalent) plastic bag into the cooler (to minimize possibility of leakage during transit).
- Starting with the largest glass containers, wrap each container with sufficient bubble wrap to ensure the best chance to prevent breakage of the container.
- Pack the largest glass containers in the bottom of the cooler, placing packing material between each of the containers to avoid breakage from bumping.
- Double-bag the ice (chips or cubes) in gallon- or quart-sized resealable plastic freezer bags and wedge the ice bags between the sample bottles.
- Add bagged ice across the top of the samples.
- When sufficiently full, seal the inner protective plastic bag, and place additional packing material on top of the bag to minimize shifting of containers during shipment.
- Tape a gallon-sized resealable plastic bag to the inside of the cooler lid, place the completed chain of custody document inside, and seal the bag shut.
- Tape the shipping container (cooler) shut using packing tape, duct tape, or other tear-resistant adhesive strips. Taping should be performed to ensure the lid cannot open during transport.
- Place a custody seal on two separate portions of the cooler, to provide evidence that the lid has not been opened prior to receipt by the intended recipient.

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6.2 Labeling

- A "This Side Up" arrow should be adhered to all sides of the cooler, especially ones without obvious handles.
- The name and address of the receiver and the shipper must be on the top of the cooler.
- The airbill must be attached to the top of the cooler.

6.3 Shipping Documentation

- A Cooler Shipment Checklist (Attachment 1) should be completed and kept in the project file.

7. ATTACHMENTS

- Attachment 1, Shaw E & I Cooler Shipment Checklist

8. FORMS

None

9. RECORDS

- Chain of Custody Form
- Chain of Custody Continuation Page(s)
- Cooler Shipment Checklist

10. REVISION HISTORY AND APPROVAL

Revision Level / Revision Date	Revision Description	Responsible Manager
00 / 06/05/2003	Initial issue	N/A
01 / 09/08/2006	Updated template and numbering of procedure, content was added to Section 2-Scope	Guy Gallello
02 / 08/25/2011	Modified format only to align with Governance Management framework.	Scott Logan

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Shaw® a world of Solutions™	Title: Shipping and Packaging of Non Hazardous Samples	No: EID-FS-012 Attachment No. 1

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Attachment 1
Sample Shipment Checklist

Project Name _____ Project Number _____

Address _____ Date_____ Time _____

City, State, Zip _____ Fax No._____

Site Contact No. _____

SAMPLE CHECKLIST	YES	NO	COMMENTS
SAMPLE LIDS ARE TIGHT AND CUSTODY SEALS IN PLACE?	❒	❒	
ARE ALL SAMPLE NUMBERS, DATES, TIMES AND OTHER LABEL INFORMATION LEGIBLE AND COMPLETE?	❒	❒	
HAVE ALL SAMPLE NUMBERS, DATES, TIMES AND OTHER SAMPLING DATA BEEN LOGGED INTO THE SAMPLE LOG BOOK?	❒	❒	
DO SAMPLE NUMBERS AND SAMPLE DESCRIPTIONS ON THE LABELS MATCH THOSE ON THE COC?	❒	❒	
HAVE THE SAMPLES BEEN PROPERLY PRESERVED?	❒	❒	
HAVE THE CHAIN OF CUSTODIES BEEN FILLED OUT COMPLETELY AND CORRECTLY?	❒	❒	
DOES THE ANALYTICAL SPECIFIED ON THE COC MATCH THE ANALYTICAL SPECIFIED IN THE SCOPE OF WORK?	❒	❒	
HAVE THE COC'S BEEN PROPERLY SIGNED IN THE TRANSFER SECTION?	❒	❒	

PACKAGING CHECKLIST	YES	NO	COMMENTS
HAS EACH SAMPLE BEEN PLACED INTO AN INDIVIDUAL PLASTIC BAG?	❒	❒	
HAS THE DRAIN PLUG OF THE COOLER BEEN TAPED CLOSED WITH WATER PROFF TAPE FROM THE INSIDE?	❒	❒	
HAVE ALL THE SAMPLES BEEN PLACED INTO THE COOLER IN AN UPRIGHT POSITION?	❒	❒	
IS THERE ADEQUATE SPACING OF SAMPLES SO THAT THEY WILL NOT TOUCH DURING SHIPMENT?	❒	❒	
HAVE AN ADEQUATE NUMBER OF BLUE ICE PACKS OR WATER ICE BEEN PLACED AROUND AND ON TOP OF THE SAMPLE?	❒	❒	
HAS FRESH BLUE ICE OR WATER ICE BEEN ADDED TO THE COOLER THE DAY OF THE SHIPMENT?	❒	❒	
HAS THE COOLER BEEN FILLED WITH ADDITIONAL CUSHIONING MATERIAL?	❒	❒	
HAS THE COC BEEN PLACE IN A ZIPLOCK BAG AND TAPED TO THE INSIDE OF THE LID OF THE COOLER?	❒	❒	
HAVE CUSTODY SEALS BEEN PLACED ONTO THE LID?	❒	❒	
HAS THE COOLER BEEN LABELED "THIS SIDE UP"?	❒	❒	
IF REQUIRED, HAS THE COOLER BEEN LABELED WITH THE DOT PROPER SHIPPING NAME, UN NUMBER AND LABEL?	❒	❒	
HAS THE LABORATORY PERFORMING THE ANALYSES BEEN NOTIFIED OF THE SHIPMENT OF SAMPLES?	❒	❒	

PROBLEMS/RESOLUTIONS: _____

_____

_____

PREPARED BY: _____ SIGNATURE _____

1. PURPOSE

This procedure prescribes the steps to be followed in order to prevent accidents involving the contact with or damage of underground/overhead utilities. The company provides the operational and training practices required to safely execute work where underground/overhead utility hazards may exist.

2. SCOPE

This procedure applies to all excavation and trenching activities.

2.1 Exception Provisions

Anytime a minimum of a 5-foot clearance cannot be obtained by either hand digging, vacuum excavation, or by using geophysical means, the Field Team Leader (FTL) must obtain a variance from the Regional Vice President (or equivalent level such as Operations Director for Federal Business Line) or designee to proceed with drilling operations in that area. This would include an initial verbal variance documented in the field log followed up by a written (email) approval from either the Regional Vice President (or equivalent level or title) or designee. The record of communication will be noted in the field log for the project, and a record of the approval or denial will be placed in the project file. The Health and Safety Department will only serve as a consultant to this procedure and is not required to sign the variance.

A variance form can be obtained in Form EIG-HS-308.01, “Variance Request Form.” A flowchart to assist one in determining how and when a variance should be obtained can be found as Attachment 1, “Flowchart to Obtain a Variance.”

3. REFERENCES

- Shaw Environmental & Infrastructure, Inc. (Shaw E&I) Procedure No. EIG-HS-013, “Health and Safety Procedure Variances”
- Shaw E&I Procedure No. EIG-HS-020, “Accident Prevention Program: Reporting, Investigation, and Review”
- Shaw E&I Procedure No. EIG-HS-050, “Training Requirements”
- Shaw E&I Procedure No. EIG-HS-307, “Excavation and Trenching”
- Shaw E&I Form EIG-HS-308.01, “Variance Request Form”

4. DEFINITIONS

- **Boring Activities**—Any mechanical or manual penetration of the earth’s surface below 5 feet using drilling, Geoprobes, hand auguring equipment, or similar type of equipment. Boring activities also include the installation of stakes or fence posts to a depth of 5 feet or greater.
- **Company**—All wholly-owned subsidiaries of Shaw E&I.
- **Competent Person – Drilling Oversight (CPDO) Training**—When drilling activity is to take place the Shaw FTL must have successfully completed Shaw’s in-house training pertinent to competent person drilling oversight (CPDO Training). The FTL is required not only to have successfully completed CPDO training but to have an appropriate educational background,

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coupled with field experience and the authority to make changes to correct deficiencies, or to stop the job if need be.

- **Competent Person – Excavation and Trenching—A person** who is capable of identifying existing and predictable hazards in the excavation/trenching work area and who has the authority to take prompt corrective measures to eliminate them. NOTE: Excavation/Trenching training is required when trenching/excavation hazards are present/anticipated (i.e., spoil piles, use of 3-foot or larger diameter augers, or other circumstances) but only recommended when trenching/excavation hazards are not present/anticipated.
- **Excavation Activities**—Any mechanical or manual penetration of the earth's surface below 5 feet using heavy equipment such as excavators, backhoes, dozers, etc. Excavation activities also include manual use of hand shovels, pick-axes, etc. to a depth of 5 feet or greater. The use of 3-foot or larger diameter augers is also included.
- **Excavation**—Any manmade cut, cavity, trench, or depression in an earth surface formed by earth removal.
- **Underground Utility**—Any active or inactive subsurface or buried structure that is or was designed to service a public or private facility. These may include, but are not limited, to the following:
  - Electric power lines
  - Natural gas lines
  - Telephone lines
  - Telephone cables and fiber optic lines
  - Water lines
  - Steam and pneumatic lines
  - Sewer lines
  - Drain lines
  - Underground storage tanks
  - Septic tanks
  - Process or product lines
- **Overhead Utility**—Any active or inactive overhead structure that is or was designed to service a public or private facility. These may include, but are not limited, to the following:
  - Overhead power lines
  - Overhead telephone lines
  - Overhead fiber optic lines
  - Overhead cables
  - Overhead supports
  - Overhead piping
  - Traffic lights
  - Utility bridges

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- **One Call Center**—Each state has a One Call, Dig Safe, Miss Dig, etc. dial-in number for requesting mark-out of buried public utilities, such as gas lines, electrical lines, telephone/cable lines, sewer lines, and water lines. This number is typically called a minimum of 72 hours prior to subsurface activities depending on the particular state in which the work will be conducted. The One Call Center will notify the local public utilities for a line location mark-out for the particular location. The individual public utilities must locate and mark-out the utilities upon request. In most cases, the markouts will not be performed on private property. A confirmation number is established and confirmation report generated and submitted to the requester.

- **As-Built Drawings**—As-built drawings are blueprints that are usually obtained from the facility owner or client. They show original buried utilities and any modifications that have been made.

- **Private Utility Locating Service**—A private utility locating service is a firm established to locate underground utilities using specialized locating equipment, such as ground penetrating radar location devices or radio transmitter type utility locating equipment.

- **Fiber Optic Service Lines**—Fiber optic service lines are communication lines that are buried underground. When damaged, these lines are very expensive to replace. Fiber optic companies routinely provide on-site supervision, if requested. The company encourages this practice.

- **Field Team Leader**—The FTL is the person with whom the responsibility of the execution of the field work resides. This person may be the Project Manager, Senior Geologist, Staff Geologist, etc. This individual must have the sufficient experience, training, and field knowledge to ensure all site configuration information is collected and analyzed.

- **Site Survey**—A site survey is an inspection of the work site to look for signs of other buried utilities that may not be indicated through as-built drawings or through utility locating services. The survey typically involves inspection of overhead electrical services, inspection of basements, utility rooms, garages, etc., for signs of old electrical conduits or fuel/water/septic lines. The FTL must contact the appropriate site representative to provide any additional information that may be marked on the as-builts.

- **Vacuum Excavator**—Equipment that excavates underground utilities with a combination of alternating water-and-air or air-and air pulsations (e.g., Air knife, water knife, etc.)

5. RESPONSIBILITY

5.1 Procedure Responsibility

The Executive Director of Health and Safety is responsible for the issuance, revision, and maintenance of this procedure. Also, see Attachment 2, “Underground/Overhead Utility Contact Prevention Responsibility Matrix,” for matrix of responsibilities.

5.2 Action/Approval Responsibilities

The Responsibility Matrix is Attachment 2.

6. PROCEDURE

Underground/overhead utilities may be encountered at any job site. The guidelines established in this procedure were developed to help identify and mitigate the potential hazards associated with this type of work.

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Any subsurface activity is subject to the underground utility locating regulations for the state where the work will be conducted. This procedure authorizes the use of state, local, or other required practices, but requires that the practice, which most limits the liability to Shaw for damaged utilities, is utilized. No variance is required under these circumstances, but the project-specific Health and Safety Plan (HASP) or Work Plan shall fully document these more protective procedures.

6.1 Boring Activity Requirements

6.1.1 Preliminary Requirements

The Project Manager or designee must visit the site to mark the boring locations so they can be clearly identified and then contact the One Call Center for the state in which the work is to be performed in to formally request a utility mark out at the particular work location(s).

Prior to assignment of work the FTL will assure that all affected employees receive an overview of the hazards of encountering underground/overhead utilities. The FTL is responsible to review this procedure, the work practices to control these hazards, and the roles and responsibilities of each worker with the work crew. This procedure and other requirements that may be contained in the site specific HASP shall be reinforced during daily Tailgate Safety Meetings.

6.1.2 Operating Requirements

Prior to conducting any project site activities, the FTL must ensure that all existing underground/overhead utilities in the work area are located per the state or local mark-out protocols. The Pre-Boring/Excavation Checklist (Form EIG-HS-308.02) will assist the FTL with this assessment. Documentation of utility mark-out must be completed using the Utility Mark-out Documentation form (EIG-HS-308.03). No boring work is to be performed until all utility mark-outs are verified.

While on site, the FTL must conduct a site survey to search for signs of other buried or overhead utilities. This will include areas such as garages, basements, etc. The results of such surveys must be documented on the Utility Mark-out Documentation form (EIG-HS-308.03). The property owner, client, or facility operator must be consulted on the issue of underground utilities. All knowledge of past and present utilities must be evaluated prior to conducting work.

After all mark outs have been completed, and the boring locations have been accepted by the FTL prior to drilling, each borehole location must be hand dug or vacuum excavated to a minimum of 5 feet bgs.

If the investigation requires boreholes in an area not covered by a municipal one call system (on private property), then the FTL must utilize appropriate geophysical techniques, hand held utility locating devices, a private utility locating firm, or other approved method to determine the locations of underground utilities. The current accepted geophysical methods for the investigation and location of buried utilities include: Ground Penetrating Radar (GPR), Time Domain and/or Frequency Domain Electromagnetic methods, Magnetometer, and Inductive/Conductive Radio-Magnetic methods. The geophysical methods can be very useful for locating buried utility lines in areas where hand digging is not possible or practical. However, it must be noted that these methods do have limitations that are a function of soil conditions, depth of investigation, imaging resolution, or other factors.

If it is determined that a noninvasive geophysical investigation may be needed, assistance with selecting the appropriate method(s) can be obtained from the Shaw E&I Science and Technology Division, Geophysics & Mapping Group, and a variance request must be submitted and approved prior to the inception of intrusive field activity.

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Should the local geology be prone to refusal or should there be any other reason the boring location cannot be cleared to a minimum of 5 feet bgs then the appropriate aforementioned alternative methods should be utilized to ensure the boring location is clear of utilities 5 feet bgs, and a variance request must be submitted for review.

6.2 Excavation Activity Requirements

6.2.1 Preliminary Requirements

The Project Manager or designee must visit the site to mark the excavation locations so they can be clearly identified and then contact the One Call Center for the state in which the work is to be performed in to formally request a utility mark out at the particular work location(s).

Prior to assignment of work the FTL will assure that all affected employees receive an overview of the hazards of encountering underground/overhead utilities. The FTL is responsible for reviewing this procedure, the work practices to control these hazards, and the roles and responsibilities of each worker with the work crew. This procedure and other requirements that may be contained in the site specific HASP shall be reinforced during daily Tailgate Safety Meetings.

6.2.2 Operating Requirements

Prior to conducting any project site activities, the FTL must ensure that all existing underground/overhead utilities in the work area are located per the state or local mark-out protocols. Documentation of utility mark-out must be completed using the Utility Mark-out Documentation form (EIG-HS-308.03). No boring work is to be performed until all utility mark-outs are verified.

While on site, the FTL must conduct a site survey to search for signs of other buried or overhead utilities. This will include areas such as garages, basements, etc. The results of such surveys must be documented on the Utility Mark-out Documentation form (EIG-HS-308.03). The property owner, client, or facility operator must be consulted on the issue of underground utilities. All knowledge of past and present utilities must be evaluated prior to conducting work.

After all mark outs have been completed, and the excavation locations have been accepted by the FTL prior to excavation, each utility identified inside the excavation location must be hand dug (see restrictions under Section 6.3) or vacuum excavated to a verify the utility location. The utility locations must be exposed in enough locations to verify its path of travel. If possible, the excavation location should be moved away from any utilities.

If the investigation requires excavation activities in an area not covered by a municipal one call system (on private property), then the FTL must utilize appropriate geophysical techniques, hand held utility locating devices, a private utility locating firm, or other approved method to determine the locations of underground utilities. The current accepted geophysical methods for the investigation and location of buried utilities include: GPR, Time Domain and/or Frequency Domain Electromagnetic methods, Magnetometer, and Inductive/Conductive Radio-Magnetic methods. The geophysical methods can be very useful for locating buried utility lines in areas where hand digging is not possible or practical. However, it must be noted that these methods do have limitations that are a function of soil conditions, depth of investigation, imaging resolution, or other factors.

If it is determined that a noninvasive geophysical investigation may be needed, assistance with selecting the appropriate method(s) can be obtained from the Shaw E&I Science and Technology Division, Geophysics & Mapping Group, and a variance request must be submitted and approved prior to the inception of intrusive field activity.

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6.3 Other Requirements

Only hand digging is permitted within 3 feet of underground high voltage, product, or gas lines. Once the line is exposed heavy equipment can be used, but must remain at least 3 feet from the exposed line.

Only experienced, demonstrably proficient equipment operators, as determined by the Project Manager, will be used to operate such heavy equipment as drill rigs, backhoes, front-end loaders, cranes, etc.

Due to the sensitivity and costs associated with damage to fiber optic cables, the FTL must have documented verbal contact and an agreement with the fiber optic company for all work within 50 feet of the fiber optic cables. Subsurface investigations near fiber optic cables are more fully discussed in site specific HASPs.

6.4 Overhead Utilities Requirements

The FTL is responsible for marking (warning tape, flags, etc.) overhead utility locations where heavy equipment, or other equipment, has the potential for contacting overhead utilities. Conduct a site inspection on a daily basis to determine where activities will take place and the location of overhead utilities and overhead obstructions. Once they have been identified, place warning tape on poles and/or guy wires and attempt to plan the work so that no contact will be made with the overhead utilities or obstructions. Share the information with all site personnel during the tailgate safety meeting.

When working around overhead utilities, one or more of the following conditions shall be met:

- The Project Manager shall confirm with the utility company that the power is de-energized (preferably in writing).
- The minimal clearance distances shall be established and maintained according to Attachment 3, “Minimum Clearance Distances.”
- Insulating blankets shall be used to isolate the power line and the utility company shall provide the minimum safe operating distance in writing to the Project Manager. Insulating blankets must be placed by the utility company.

Maintain at least 10 feet from overhead power lines, up to 50 kilovolts (kV). For voltages over 50 kV, add 0.4 inches per kV to obtain the safe distance between equipment and power lines. If voltage is unknown, remain at least 20 feet from overhead power lines. See Attachment 3 for the Minimum Clearance Distance table. As a precaution, a spotter must be used at all times when it is possible to violate the minimum distance requirements for overhead utilities. If contact is deemed unavoidable, consult with the client and the respective health and safety representative to evaluate the area to determine if the particular overhead utility can be removed prior to engaging in the activity.

6.5 Training Requirements

6.5.1 Competent Person Drilling Oversight Training

The FTL (at least one on-site Shaw person will be performing the drilling oversight) will be required to have successfully completed the approved internal CPDO training. It is the Project Manager’s responsibility to ensure that the FTL has completed the CPDO training prior to overseeing boring activities.

Prior to assignment of work the FTL will assure that all affected employees receive an overview of the hazards of encountering underground/overhead utilities. The FTL is responsible for reviewing

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this procedure, the work practices to control these hazards, and the roles and responsibilities of each worker with the work crew. This procedure and other requirements that may be contained in the site specific HASP shall be reinforced during daily tailgate safety meetings. A list of Frequently Asked Questions is provided as Attachment 4, "Frequently Asked Questions."

6.5.2 Trenching/Excavation Training

The FTL or at least one on-site Shaw employee will be required to have successfully completed Trenching/Excavation training prior to the inception of site work activity when excavation activities (i.e., excavations, test pits, use of 3-foot diameter augers, or anytime similar hazards are present) are present/anticipated. NOTE: This training is now recommended rather than required when trenching/excavation hazards are NOT anticipated/required.

6.6 Incident Reporting Requirements

Employees are required to immediately report to their direct supervisor any overhead or underground utility contact incident, or near miss incidents. Any supervisor (but preferably the supervisor directly responsible for the involved employees) with first-hand knowledge of an incident is required to investigate the incident. The Project Manager and respective Health and Safety Manager or Representative shall be informed of the incident immediately.

At a minimum, the incident investigation will require completion of the incident investigation report and General Liability Property Damage and Loss Report form found in Shaw E&I Procedure No. EIG-HS-020.

In addition, Attachment 5, "Underground Utility Hits – Tip Sheet for Incident Investigations," provides a "Tip Sheet" to help properly assess and investigate the incident causes and recommendations or requirements.

6.7 Local Jurisdiction Requirements

Where local jurisdictions or clients have established requirements different from those in this procedure, the practice which most limits the liability to Shaw for damaged utilities shall be utilized. No variance is required under these circumstances but the project-specific HASP or Work Plan shall fully document the alternate procedures.

7. ATTACHMENTS

- Attachment 1, Flowchart to Obtain a Variance
- Attachment 2, Underground/Overhead Utility Contact Prevention Responsibility Matrix
- Attachment 3, Minimum Clearance Distances
- Attachment 4, Frequently Asked Questions
- Attachment 5, Underground Utility Hits – Tip Sheet for Incident Investigations

8. FORMS

- EIG-HS-308.01, Variance Request Form
- EIG-HS-308.02, Pre-Boring Checklist
- EIG-HS-308.03, Utility Mark-Out Documentation

9. RECORDS

- EIG-HS-308.01, Variance Request Form

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- EIG-HS-308.02, Pre-Boring Checklist
- EIG-HS-308.03, Utility Mark-Out Documentation

10. REVISION HISTORY AND APPROVAL

Revision Level / Revision Date	Revision Description	Responsible Manager
00 N/A	Initial issue information is unavailable.	N/A
01 2/20/2006	Revision 1 information is unavailable.	Troy Allen
02 9/28/2010	Revised procedure format. Added “boring activities, “excavation activities,” and “vacuum excavator” to definitions section. Provided separate section for “boring activities” and “excavation activities.” After Revision 1 posting and individual found an error that was corrected regarding Competent Person- Drilling Oversight (CPDO) training. The Note that said: “The CPDO training requirement will become effective September 1, 2006> This means that every FTL will have successfully completed CPDO Training prior to August 31, 2006.” Was removed as it was not relevant anymore.	Troy Allen
03 8/25/2011	Modified format only to align with Governance Management framework.	Andrew Johnson
04 2/20/2012	Corrected reference in 6.2.2 that referred to section 5.3, corrected to reflect appropriate section 6.3.	Andrew Johnson

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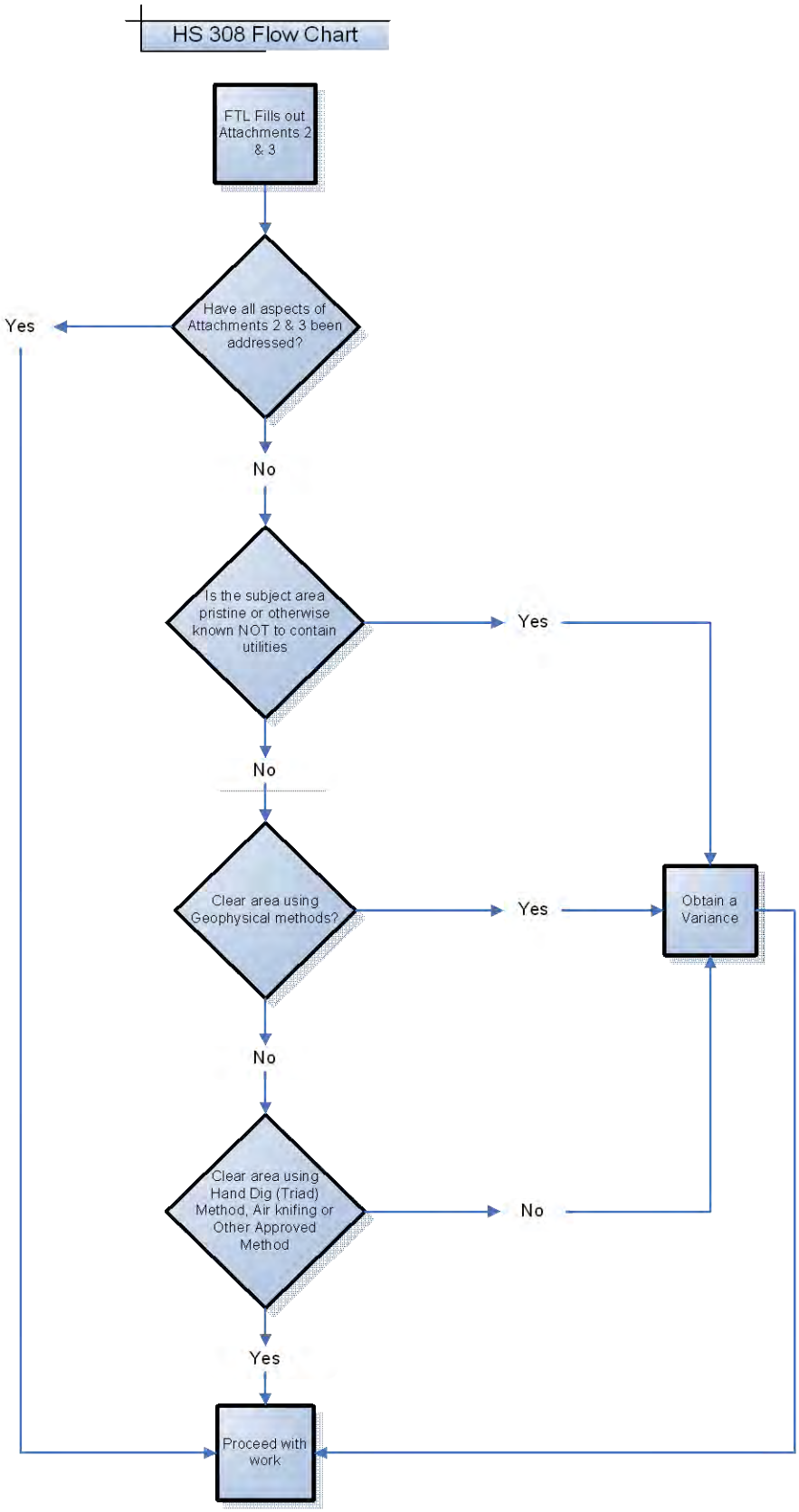
Attachment 1
Flowchart to Obtain a Variance



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Attachment 2
Underground/Overhead Utility Contact Prevention Responsibility Matrix

Action	Procedure Section	Vice President	Project Manager	Field Team Leader	Supervisor	HS Representative
Project-specific HASP or Work Plan shall document the practices to be used at a particular site.	6.0		X	X		X
Contact the One Call Center for mark out of utilities at the site	6.1.2		X			
Complete Utility Mark-out Documentation Form	6.1.2		X	X		
Only experienced demonstrably proficient equipment operators will be used to operate such heavy equipment as backhoes, front-end loaders, cranes, etc.	6.3			X		
Provide training*	6.5					
Incident Investigation and Reporting	6.6		X		X	
Exceptions to Procedure	2.1	X	X	X		

*Provided by Shaw's Training Department.

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Attachment 3
Minimum Clearance Distances

When work is undertaken near electrical lines, the distance maintained from those lines shall also meet the minimum distances for electrical hazards as defined below:

NOTE: This procedure primarily focuses on electrical overhead utilities; however, all other hazards shall be taken into consideration when performing work.

Normal System Voltage	Required Minimum Clearance Distances
0-50kV	10'
51-100kV	11.6'
101-200kV	15'
201-300kV	18.3'
301-500kV	25'
501-750kV	33.3'
751-1000kV	41.7'

***For those locations where utility companies specify more stringent safe distances, those distances shall be observed.**

Attachment 4
Frequently Asked Questions (FAQ)

During the roll-out of this revision of EIG-HS-308 a variety of questions/comments/concerns arose. These concerns have been put in the form of most frequently asked questions (FAQs) and their respective responses. These FAQs will clear up misunderstanding pertaining to this procedure, and provide valuable information that will help our workforce have a better understanding of how this procedure should be implemented. Please review the FAQs below:

1. *No other competitor of Shaw has felt the need to do anything as extreme as this procedure to ensure minimization of utility hits. Instituting this procedure will put us out of business.*

Response: After thorough review of claims and incidents involving drilling activities and underground utilities, the committee believes that our business/client needs are best served by adopting this policy. And that the likelihood of being put out of business is much greater from continuing to do business the way we currently do it than by adopting this improved policy. The committee realized that 100% adherence to this procedure at all work sites is likely not possible. For those cases where legitimate reasons exist for non-compliance, the committee realized that an effective responsive (variance) system must be in place. The committee believes that the variance procedure, as stated in the policy, should address the exceptions as they occur.

The Committee is not aware of any specific ASTM or true “industry standard”. However, the committee is aware that best practices can vary tremendously and many times are client dependent. For example one extremely large Shaw client requires that we continuously probe. On the other end of the spectrum some clients look completely to Shaw for guidance in these matters.

2. *Our clients want us to do the work but do not wish to pay the additional fees involved with this new procedure. Could we offer them a two tiered pricing, one to do it the old way, and one to do it the new way?*

Response: The committee believes that contacting an underground utility of any type, no matter who is at fault or who ultimately pays for fixing, the outcome is a “black eye” for all involved. When these events occur, even if Shaw is not at fault, the committee believes that continued good client relations, and the potential for obtaining future business lessens as utility hits/incidents occur. This procedure is designed to minimize health and safety risks to our workers AND to mitigate liability to Shaw. Receiving the necessary compensation for the precautionary measures outlined in the procedure would be expected, and should be itemized in the initial proposal including a statement as to what will specifically be done in the field to mitigate risks relative to underground utilities and WHY Shaw believes these steps are necessary. However, if the client is willing to assume the entire liability resulting from “hitting” an underground utility, the contract should be written to reflect this and a variance would be in order. Keep in mind that Shaw cannot allow a client’s desires to take on liability to affect the health and safety of workers. No matter what the client desires might be, Shaw would still expect the basic procedures to be followed for health and safety purposes. The training though yet to be

finalized will provide project manager's examples of wording to be used in proposals and contracts.

3. *Hand digging to 5' is impossible during frost conditions in Minnesota, Wisconsin and many northern areas. How should this be addressed?*

Response: When conditions present themselves that do not allow for hand digging each borehole, other methods must be used for clearance and a variance must be obtained. The alternative methods include a range of non-invasive geophysical survey techniques designed specifically for locating buried utilities, pipelines, tank (UST), and other buried objects that can interfere with drilling. These non-invasive geophysical methods are suggested and mentioned in the procedure.

4. *What if the field crew runs into refusal during hand dig clearance?*

Response: If refusal occurs and moving to an alternate spot presents the same problem, hand digging may not be possible as mentioned in #2 above. When conditions present themselves that do not allow for hand digging each borehole, other methods must be used for clearance and/or a variance must be obtained. Of course, we expect that the dig safe folks to be contacted, and that a private locating service be utilized if available. Should a private locating service not be available, we can use trained internal sources.

The alternative methods include a range of non-invasive geophysical survey techniques designed specifically for locating buried utilities, pipelines, tank (UST), and other buried objects that can interfere with drilling. The current accepted geophysical methods for the investigation and location of buried utilities include: Ground Penetrating Radar (GPR), Time Domain and/or Frequency Domain Electromagnetic methods, Magnetometer, and Inductive/Conductive Radio-Magnetic methods. These non-invasive geophysical methods are suggested and discussed in the procedures. The geophysical methods can be very useful for locating buried utility lines in areas where drilling and digging are not possible or practical, but these methods do have some limitations that are a function of soil conditions, depth of investigation, and imaging resolution.

If it is determined that a non-invasive geophysical investigation may be needed, assistance with selecting the appropriate method(s) can be obtained from the Shaw E&I Science and Technology Division, Geophysics & Mapping Group. Of course, it is expected that the "dig safe" folks will be contacted, and that a private utility locating service be utilized when appropriate (utility location method is known to be feasible), and if available. Should a private locating service not be available, we can use trained internal Shaw E&I personnel resources to perform utility line location work. Finally, if the Project Manager has determined that a variance to the procedure is justified, a variance request should be submitted for review.

5. *Why is trenching/excavation training required for putting in Geoprobe® boreholes? This seems like tremendous overkill.*

Response: The committee believes that, in general, trenching/excavation training is a good educational tool that promotes overall health and safety awareness and provides important information/techniques for our field staff. Trenching/excavation training provides insights into

fall hazards, spoil pile placement, and many other related safety issues. Many of our drilling jobs have involved oversized auger bits (3' in diameter) where a large deep borehole is created. The committee agrees that when the diameter of the borehole lessens (i.e. use of a Geoprobe®), the impact of trenching/excavation training decreases. Trenching excavation training is now a requirement only when large boreholes are created or other hazards as mentioned above are present, but only recommended training when Geoprobe ® or similar equipment is being used and the result is trenching excavation type hazards do NOT exist. NOTE: Specific training pertinent to drilling/ Geoprobing ®/boring (CPDO training) will be provided and will be mandatory. Additionally, CPDO and trenching / excavation training are both required on projects where 3' or larger diameter boreholes are to be drilled.

6. *Are there any training requirements besides trenching/excavation training?*

Response: The committee evaluated a need for training specific to the HS 308 policy (drilling) and solicited the assistance of the training department and certain operations employees to develop CPDO training. This CPDO training includes basic steps needed to be taken from call the dig-safe number, private utility searches, geo-physical capabilities, probing, hand augering, air knifing, water pumping/knifing, hand digging, and others.

7. *Hand diggings create heat stress, tripping hazards, back injuries, and other hazards and are unnecessary.*

Response: The committee did not envision using a spade and a strong back to dig various 5' holes at the field site. The committee does envision using an air knife, water knife, probe, or other method rather than a hand shovel. The committee understands that not all methods may be acceptable in all states, municipalities or to all clients. The committee was also aware that when all else fails one could consider using a l" diameter stainless steel auger placing 5' bgs hand borings in a triangular pattern where the auger bit could be placed in between these small hand borings. The committee envisions this theme and methodology to be expanded within the upcoming training. Additional information on augering techniques will be provided in the specific training (CPDO) mentioned above.

8. *I need to put borings in pristine farmland next door to a contamination zone. There are no and have never been any utilities in this area. What should I do?*

Response: Once you go through the proper utility locate procedure and are confident that no utilities exist in the subject area, you need to obtain a variance. This would also hold true for pristine forest preserves, wildlife refuges, or other areas not affected by utilities.

9. *Who needs to sign off on a variance?*

Response: Variances are signed by the Area Vice President (or designee, which may be delegated to the BLM for each office) along with the Project/Program Manager/Director. When we know in advance that EIG-HS-308 cannot be adhered to, one should make plans to get a formal variance approval and appropriate paperwork developed two weeks prior to field activity. Variances can also be obtained when field conditions arise that make adherence to EIG-HS-308

impossible. The variance can be obtained via cell phone in the field with the PM and appropriate management with the outcome noted in the field logbook followed up by an appropriate e-mail. This e-mail should be kept in the project file as proof of variance approval. It is recommended that variances be obtained as soon as it is known that they will be required.

10. What constitutes a "probe"? I assume a Geoprobe® is not valid?

Response: A Geoprobe® is NOT a valid probe in that Geoprobes® have caused damage to sewer lines and other utilities. Probes are typically made of a fiberglass-like material that have a pointed end but will not damage subsurface utilities and allows for the field staff to sense if underground items are encountered.

11. Under 5.1, is a subcontractor a designee?

Response: Although a subcontractor can make arrangements to contact dig safe and more, Shaw must ensure that the sub has, in fact, done what they had agreed to do. It should be remembered that typically on drilling projects, from many of our customer's perspective, the liability remains with Shaw, and they will look to Shaw, not our subs, for resolution of any events that occur. Hence, it is incumbent on Shaw to insure that our procedures are followed by Shaw and Shaw subs.

12. Does ground surface include concrete, asphalt or other man-made coverings?

Response: A simple NO. Some of our projects include drilling through airport runways or tarmacs which can be up to 15" in depth. Manmade surfaces do NOT count in the 5' hand dig clearance specification. If we are attempting to advance boreholes below existing concrete surfaces, the geology below the concrete will be exposed by cutting the concrete and removal of the concrete. After the concrete is removed and the geology is exposed, a hand auger can then be used.

Hopefully, the twelve concerns above and the responses to these comments will have helped users understand the implementation of this EIG-HS-308 policy. More importantly the committee realizes that information on this subject will be provided during the training mentioned above. It is the committee's belief that once this program has been completely rolled out the need for variances will be minimal and the interactions of the safety department with operations management with this entire process will make ensure success.

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Attachment 5
Underground Utility Hits
Tip Sheet for Incident Investigations

1. Location of the incident.
2. The time of day the incident occurred.
3. What type of utility was hit?
4. How deep was the line hit (in feet)?
5. Who called Designated Locator Service?
6. Note the "One Call" number on the Incident Investigation Follow-up report.
7. Attach the "One Call" record keeping documentation.
8. Were mark-outs completed by the utilities? If so, please identify.
9. Were mark-outs legible at the site?
10. Was the mark-out of the line that was hit accurate?
11. Was the mark-out misinterpreted?
12. Is there a utility damage sheet attached to the Incident Investigation Follow-up Report?
13. Have there been any faults or oversights by any 3rd party? If so, is it documented on the Incident Investigation Follow-up Report?
14. Did the FTL interview the property owner/manager prior to the incident?
15. Was pre-screened by hand digging 5 feet?
16. Were any supplemental utility locator devices used? If so, did we obtain them? If so, were they used on site?
17. Were there blueprints/as built plans available? If so, did we obtain them? If so, were they used on site?
18. Who is paying for the repairs?
19. Please define the total hours and cost estimate/impact to address the utility damage incident:

    _____ Site time in hours (not billed to the job)

    _____ PM time hours (not billed to the job)

    _____ H&S time in hours (not billed to the job)

    _____ BLM Time in hours (not billed to the job)

    _____ Rework/non-billable time (estimate)

    _____ Subcontractor rework/non-billable costs (estimate)

    _____ Repair costs to company (estimate)

    _____ Repair cost to customer (estimate)

20. Has the FTL completed Shaw's in-house CPDO training?
21. Has the FTL completed trenching/excavation training?
22. Is he/she current with the OSHA 40 hour and 8 hour refresher? If so, what are the dates of the training?
23. Who was the Site Safety Officer on the job site?
24. Does he/she have OSHA 8 hour supervisor training? If so, what are the dates of the training?
25. What was the name of the drilling subcontractor that was on site?
26. Have we researched the training background for this vendor?
27. Was a JSA performed at least once during the day that covered utility contacts and associated hazards?
28. Does this vendor have approved status?
29. Was there a tailgate safety meeting that took place?
30. Were utility mark-outs addressed at the tailgate safety meeting?
31. Were there any markings nearby the "hit" area?

Shaw a world of Solutions	Title: Variance Request Form	Form No: EIG-HS-308.01_4

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Variance Request Form

Variance Request for Company Procedure: EIG-HS-308-Underground/Overhead Utility Clearance procedure	Date of Request:
Requestor:	Location:
Reason for the variance:	
Alternate Procedure(s) that will be implemented:	
APPROVED	**REJECTED**
Regional VP or Designee	

Shaw a world of Solutions	Title: Pre-Boring Checklist	Form No: EIG-HS-308.02_4

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Pre-Boring Checklist

Purpose: This form is designed to help the FTL make decisions during boring/excavation around underground/overhead utilities.

DATE _____ PROJECT NAME/NUMBER _____

Field Team Leader Name: _____

DURATION/SUMMARY OF WORK TO BE PERFORMED: _____

_____

Consideration	Check	Check	Explanation	Initial
Has the state one-call been contacted?	☐ Yes	☐ No		
Are any as-built drawings available? If so, do they show any utilities?	☐ Yes	☐ No		
Has a visual inspection of the work area(s) been completed?	☐ Yes	☐ No		
If one-call not available has a private locating service or Shaw S&T group been contacted?	☐ Yes	☐ No		
Were any utilities identified through private locating service? If so, indicate on site drawings.	☐ Yes	☐ No		
Are there any fiber optic cables within 50 feet of hole locations?	☐ Yes	☐ No		
If fiber optic cables are within 50 feet has an agreement with the fiber optic company been established?	☐ Yes	☐ No		
Can a test borehole be advanced by hand digging, probing, post hole digging, and/or air knifed to 5 feet bgs?	☐ Yes	☐ No		
If hand digging, probing, post hole digging, and or air knifing to 5 feet bgs is not possible, can a non-invasive geophysical investigation be conducted? If not, why?	☐ Yes	☐ No		
Are you comfortable with approving this authorization?	☐ Yes	☐ No		
Other considerations:				

Shaw a world of Solutions	Title: Utility Mark-Out Documentation	Form No: EIG-HS-308.03_4

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Utility Mark-Out Documentation

Project Name: _____ **Location:** _____
FTL Name: _____ **Date:** _____
Utility Called: _____ **Confirmation #:** _____
Subcontractor: _____ **Task/Activity:** _____
County of work: _____ **Municipality of work:** _____

Before work is done on any site, contact the appropriate local utility locating service (One Call, Miss Dig, Uloco, etc.) or a local utility contractor to have sub grade utilities marked. NOTE: Boring locations to be placed not in the public right of way are typically not marked out by the public utility mark out, and a private utility locate service must be engaged. Indicate to the utility locator the nearest intersecting street for the site: _____
_____ **Confirmation No:** _____.

List utility firms (public and private) and the utility they will mark.

Utility Marker Emergency Telephone Numbers Major Utilities Marked by Color Code			
Name of Utility Company	Utility	Color Code	Emergency Telephone Number
	Water	**Blue**	
	Gas	**Yellow**	
	Electric	**Red**	
	Telephone/ Cable/ Communication	**Orange**	
	Sewer	**Green**	
"ALL UNDERGROUND UTILITIES MAY NOT BE LOCATED BY THE LOCAL UTILITY SERVICE". Accordingly, you must list other known utilities in the area that the "One Call" service will not contact:			

Attach photos of the area prior to placing boreholes.
Take photos of the area indicating minimum 5' hand dig, post hole dig, probe, GPR or other:
NOTE: For any borehole, should 5' minimum clearance not be obtained, you must contact Business Line Vice President or equivalent (Operations Director or other on the Federal Business Line) and obtain a variance.

Completed by:_____
_____

_____	_____	_____
Name	**Signature**	**Date**

Shaw a world of Solutions	Document Type: **Discipline-Specific Procedure**	Level: 3 Owner: Applied Science & Engineering Origination Date: 4/8/2003 Revision Date: 1/2/2013
Group: E&I	Title: Standards for Conducting Subsurface Soil Sampling While Drilling	No: EID-GS-001 Revision No.: 2 Page 1 of 7

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1. PURPOSE

This procedure provides the standard practice for subsurface soil sampling while drilling. The procedure includes the minimum recommended steps and quality checks that employees and subcontractors are to follow when performing the subject task.

This procedure may also contain guidance for other recommended or suggested practice that is based upon collective professional experience. Recommended practice goes beyond the minimum requirements of the procedure, and should be implemented when appropriate.

2. SCOPE

Geosciences Standard Operating Procedure (SOP) EID-GS-001 describes standards for collecting subsurface soil samples while drilling, and defines how such sampling will be conducted and documented for projects executed by Shaw Environmental & Infrastructure Inc. (Shaw E & I). This standard is specific to sampling activities that are intended for the collection of soil samples for chemical analysis. Proper collection procedures are necessary to ensure the quality and integrity of all subsurface soil samples.

This SOP addresses technical requirements and required documentation. Responsibilities of individuals performing the work are also detailed. Additional project-specific requirements for subsurface soil sampling while drilling may be developed, as necessary, to supplement this procedure and to address project-specific conditions and/or objectives. This standard does not address subsurface soil sampling using direct-push techniques. Such sampling is covered under another SOP.

3. REFERENCES

Soil sampling should follow accepted industry practices while drilling. These are as defined by the latest version of the following ASTM Standards:

ASTM D 1586	Standard Method for Penetration Test and Split- Barrel Sampling of Soils.
ASTM D 1587	Standard Practice for Thin-Walled Tube Sampling of Soils.
ASTM D 3550	Standard Practice for Thick Wall Ring-Lined Split Barrel Sampling of Soils.
ASTM D 6169	Selection of Soil and Rock Sampling Devices Used with Drill Rigs for Environmental Investigations.

4. DEFINITIONS

The following definitions are applicable to the collection of subsurface soil samples while drilling, and are used in this SOP.

- **Borehole**—Any hole drilled into the subsurface for the purpose of identifying lithology, collecting soil samples, and/or installing monitoring wells.

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- **Split-Spoon Sampler**—A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. This device can be driven into resistant (semiconsolidated) materials using a drive weight or drilling jars mounted to the drilling rig. A standard split-spoon sampler (used for performing standard penetration tests, ASTM D-1586) is 2 inches in outside diameter and 1 3/8 inches in inside diameter. This standard spoon typically is available in two common lengths, providing either 20-inch or 26-inch internal longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively. Six-inch long sleeves (tubes) of brass, stainless steel, or plastic are commonly placed inside the sampler to collect and retain soil samples. A 5-foot long split-spoon sampler is available. A modified split-spoon sampler is also commonly used. The modified design is similar to the standard split-spoon, except the outside diameter varies from 2 to 3½ inches, and the inside diameter varies from 1½ to 3 inches (ASTM D 3550). The 2½-inch outside diameter sampler is referred to as the California Sampler.

- **Shelby Tube Sampler**—A thin-walled metal tube used to recover relatively undisturbed samples. These tubes are available in various sizes, ranging from 2 to 6 inches in outside diameter and from 18 to 54 inches in length (ASTM D 1587). A stationary piston device is included in the sampler to reduce sampling disturbance and to increase sample recovery. It has been found to be advantageous to collect Shelby tube samples from soft soil with the use of a hydraulically operated sampler (ASTM D 6519), often referred to as the Osterberg sampler. It has also been found to be advantageous to collect Shelby tube samples from hard soil with the use of a core barrel sampler, such as the Pitcher and Dennison samplers.

- **Drilling Jars**—A set pair of linked, heat-treated steel bars. The jars may be attached to a wireline sampling string incorporating a split spoon or other impact sampler. The jars are used to drive the sampler into the soil ahead of the bottom of the borehole, such as in cable tool drilling.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Geosciences Discipline Lead is responsible for the development, maintenance, and revision of this procedure. Any questions, comments, or suggestions regarding this technical SOP should be directed to the Geosciences Discipline Lead. The Geosciences Discipline Lead's location and associated contact information can be found on the Shaw Group intranet site, ShawNet.

5.2 Project Responsibility

Employees conducting subsurface soil sampling while drilling, or any portion thereof, are responsible for meeting the requirements of this procedure. Employees conducting technical review or oversight of such efforts are also responsible for following appropriate portions of this SOP. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (forms, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURES (TECHNICAL REQUIREMENTS AND STANDARDS)

This section addresses the process and procedures involved with subsurface soil sampling while drilling. Proper subsurface soil sampling procedures are necessary to ensure the quality and integrity of the samples.

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The details within this SOP should be used in conjunction with project-specific work plans. The project work plans will generally provide the following information:

- Sample collection objectives
- Anticipated locations of soil borings and target horizons or depths of soil samples to be collected
- Numbers and volumes of samples to be collected
- Types of chemical analyses to be conducted for the samples
- Specific quality control (QC) procedures and sampling required
- Any additional subsurface soil boring sampling requirements or procedures beyond those covered in this SOP, as necessary

Many different methods may be used for subsurface soil sample collection during drilling. Refer to ASTM D 6169-98 for guidance for the selection of soil sampling devices used with drill rigs. This SOP focuses on the two most common methods of soil sample collection: split-spoon sampling and Shelby tube sampling. At a minimum, the basic procedures outlined below for these two subsurface soil sampling methods will be followed.

6.1 General Sampling Considerations

The two subsurface soil sampling methods covered in this SOP, split-spoon and Shelby tube, are commonly used in conjunction with hollow stem auger, air rotary, and dual tube percussion drilling methods. Split-spoon or Shelby tube sampling may also be conducted when drilling with mud rotary methods; however, when using this drilling method the samples are not generally used for chemical analyses. This is because the samples may become invaded or chemically altered when they are tripped through the drilling mud during sample retrieval. In addition, loose unconsolidated soils may also literally wash out of the samplers when they are tripped through the mud column.

The procedures described in this SOP should be used in conjunction with the SOP for the specific drilling method used at the site. The drilling method SOPs are listed on the Insider. Included in these drilling method SOPs are specific drilling requirements related to subsurface soil sampling. These also include, but are not limited to, site clearance, site preparation, and health and safety requirements. Consequently, this SOP, the SOP for the specific drilling method to be used at the site, and the project work plans should be reviewed together before the initiation of drilling and sampling.

6.2 Split-Spoon Sampling

Split-spoon samples for chemical analysis are usually obtained in brass, plastic, or stainless steel sleeves. The types, dimensions, and number of sleeves to be used, along with the length and type of sampler, should be stated in the project work plans. The split-spoon sampler, lined with the appropriate sleeves, is connected to the drill rod string or a wireline sampling string and is driven by a drive hammer (140 or 340 pound, depending on the size of the sampler) or drilling jars into the undisturbed soil ahead of the bottom of the borehole. The project-specific procedure for collecting and preserving samples from the split-spoon sampler should be outlined in the project work plans. The basic standard procedure for split-spoon sampling is as follows:

1. Calibrate all field analytical and health and safety monitoring equipment according to the instrument manufacturer's specifications. Calibration results must be recorded on the appropriate form(s) as specified by the project work plan or health and safety plan.

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Instruments that cannot be calibrated according to the manufacturer's specifications must be removed from service and tagged.

2. Wear the appropriate personal protective equipment as specified in the project work plan or health and safety plan. Personal protection will typically include the following, at a minimum: hard hat, safety glasses, gloves, steel-toed boots, hearing protection, and coveralls.

3. Between each sampling location and prior to each sampling run, decontaminate the sampler, sleeves, and other sampling equipment according to applicable Shaw- and/or project-specific procedures.

4. Drill or advance the borehole to the desired depth or target horizon where the sampling run is to begin. During drilling, monitor vapors in the breathing zone according to the project work plan and health and safety plan.

5. When the desired sampling depth or target horizon is reached, remove the drill bit or plug from inside the drive casing or augers. Check the bottom depth with a tape to measure for the presence of "flowing sands" or slough inside the auger, casing, or borehole.

6. Insert the sleeves into the split-spoon sampler, connect the halves, and screw together the rear threaded collar and front drive shoe. Attach the split-spoon sampler to the bottom end of the drill rod string or wireline sampling string. Set up and attach the specified-weight hammer, if used.

7. Drive the sampler into the soil at the bottom of the borehole. Record the type of sampler assembly and hammer weight on the appropriate form(s) (an example Visual Classification of Soil Form [i.e., field log] is included as an attachment to this SOP), as specified in the project work plans. To minimize off-gassing of the volatiles, the sampler should not be driven until the sampling team is ready to process the sample.

8. When conducting penetration testing, observe and record on the appropriate form the number of hammer blows as described in appropriate Shaw- and/or project-specific procedures.

9. Pull the drill rod or wireline sampling string up from the bottom of the borehole and remove the sampler.

10. Remove the drive shoe and rear collar from the sampler and open the split barrel.

11. Remove the sleeves one at a time, starting with the sleeve adjoining the drive shoe. Observe and record the amount of sample recovery on the appropriate form per applicable Shaw procedures. Any observed field problems associated with the sampling attempt (e.g., refusal) or lack of recovery should be noted on the appropriate form. Log the sample in accordance with applicable Shaw and/or project-specific requirements.

12. Select the sleeve(s) to be submitted for laboratory analysis. Sample sleeve selection should be based on five factors: (1) judgment that the sample represents relatively undisturbed intact material, not slough; (2) proximity to the drive shoe; (3) minimal exposure to air; (4) lithology; and (5) obvious evidence of contamination. The project work plans should specify which sample sleeves will be submitted for specific analyses and confirm the selection factor(s).

13. Place Teflon™ film over each end of sleeves to be submitted for chemical analysis, and seal each end with plastic end caps. Do not use any type of tape to seal the cap, because tape causes a toluene interference. All samples should be individually stored in resealable plastic bags. Note: Additional project-specific sample preparation steps or modifications may be required as stated in the project work plans.

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14. Appropriately label and number each sleeve to be submitted for analysis. The label will be filled out using waterproof ink and may contain the following information:
    - Project number
    - Boring number
    - Sample number
    - Bottom depth of sleeve
    - Date and time of sample collection
    - Parameters of analysis
    - Sampler's initials
15. Document the sampling event on the appropriate form(s), as specified in the project work plans. The information listed on the form should, at a minimum, include the following:
    - Project name and number
    - Date and time of the sampling event
    - Drilling and sampling methods used – specify sample type
    - Sample number
    - Sample location
    - Boring number
    - Sample depth interval
    - Sample description (type of matrix)
    - Weather conditions
    - Unusual events
    - Signature or initials of the sampler
16. Appropriately preserve, package, handle, and ship the sample in accordance with applicable Shaw and/or project-specific procedures. The samples shall also be maintained under custody. Samples stored on site will be subject to the provisions of applicable Shaw procedures and/or project work plans. However, all reasonable attempts should be made to ship samples on the date they are collected.
17. One of the sample sleeves may also be utilized for lithologic logging. This sleeve may not then be retained for chemical analysis, as soil must be removed from the sleeve to effectively describe the soils/lithology and compile the lithologic log.
18. Where headspace organic vapor screening is required by the project work plans, remove the soil from one of the remaining sleeves and place in a seam-sealing, polyethylene bag. Place the bag in the sunlight (warm) for at least five minutes, then using an organic vapor probe (portable photoionization detector, flame ionization detector, or other appropriate instrument), monitor the soil headspace for organic vapors. Record the reading on the appropriate form(s) specified in the project work plans.

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19. Repeat this sampling procedure at the intervals specified in the project work plans, and/or at suspected significant lithology changes until the bottom of the borehole is reached and/or the last sample is collected.

6.3 Thin-Walled or Shelby Tube Sampling

A thin-walled tube, or Shelby tube sampler may be used to collect relatively undisturbed soil samples. The project-specific procedure for collecting soil samples using a Shelby tube sampler should be outlined in the project work plans. The basic or standard procedure for Shelby tube sampling is described in the following text.

1. Calibrate all field analytical and health and safety monitoring equipment as discussed in Section 6.2, step 1.

2. Wear the appropriate personal protective equipment as described in Section 6.2, step 2.

3. Between each sampling location and prior to each sampling run, decontaminate the sampler and other sampling equipment according to applicable Shaw- and/or project-specific procedures.

4. Drill or advance the borehole to the desired depth or target horizon where the sampling run is to begin. While drilling, monitor the breathing zone according to the project work plans and health and safety plan.

5. Once the desired sampling depth or target horizon is reached, check the bottom depth with a tape to measure for the presence of “flowing sands” or slough inside the auger, casing, or borehole. Then connect the sampling tube to the drill rod string and advance the tube to the bottom of the boring. Then push the tube about 2 to 2.5 feet into the soil with a continuous, rapid motion without impact or twisting. If Osterberg, Pitcher, or Dennison samplers are used, follow the manufacturers’ instructions for advancement of the sampler.

6. Pull the drill rod string up from the bottom of the borehole and remove the sampling tube from the string. Observe and record the amount of sample recovery and any associated problems as discussed in Section 6.2, step 11.

7. Place Teflon™ film over each end of the tube if it is to be submitted for chemical analysis and seal the ends with plastic end caps. With a waterproof marker, write a “T” for top on the leading end and a “B” for bottom on the trailing end of the tube. Note: Additional project-specific sample preparation steps or modifications may be required, as stated in the project work plans.

8. Appropriately label and number the tube as described in Section 6.2, step 14.

9. Document the sampling event on the appropriate form(s), as discussed in Section 6.2, step 15.

10. Appropriately preserve, package, handle, and ship the sample in accordance with applicable Shaw- and/or project-specific procedures. The samples shall also be maintained under custody. Samples stored on site will be subject to the provisions of applicable Shaw procedures and/or project work plans. However, all reasonable attempts should be made to ship samples on the date they are collected.

11. Repeat this sampling procedure at the intervals specified in the project work plans until the bottom of the borehole is reached and/or the last sample is collected.

Records generated as a result of this SOP will be controlled and maintained in the project record files.

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7. ATTACHMENTS

Attachment 1, Example Visual Classification of Soils Form (Field Log)

8. FORMS

None

9. RECORDS

- Project Specific Work Plan
- Calibration Results
- Visual Classification of Soil Form
- Field Logs

10. REVISION HISTORY AND APPROVAL

Revision Level Revision Date	Revision Description	Responsible Manager
00 07/21/2003	Initial Issue	John E. Sciacca
01 01/26/2007	Changed from Standard to procedure. Procedure number changed from SOP-T-GS-001 to EI-GS001, added Shaw E&I, edited ASTM reference numbers in references section, Section 5.1 Procedure responsibility: replaced reference to the Insider with ShawNet, revised Project Responsibility, Split-Spoon Sampling: numbering system changed, numbering system changed for thin-walled or Shelby Tube Sampling, Instructions to thin walled or Shelby tube sampling.	Gary Gaillot
02 01/02/2013	Modified format only to align with Governance Management framework.	Scott Logan

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Attachment 1
Example Visual Classification of Soils (Field Log)

PROJECT NUMBER:	PROJECT NAME:	
BORING NUMBER:	COORDINATES:	DATE:
ELEVATION:	GWL: Depth Date/Time	DATE STARTED:
ENGINEER/GEOLOGIST:	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS:		PAGE: OF

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER PER ( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	MEASURED CONSISTENCY (TSF)	WELL CONSTRUCTION	REMARKS

NOTES:

Drilling Contractor: _____

Drilling Equipment: _____

Driller: _____

_____

1651-9-02

1. PURPOSE

This procedure provides the standard practice for hollow stem auger drilling. This procedure includes the minimum required steps and quality checks that employees and subcontractors are to follow when performing the subject task.

This procedure may also contain guidance for recommended or suggested practice that is based upon collective professional experience. Recommended practice goes beyond the minimum requirements of the procedure and should be implemented when appropriate.

2. SCOPE

Geosciences Standard Operating Procedure (SOP) EID-GS-017 describes standards for hollow stem auger drilling, and discusses how such drilling activities will be conducted for projects executed by Shaw Environmental & Infrastructure, Inc. (Shaw E & I). The SOP addresses technical requirements and required documentation. Responsibilities of individuals performing the work are also detailed. Additional project-specific requirements for hollow stem auger drilling may be developed, as necessary, to supplement this procedure and address project-specific conditions and/or objectives.

3. REFERENCES (STANDARD INDUSTRY PRACTICES)

Hollow stem auger drilling activities should follow accepted industry practices. These industry practices are as presented in the latest version of the following ASTM Standards:

ASTM D 5784	Standard Guide for Use of Hollow Stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
ASTM D 6286	Standard Guide for Selection of Drilling Methods for Environmental Site Characterization

Additional reference materials, which are useful for planning and conducting hollow stem auger drilling, include the following:

- Aller, Linda, B.W. Truman, G. Hackett, R.J. Petty, J.H. Lehr, H. Sedoris, D.M. Nelson, J.E. Denne, 1989, *Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells*, National Water Well Association, Dublin, Ohio.
- Driscoll, Fletcher G., 1995, *Groundwater and Wells*, Johnson Division, St. Paul, Minnesota.
- Shuter, Eugene, W.E. Teasdale, 1989, "Application of Drilling, Coring and Sampling Techniques to Test Holes and Wells," *Techniques of Water Resource Investigations*, U.S. Geological Survey, Book 2 Chapter F1.
- U.S. Environmental Protection Agency (EPA), 1986, *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*, OSWER-9950.1.

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4. DEFINITIONS

The following definitions are applicable to hollow stem auger drilling and this SOP.

- **Cleanout depth**—The depth to which the end (bit or core barrel cutting end) of the drill string has reached after an interval of cutting. The cleanout depth (or drilled depth as it is referred to after clean-out of any sloughed material in the bottom of the borehole) is usually recorded to the nearest 0.1 feet (0.03 m).
- **Drawworks**—A power-driven winch, or several winches, usually equipped with a clutch and brake system(s) for hoisting or lowering a drill string or sampling device.
- **Drill hole, Boring, or Borehole**—A cylindrical hole advanced into the subsurface by mechanical means (e.g., drilling).
- **Drill string**—The complete hollow stem auger assembly under rotation including augers, bit, sample barrel or core barrel, and/or removable center plug. The total length of the auger assembly is used to determine drilling depth by referencing the position of the top of the auger assembly to a fixed datum near the ground surface.
- **Hoisting line or Drilling line**—Wire rope used on the drawworks to hoist and lower loose augers, the removable center plug, sampling rods and sample barrel, or the downhole sampling hammer assembly.
- **Hollow Stem Auger Drilling**—A drilling method using rotating hollow auger flights (typically in 5-foot joints) with a bit on the bottom of the lead flight (sometimes called the “lead auger”). The flights consist of a hollow pipe and an outer spiral plate, which when rotated, forces soil cuttings upward along the borehole wall to the surface. The auger string is advanced by rotation, with downward pressure exerted by the rig, forcing the bit to cut the soil at the bottom and direct cuttings to the augers. Hollow stem augers typically range from 4 to 14 inches in diameter.
- **Mast**—A load-bearing structure on a drilling rig used for supporting the rotation head, pulldown hydraulics, hoisting lines, and so forth. It must be constructed to safely carry the expected loads encountered in drilling and completion of wells of the diameter and depth for which the rig manufacturer specifies the equipment. To allow for contingencies, it is recommended that the rated capacity of the mast should be at least twice the anticipated weight load or normal pulling load.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Geosciences Discipline Lead is responsible for the development, maintenance, and revision of this procedure. Any questions, comments, or suggestions regarding this SOP should be directed to the Geosciences Discipline Lead. The Geosciences Discipline Lead’s location and associated contact information can be found on the Shaw Group intranet site, ShawNet.

5.2 Project Responsibility

Employees planning or supervising hollow stem auger drilling are responsible for meeting the requirements of this procedure. Employees conducting technical review or oversight of hollow stem auger drilling activities are also responsible for following appropriate portions of this SOP. Project participants are responsible for recording information in sufficient detail to provide objective documentation (field notes, logs, forms, reports, etc.) that the requirements of this SOP have been met. Such documentation should be retained as project records.

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6. PROCEDURES (TECHNICAL REQUIREMENTS AND STANDARDS)

This section contains basic requirements and procedures for hollow stem auger drilling. The hollow stem auger method is commonly used for drilling and sampling of soil borings, collection of soil gas and screening-level water samples, and installation of some smaller diameter wells for environmental projects.

Hollow stem auger method of drilling is used for soil sampling by placing a retractable plug with a pilot bit at the bottom of the auger string to prevent cuttings from entering the hollow stem. When the plug is retracted, a sampler may be sent through the hollow center to sample soil at the bottom of the borehole without requiring the augers to be removed. A wireline sampler may also be attached to the inside of the lead auger for coring as the borehole is advanced.

For monitoring well construction the well casing string may be placed through the hollow stem.

This drilling method has advantages over other drilling techniques in certain circumstances, and disadvantages in others. This method is highly suitable for unconsolidated and consolidated fine-grained soils. Hollow-stem auger drilling can achieve the most rapid rates of penetration in soft, sticky, clay-dominated soils. However, coarse and consolidated gravels and hard bedrock may be too dense for adequate drill penetration. Soil cuttings are typically disaggregated and remolded, making bedding, fabric, and soil property determination difficult.

Although hollow stem auger methods allow for the collection of driven soil samples and soil cores, these types of soil samples may be more efficiently collected using direct push methods. Hollow stem auger soil sampling methods are typically utilized when soil borings and monitoring wells are required at the same location, or when the depth or soil types limit the effectiveness or practicality of direct push methods.

The most reliable method for logging of soils during hollow stem auger drilling is to collect relatively intact samples through the hollow stem. An advantage of the hollow stem auger method is that soil samples can be readily obtained from the bottom of the hole without requiring the removal of the auger string (unlike with air or mud rotary methods).

The hollow stem auger method may be used to install monitoring wells (limited by diameter), as it allows good depth control and the auger can be progressively pulled as well construction materials are added to the borehole. The methodology may also be used to drill out monitoring wells for abandonment.

Another advantage of the hollow stem auger method is that air or mud are not required as circulating media. Therefore, there is limited to no potential for flushing of soil samples collected for chemical analyses, and a reduction in volumes of investigation-derived wastes requiring costly handling and management procedures. Auger-type rigs can be significantly smaller than other types of rigs, making them suitable for some jobs with significant space constraints, including overhead clearance.

One limitation of the hollow stem auger method is a typical maximum drilling depth of 100 to 200 feet (may be less depending on soil conditions). Another limitation is that the method tends to smear clays along the borehole wall, creating a “skin” that has to be removed through well development.

The selection and implementation of hollow stem auger drilling techniques must incorporate site-specific conditions and requirements. Consequently, the project-specific work plans should identify the following:

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- The purpose of each borehole (e.g., to install a monitoring well, to collect soil samples, to conduct soil vapor sampling, etc.)
- Specific methodology for drilling, including equipment to be utilized and cuttings/fluid containment requirements
- Specific locations, depths, and diameters of boreholes
- Type of sampling and/or logging of boreholes to be conducted
- Details of mobilization/demobilization and decontamination of equipment
- Appropriate health and safety guidelines and personal protective equipment requirements
- Additional procedures or requirements beyond those covered in this SOP

6.1 Basic Equipment Requirements and Considerations

Basic equipment requirements and considerations are as follows:

- Rigs should be of sufficient horsepower, torque, and hoisting capacity to drill boreholes of anticipated diameter to anticipated maximum depths, as specified in the project work plans. Each rig should be equipped with a pump capable of injecting water and/or grout.
- Drill rigs should preferably be self-propelled or capable of accessing anticipated site field conditions.
- Rigs used for hollow stem auger drilling should have a sampling drive hammer system attached to the mast assembly. Mechanical or automatic hammer systems are preferable; however, downhole hammers and free-falling hammers controlled with a heavy hemp rope and a “Cat-Head” are acceptable and also used. The use of retrofitted drilling rigs with anything but a manufacturer-supplied sampling drive hammer assembly should not be allowed. A rig that requires personnel to climb onto the mast to attach or detach the hammer is unacceptable for safety reasons.
- Monitoring, extraction, or injection wells may be constructed through the interior portion of the hollow stem augers. A minimum clearance of 2 inches between the outer wall of the well casing and the borehole wall is preferred (greater annular clearance usually results in fewer well construction difficulties).
- Only Teflon™-based thread compound may be used to lubricate auger bolts or threaded portions of the drill string assembly. No other compound may be used unless otherwise directed in the project work plans. Such directed use in the project work plans should take into account applicable regulatory agency requirements and/or approval.
- Drill bit teeth and associated hard facing on the auger flights should be in good or “near new” condition. Proper types of bits, augers, and sampling string apparatus are to be available at the sizes and lengths needed to properly drill the desired diameters in the formation(s) to be encountered.
- During drilling, no additives (except water) may be added to the borehole and interior portion of the auger string without appropriate regulatory approval and/or concurrence with project-specific requirements. Only “clean” water may be added to the borehole and interior portion of the auger string, and only after discussion with and approval by the rig geologist. The rig geologist is responsible for ensuring that drilling and sampling activities are conducted in a manner that is consistent with applicable Shaw E & I policies and procedures, regulatory agency requirements, and project-specific requirements/procedures.

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6.2 Health and Safety Requirements

Prior to initiating drilling activities, applicable Shaw E & I and project-specific safety requirements must be reviewed by Shaw E & I site personnel and subcontractors. This review is conducted to familiarize these individuals with specific hazards associated with the site and drilling activities, as well as with health and safety procedures associated with the operation and maintenance of drilling equipment. Such information may be found in the project health and safety plan and other applicable Shaw E & I policies and procedures, including HS316, *Drill Rig Operations*, and HS308, *Underground/Overhead Utility Contact Prevention*.

Additional health and safety requirements are presented in the following text:

- Tailgate Safety Meetings should be held in the manner and frequency stated in the project health and safety plan. All Shaw E & I and subcontractor personnel at the site should have appropriate training and qualifications, as specified by the project health and safety plan. Documentation should be kept readily available in the project files on site.
- During drilling, all personnel within the exclusion zone should pay close attention to all rig operations. Rotating drilling tools can catch or snag loose clothing causing serious injury. Sampling hammers can often create pinch points and/or crush hazards. Improper handling of augers can also create potential pinch points (hands and feet), crush hazards, and back strain.
- Clear communication signals must be established with the drilling crew, since verbal communication may not be heard during the drilling process. Hearing protection is usually mandatory around drill rigs.
- The entire crew should be aware of the need to inform the rig geologist when any unforeseen hazard arises or when anyone is approaching the exclusion zone.

6.3 Drilling Site Mobilization

Basic site preparation and mobilization requirements and procedures are as follows:

- All drilling and sampling equipment should be decontaminated before drilling as specified in applicable Shaw E & I SOPs and/or project-specific requirements/procedures.
- The driller and the rig geologist should inspect the drilling equipment for proper maintenance and appropriate decontamination. All clutches, brakes, winches, and drive heads should be in proper working order. All cables and hydraulic hoses should be in good condition. All auger connections, associated auger bolts, sampling rod joints, and plug rod joints should be in good condition with no significantly worn threads, cracked or worn joint connections, or other signs of excessive wear.
- Any excessive leakage of fluids from the rig should be immediately repaired and appropriate portions of the rig decontaminated again before it is allowed to remobilize to the site.
- The logistics of drilling, logging, sampling, cuttings/fluid containment, and/or well construction should be determined before mobilizing. The site should be prepared in accordance with the project work plans.
- Before mobilization, the Site Superintendent and the rig geologist should assess the drilling site. This assessment should identify potential hazards (e.g., slip/trip/fall, overhead, soft or sloping ground, etc.) and determine how drilling operations may impact the environment (e.g., dust, debris, noise). Potential hazards should be evaluated and corrected, or the borehole location changed or shifted in accordance with the project work plans.

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- The Site Superintendent, or designee, should ensure that all identifiable underground and overhead utilities around the drilling location have been marked and properly noted. The borehole location should be properly cleared in accordance with the project work plans. At a minimum, copies of the site clearance documents should be kept on site in a common accessible location.

- Overhead obstructions such as trees, tall shrubs, and building overhangs should be evaluated and avoided for safety reasons, as they can impair the proper function of drill mast components.

- Once site preparation is completed, the rig is mobilized to the site and positioned over the identified borehole location. The rig should then be leveled with a set of hydraulic pads at the front and rear of the equipment. Once the rig is leveled, the mast should be raised slowly and carefully to prevent tipping or damaging the rig and to avoid hitting any obstructions or hazards.

- Appropriate barriers and markers should be in place prior to drilling, in accordance with the project health and safety plan. Visqueen (plastic) may be required beneath the rig and around the auger area. When plastic is placed in the general vicinity of the rotating augers, extra precaution may be necessary to make sure that the plastic does not pose a safety hazard or unwarranted distraction or nuisance to the drill crew.

- Appropriate containment for cuttings and other investigation-derived waste should be set up on site prior to the commencement of drilling.

6.4 Basic Drilling Requirements and Procedures

Basic hollow stem auger drilling requirements and procedures are as follows:

- Immediately prior to drilling, all safety sampling and monitoring equipment will be calibrated according to manufacturer's specifications and appropriate project-specific requirements and/or procedures. The rig geologist should inform the driller of the appropriate equipment (e.g., cookie cutter, etc.) to be used for penetrating the specific surface cover (e.g., asphalt, concrete, cement, etc.) at the drilling location.

- In the event of breaking ground where a shallow subsurface hazard may exist (e.g., unidentifiable utility, trapped vapors, etc.), the driller should be informed of the potential hazard. Drilling of the surface hole should commence slowly to allow continuous visual inspection and, if necessary, probing. The shallow portion of the hole may be hand-excavated, or hand-augered, to the anticipated maximum depth of any suspected obstructions. Specific requirements for such subsurface hazard clearance should be contained in the project work plans and be consistent with Shaw E & I policies and procedures.

- Once the surface cover is removed and the subsurface hazard clearance completed (if required), hollow stem auger drilling of the borehole may commence.

- During hollow stem auger drilling operations, as the borehole is advanced, the rig geologist will generally do the following:

  – Observe and monitor rig operations

  – Conduct all health and safety monitoring and sampling, and supervise health and safety compliance

  – Prepare a boring log from cuttings or soil samples as specified by applicable Shaw E & I SOPs and project-specific requirements

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- Document drilling progress and other appropriate observations on appropriate forms
- Supervise the collection and preparation of any soil, soil vapor, or groundwater samples

The rig geologist should not leave the drill site whenever drilling operations are conducted and the borehole is being advanced. A rig geologist should be present at all times when subcontract personnel are on the project site.

- As drilling progresses, the rig geologist should observe and be in frequent communication with the driller regarding drilling operations. Conditions noted should include relative rates of penetration (as indicated by fast or slow drilling), rotation speeds, chattering and bucking of the rig, hard or sticky drilling, drilling refusal, etc. These conditions, including penetration rates, should be recorded on the appropriate logs and forms as specified by applicable Shaw E & I SOPs and/or the project work plans. Drilling should not be allowed to progress faster than the rig geologist can adequately observe conditions, compile logs, and supervise safety and sampling activities.

  The rig geologist should also observe the fitting and placement of auger connections, as well as the make-up and tightening of drill rods for the center plug and/or sampling string. Any observed drilling problems and causes, including significant down time, should be recorded on the appropriate forms.

  Cutting and fluid containment during drilling should be observed and supervised by the rig geologist in accordance with the project work plans.

- The rig geologist should continue to oversee or conduct appropriate health and safety sampling and monitoring during drilling. If any potentially unsafe conditions are evident from drilling observations or health and safety monitoring, the rig geologist may suspend drilling operations at any time and take appropriate actions, in accordance with the project health and safety plan. In the event of a suspension of drilling activities, the following actions are required:
  - The Site Superintendent must be informed of the situation
  - Appropriate corrective action must be implemented before drilling may continue
  - The observed problem, suspension, and corrective action must be entered on the appropriate forms
- During drilling, the rig geologist will compile a boring log in accordance with applicable Shaw E & I SOPs. The boring log should include the following:
  - Borehole location
  - Name of the drilling company and driller
  - Dates and times of drilling events, including when drilling began, the total depth and when it was reached, intermediate milestones, and any changes in equipment (e.g., over ream auger sizes, etc.)
  - Relative drilling rate(s) and presence of drill chatter (these parameters may aid in confirming lithologic boundaries)
  - Lithologic data and descriptions from cuttings or soil samples including depths, frequency, and quality
  - Sampling depths and recovery of soil samples

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- Premature total depth due to refusal and the cause of refusal (if known)
- Any other observed drilling conditions such as observed groundwater levels, zones of hard or soft drilling, flowing sands, etc.

- The rig geologist will also enter pertinent information on the appropriate forms (in addition to the boring log), as required in the project work plans. This information includes but is not limited to the following:
  - The dates and times of drilling events including when drilling began, the total depth and when it was reached, intermediate milestones, and any changes in equipment (e.g., over ream auger sizes, etc.)
  - The dates, times, and causes of any significant down time
  - Premature total depth due to refusal and the cause of refusal
- Subsurface soil sampling with a drive sampler can be done at discrete intervals while drilling with hollow stem auger methods. Though sample breaks are commonly made at 5-foot intervals (when new flights are added to the auger string), drive sampling can be conducted at any depth interval. The sampling depths or intervals should be specified in the project work plans. Driven samples typically require the removal of the drive head and extraction of the center plug to allow the insertion of a sampling string. The sampler is advanced (driven or pushed) beyond the bit to obtain a relatively undisturbed sample. Drive sampling conducted during hollow stem auger drilling should follow requirements in appropriate Shaw E & I SOPs and/or the project work plans.
- Soil organic vapor (SOV) sampling may be conducted in the vadose zone at discrete intervals during hollow stem auger drilling. This is done by stopping at the desired depth and driving a sample probe through the hollow stem into the soil ahead of the bit, and then collecting a vapor sample. The sampling should be supervised by the rig geologist following applicable Shaw E & I SOPs and/or project-specific requirements/procedures.
- Direct push groundwater samples can be obtained at discrete intervals during hollow stem auger drilling. This is done by stopping at the selected interval or zone and advancing a direct push sampler beyond the lead auger to retrieve a water sample. The direct push groundwater sampling should be supervised by the rig geologist following applicable Shaw E & I SOPs and/or project-specific requirements/procedures.
- If the borehole is to be abandoned once drilling is completed, the abandonment should follow procedures outlined in applicable Shaw E & I SOPs and the project work plans. The abandonment will be supervised by the rig geologist.
- Hollow stem auger boreholes may be used for monitoring, extraction, or injection well installation. If a monitoring, extraction, or injection well is to be installed in the borehole, installation should follow appropriate Shaw E & I SOPs and project-specific requirements/procedures. The well installation will be supervised by the rig geologist. In the process of constructing a well, the auger string should be extracted from the borehole using the rig's hydraulics, or hoisting line; providing a vertical lift with as little rotation of the auger string as possible. Rotation of the auger string while constructing wells should be minimized in order to avoid damaging or lifting the well casing.

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6.5 Demobilization

After drilling, sampling, and well installation or borehole abandonment is completed, the augers and rods are laid down, the mast is lowered, and the rig is moved off of the location. Demobilization/site restoration will be supervised by the rig geologist or appropriate designee. Additional demobilization requirements/procedures are as follows:

- All debris generated by the drilling operation should be removed and appropriately disposed of.
- The site should be cleaned, the ground washed as necessary, and the site conditions restored as specified by the project work plans.
- All abandoned borings should be topped off and completed as specified in the project work plans. All wells should also have their surface completions finished in accordance with the project work plans.
- Any hazards remaining as a result of drilling activities should be identified, and appropriate barriers and markers should be put in place, in accordance with the project health and safety plan.
- All soil cuttings, drilling fluids, and decontamination fluids should be properly contained, clearly labeled, and maintained, in compliance with the project work plans and/or other applicable local, state, and federal requirements and regulations.

6.6 Technical Review

All hollow stem auger drilling specifications, procedures, and results (e.g., reports, forms, etc.) should undergo technical review. It is recommended that the technical reviewer also provide review/oversight of the actual field implementation of the hollow stem auger drilling activities. This should include aiding in troubleshooting drilling problems. The technical reviewer should be an experienced senior geologist or hydrogeologist. At a minimum, the technical reviewer should be a person capable of planning and supervising hollow stem auger drilling and associated sampling and well installation programs. Individuals needing assistance in finding qualified technical reviewers may consult internal Shaw technical listings for experts in drilling or hollow stem auger drilling.

Any issues raised during the technical review shall be resolved between the reviewer and the staff planning, conducting, or preparing results of hollow stem auger drilling activities as follows:

- Comments/issues raised relative to planning and developing detailed procedures for hollow stem auger drilling should be resolved before mobilization and drilling commences.
- Comments/issues raised relative to results of drilling activities should be resolved before external (i.e., outside of Shaw E & I) use or submission of the results.

The technical review comments and issues, and corresponding resolution, shall be documented and filed with the project records. The records should be maintained until project close-out.

7. ATTACHMENTS

None.

8. FORMS

None.

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9. RECORDS

- Project Specific Work Plan
- Documentation of drilling progress
- Tailgate Safety Meeting Documentation
- Boring Log
- Drilling Specifications
- Procedures
- Results
- Technical review comments and issues, and corresponding resolution
- Site Clearance Documents

10. REVISION HISTORY AND APPROVAL

Revision Level / Revision Date	Revision Description	Responsible Manager
00 08/07/2003	Initial issue	John E. Sciacca
01 02/13/2007	Changed from Standard to Procedure, Procedure number changed from SOP-T-GS-017 to EI-GS017, edited ASTM Reference numbers, Edited definition for Hollow Stem Auger Drilling, replaced reference to the Insider with ShawNet in section 5.1, revised project responsibility in section 5.2, Section 6 was reworked, added reference to HS308 in section 6.2, changed requirement for onsite personnel in section 6.4	Gary Gaillot
02 01/02/2013	Modified format only to align with Governance Management framework.	Scott Logan

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1. PURPOSE

This procedure provides the standard practice for mud rotary drilling. The procedure includes the minimum required steps and quality checks that employees and subcontractors are to follow when performing the subject task.

This procedure may also contain guidance for recommended or suggested practice that is based upon collective professional experience. Recommended practice goes beyond the minimum requirements of the procedure and should be implemented when appropriate.

2. SCOPE

Geosciences Standard Operating Procedure (SOP) EID-GS-018 describes standards for mud rotary drilling and discusses how such drilling activities will be conducted for projects executed by Shaw Environmental & Infrastructure, Inc. (Shaw E & I). This SOP addresses technical requirements and required documentation. Responsibilities of individuals performing the work are also detailed. Additional project-specific requirements for mud rotary drilling may be developed, as necessary, to supplement this procedure and address project-specific conditions and/or objectives.

3. REFERENCES (STANDARD INDUSTRY PRACTICES)

Mud rotary drilling should follow accepted industry practices. These industry practices are as presented in the latest version of the following ASTM Standards:

ASTM D 5783	Standard Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
ASTM D 6286	Standard Guide for Selection of Drilling Methods for Environmental Site Characterization

Additional reference materials, which are useful for planning and conducting mud rotary drilling, include the following:

- Aller, Linda, B.W. Truman, G. Hackett, R.J. Petty, J.H. Lehr, H. Sedoris, D.M. Nelson, J.E. Denne, 1989, *Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells*, National Water Well Association, Dublin, Ohio.
- Driscoll, Fletcher G., 1995, *Groundwater and Wells*, Johnson Division, St. Paul, Minnesota.
- Shuter, Eugene, W.E. Teasdale, 1989, "Application of Drilling, Coring and Sampling Techniques to Test Holes and Wells," *Techniques of Water Resource Investigations*, U.S. Geological Survey, Book 2 Chapter F1.
- U.S. Environmental Protection Agency, 1986, RCRA *Ground-Water Monitoring Technical Enforcement Guidance Document*, OSWER-9950.1.

4. DEFINITIONS

The following definitions are applicable to mud rotary drilling and this SOP.

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- **Bentonite**—A common drilling fluid additive and well-construction product consisting mostly of naturally-occurring montmorillonite. Some bentonite products have chemical additives that may affect water-quality analyses.
- **Cleanout depth**—The depth to which the end of the drill string (bit or core barrel cutting end) has reached after an interval of cutting. The cleanout depth (or drilled depth as it is referred to after clean-out of any sloughed material in the bottom of the borehole) is usually recorded to the nearest 0.1 feet (0.03 m).
- **Drawworks**—A power-driven winch, or several winches, usually equipped with a clutch and brake system(s), for hoisting or lowering a drill string.
- **Drill hole, Boring, or Borehole**—A cylindrical hole advanced into the subsurface by mechanical means (e.g., drilling).
- **Drill Mud**—Water-based drilling fluid used in rotary drilling that is circulated through the drill pipe, bit, and borehole. The mud commonly consists of clean fresh water (with some fine-grained particles from the formation that remain in suspension), water with bentonite additives, or water with polymeric additives. The mud functions to lift cuttings from the borehole to the settling pit; support and stabilize the borehole wall; seal the formation(s) to reduce fluid loss; cool and clean the drill bit; and lubricate the bit, bearings, drill pipe, and mud pump.
- **Drill string**—The complete mud-rotary drilling assembly under rotation including bit, sampler/core barrel, drill pipe, collars, stabilizers, and connector assemblies (subs). The total length of this assembly is used to determine drilling depth by referencing the position of the top of the string to a datum near the ground surface.
- **Hoisting line or Drilling line**—Wire rope used on the drawworks to hoist and lower the drill string.
- **Mast**—A load-bearing structure on a drilling rig used for supporting the crown block, top drive, pulldown chains, hoisting lines, and so forth. It must be constructed to safely carry the expected loads encountered in drilling and completion of wells of the diameter and depth for which the rig manufacturer specifies the equipment. To allow for contingencies, it is recommended that the rated capacity of the mast be at least twice the anticipated weight load or normal pulling load.
- **Mud Rotary Drilling**—A drilling technique that uses a water-based fluid, usually water with bentonite or a polymer additive, pumped down through the drill pipe and out through a rotating drill bit attached to the lower end of the drill string. This “mud” mixture cools the drill bit, jets cuttings away from the bit face, and flows upward in the annular space between the borehole and the drill pipe, carrying the cuttings in suspension to the surface.

  A similar drilling technique referred to as “reverse circulation mud rotary” involves circulating mud down the annular space of the borehole and back up through the bit inside the drill pipe. This technique is not specifically discussed in this SOP.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Geosciences Discipline Lead is responsible for the development, maintenance, and revision of this procedure. Any questions, comments, or suggestions regarding this technical SOP should be directed to the Geosciences Discipline Lead. The Geosciences Discipline Lead’s location and associated contact information can be found on the Shaw Group intranet site, ShawNet.

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5.2 Project Responsibility

Employees planning or supervising mud rotary drilling activities are responsible for meeting the requirements of this procedure. Employees conducting field technical review of mud rotary drilling activities are also responsible for following appropriate portions of this SOP. Project participants are responsible for recording information in sufficient detail to provide objective documentation (field notes, logs, forms, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURES (TECHNICAL REQUIREMENTS AND STANDARDS)

This section contains basic requirements and procedures for mud rotary drilling. The selection and implementation of mud rotary drilling techniques must incorporate knowledge of site-specific conditions and requirements. Consequently, the project-specific work plans should identify the following:

- The purpose of each borehole (e.g., monitoring well installation, geophysical logging, coring or soil sampling, etc.)
- Specific methodology for drilling, including equipment, mud type(s), and cuttings/fluid containment
- Specific locations, depths, and diameters of boreholes
- Type of sampling and/or logging of borehole to be conducted
- Details of mobilization/demobilization and decontamination of equipment
- Appropriate health and safety guidelines and personal protective equipment requirements
- Additional mud rotary drilling requirements or procedures beyond those covered in this SOP

6.1 Basic Equipment Requirements and Considerations

Basic equipment requirements and considerations are as follows:

- Mud rotary drill rigs should be of sufficient horsepower, torque, and hoisting capacity to drill boreholes of the anticipated diameter to anticipated maximum depths, as specified in the project work plans.
- Drill rigs should preferably be self-propelled or capable of accessing anticipated site field conditions.
- Mud pits should be of sufficient volume to allow for adequate circulation of the drilling fluids. Portable mud pits with a “U”-shaped arrangement or comprised of two separate tanks are preferred.
- The drilling fluid conveyance system from the mud pits to the drill pipe should be entirely enclosed and fluid-tight to minimize exposure of the drill crew to contaminated drilling mud.
- Return drilling mud should be conveyed from the borehole to a shaker by a method that is fluid-tight and does not allow cuttings to settle along the way. This shall be an entirely enclosed hose or pipeline.
- The shaker should be constructed and set up at each drilling site such that a field representative can easily reach across the top of the shaker screen to collect cuttings samples. The shaker screen should be of the correct type and mesh. Window screen is not acceptable.

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- Only preapproved additives may be used in the drilling mud. The additives must also meet regulatory requirements specific to the site and any other project-specific requirements.
- Only Teflon™-based thread compound may be used to lubricate drill pipe threads. No other compound may be used unless otherwise directed in the project work plans. Such directed use in the work plans should incorporate applicable regulatory agency requirements and/or approvals.
- Drill bit bearings, cones, rollers, and teeth should be in top operating condition. Proper types of bits, slips, collars, and subs are to be available at sizes needed to drill the desired diameters in the formation(s) to be encountered. A variety of different drill bits are available for mud rotary drilling. The type of bit used for a particular borehole depends upon the type of subsurface formation encountered. Button or cone-type drilling bits are typically used to drill through granular soils, including coarse gravels. Bladed “drag” or “fishtail”-type bits are commonly used to penetrate through clayey and silty soils. Some consolidated gravels and hard bedrock may require diamond bits or may be too dense for adequate penetration rates.
- Hydraulic and/or other fluid lines that can move or whip rapidly, in an unsafe manner, when under pressure or variations in pressure, should be restrained with appropriate safety lines or cables (e.g., whip checks).

6.2 Health and Safety Requirements

Prior to initiating drilling activities, applicable Shaw E & I and project-specific safety requirements must be reviewed by Shaw E & I site personnel and subcontractors. This review is conducted to familiarize these individuals with specific hazards associated with the site and drilling activities, as well as with health and safety procedures associated with the operation and maintenance of drilling equipment. Such information may be found in the project health and safety plan and other applicable Shaw E & I policies and procedures, such as HS316, *Drilling Operations*, and HS308, *Underground/Overhead Utility Contact Prevention*. Additional health and safety requirements include the following:

- Tailgate Safety Meetings should be held in the manner and frequency stated in the project health and safety plan. All Shaw E & I and subcontractor personnel at the site should have appropriate training and qualifications as specified in the project health and safety plan. Documentation should be kept readily available in the project files on site.
- During drilling, all personnel within the exclusion zone should pay close attention to all rig operations. Rapidly rotating drill tools can catch or snag loose clothing causing serious injury.
- Clear communication signals must be established with the drilling crew, since verbal communication may not be heard during the drilling process.
- The entire crew should be made aware to inform the rig geologist when any unforeseen hazard arises or when anyone is approaching the exclusion zone.

6.3 Drilling Site Mobilization

Basic site preparation and mobilization requirements and procedures are as follows:

- All drilling and sampling equipment should be decontaminated before drilling, in accordance with applicable Shaw E & I technical SOPs and/or project-specific requirements/procedures.
- The driller and the rig geologist should inspect the drilling equipment for proper maintenance and appropriate decontamination. All clutches, brakes, rotary tables, swivels, kellys, and drive heads should be in proper working order. All cables, hydraulic hoses, mud pumps, and shakers should be in good condition. All pipe joints and bits should be in good condition with no worn threads, cracked tool joint connections, or excessive wear, etc.

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- Any excessive leakage of fluids from the rig or fluid circulation system (e.g., portable mud pits, mud pumps, hoses, etc.) should be immediately repaired and the rig or circulation equipment decontaminated again before it is allowed to mobilize to the site.
- The logistics of drilling, logging, sampling, cuttings/fluid containment, and/or well construction should be determined before mobilizing. The site should be prepared as specified in the project work plans.
- Before mobilization, the Site Superintendent and the rig geologist should assess the drilling site. This assessment should identify potential hazards (e.g., slip/trip/fall, overhead, etc.), and determine how drilling operations may impact the environment (e.g., dust, debris, noise). Potential hazards should be evaluated and corrected, or the borehole location changed or shifted, in accordance with the project work plans.
- The Site Superintendent, or designee, should ensure that all identifiable underground utilities around the drilling location have been marked and the borehole location cleared in accordance with the project work plans. At a minimum, copies of the site clearance documents should be kept on site in a common accessible location.
- Once site preparation is completed, the rig is mobilized to the site and positioned over the identified borehole location. The rig should then be leveled with a set of hydraulic pads at the front and rear of the equipment. Once the rig is leveled, the mast should be raised slowly and carefully to prevent tipping or damaging the rig and to avoid hitting any obstructions or hazards.
- Appropriate barriers and markers should be in place prior to drilling, in accordance with the project health and safety plan. Visqueen (plastic) may be required beneath the rig and mud circulation system.
- Appropriate containment for fluids, cuttings, and other investigation-derived waste should be set up on site prior to drilling.

6.4 Basic Drilling Requirements and Procedures

Basic mud rotary drilling requirements and procedures are as follows:

- Immediately prior to drilling, all safety sampling and monitoring equipment will be appropriately calibrated in accordance with manufacturer's specifications and appropriate project-specific requirements/procedures. The rig geologist should inform the driller of the appropriate equipment (e.g., cookie cutter, etc.) to be used for penetrating the specific surface cover (e.g., asphalt, concrete cement, etc.) at the drilling location.
- The upper or "surface hole" portion (first 5 to 20 feet below ground surface) of a mud rotary borehole may be drilled with auger or rotary drilling methods in order to set a temporary conductor casing. The conductor casing is used to keep the upper portion of the hole open and to prevent drilling mud from channeling to the surface through shallow unconsolidated soils. The length of the conductor casing depends, in part, on the consolidation and permeability of the shallow subsurface soils. If geophysical logging is planned, the conductor pipe should only be as long as is necessary to keep the upper part of the hole open.
- In the event of breaking ground where a shallow subsurface hazard may exist (e.g., unidentifiable utility, trapped vapors, etc.), the driller should be informed of the potential hazard. Drilling of the surface hole should commence slowly to allow continuous visual inspection and, if necessary, probing. The shallow portion of the hole may be hand-excavated to the anticipated maximum depth of any suspected obstruction(s). Specific requirements for such subsurface hazard clearance should be described in the project work plans.

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- Once the surface hole is drilled to the necessary depth, the conductor casing is then set in the borehole. The drilling fluid or mud should then be "made up" in the mud pits. The drilling mud properties (as specified in the project work plans) should then be verified to the satisfaction of the rig geologist before allowing drilling to proceed. These observations should also be documented by the rig geologist on the appropriate forms. Mud rotary drilling of the borehole may then commence.

- During mud rotary drilling operations, as the borehole is advanced beyond the conductor casing, the rig geologist will generally do the following:

  – Observe and monitor rig operations

  – Conduct all health and safety monitoring and sampling, and supervise health and safety compliance

  – Prepare a lithologic log from cuttings, core, or soil samples in accordance with applicable Shaw E & I technical SOPs and project-specific requirements

  – Document drilling progress and other appropriate observations on the appropriate forms

  – Supervise the collection and preparation of any soil or rock samples

  – Supervise any borehole geophysical logging conducted in the borehole

  The field geologist should not leave the drill site while drilling operations are conducted and the borehole is being advanced.

- As drilling progresses, the rig geologist should observe and be in frequent communication with the driller regarding drilling operations. Conditions noted should include relative rates of penetration (as indicated by fast or slow drilling), rotation speeds, chattering and bucking of the rig, lost returns, lost circulation zones, hard or sticky drilling, drilling refusal, etc. These conditions, including penetration rates, should be recorded on the appropriate logs and forms as per applicable Shaw E & I technical SOPs and the project work plans. Drilling should not be allowed to progress faster than the rig geologist can adequately observe conditions, compile logs, and supervise safety and sampling activities.

  The rig geologist should also observe the make-up and tightening of connections as additional pipe joints are added to the drill string. Any observed drilling problems and causes, including significant down time, should be recorded on the appropriate forms.

  Cutting and fluid containment during drilling should be observed and supervised by the rig geologist in accordance with the project work plans. The mud circulation system should be inspected periodically for leaks.

- The rig geologist should continue to oversee or conduct appropriate health and safety sampling and monitoring during drilling. If any potentially unsafe conditions are evident from drilling observations or health and safety monitoring, the rig geologist may suspend drilling operations at any time and take appropriate actions as per the project health and safety plan. In the event of a suspension of drilling activities, the following actions shall be taken:

  – The Site Superintendent must be informed of the situation.

  – Appropriate corrective action must be implemented before drilling may continue.

  – The observed problem, suspension, and corrective action must be entered on the appropriate forms.

- During drilling, the rig geologist will compile a boring log in accordance with applicable Shaw E & I technical SOPs. The boring log should include the following information:

  – Borehole location

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- Name of the drilling company and driller
- Dates and times of drilling events, including when drilling began, the total depth and when it was reached, intermediate milestones (additional casing, geophysical logs etc.), and any changes in equipment (bits, drill pipe, tools, etc.)
- Available mud data including volume gains or losses, mud weight, viscosity, yield point, and additives
- Relative drilling rate(s) and presence of drill chatter (these parameters may confirm lithologic boundaries)
- Lithologic data and descriptions from cuttings, core, or soil samples including depths, frequency, and quality
- Sampling depths for core or soil samples
- Premature total depth due to refusal and the cause of refusal (if known)
- Any other observed drilling conditions such as lost circulation zones, zones of hard or soft drilling, dropping of the drill string, etc.

There is a certain “lag time” between when the formation is cut by the bit at the bottom of the borehole and when the associated cuttings are circulated through the mud column and discharged at the surface. Rig geologists preparing boring logs from the cuttings must know and account for this “lag time” in recording the depth from which the cuttings were generated. Those rig geologists needing help in evaluating lag times and logging mud rotary boreholes should seek a senior geologist with associated mud rotary logging experience.

- The rig geologist will also enter pertinent drilling information on the appropriate forms (in addition to the boring log), in accordance with the project work plans. The information to be recorded includes but is not limited to the following:
  - The dates and times of drilling events, including when drilling began, the total depth and when it was reached, intermediate milestones (additional casing, geophysical logs etc.), and any changes in equipment (e.g., bits, drill pipe, tools, etc.)
  - The dates, times, and causes of any significant down time
  - Premature total depth due to refusal and the cause of refusal
- Subsurface soil sampling with a drive sampler can be conducted at discrete intervals while drilling with mud rotary methods. However, driven samples typically require the removal of the drill pipe to advance the sampler beyond the bit. Because the sampler passes through a mud medium, this method is not usually recommended for sampling soil for analytical parameters. Drive sampling conducted during mud rotary drilling should follow requirements in applicable Shaw E & I technical SOPs and/or the project work plans. Soil vapor and groundwater (grab) samples are also generally not obtained during mud rotary drilling. Collection of rock core samples using conventional or wireline coring techniques may be conducted while drilling with mud rotary methods. Coring activities should follow requirements and specifications in applicable Shaw E & I technical SOPs and the project work plans.
- Borehole geophysical logs may be run at various depths or prior to completing a well. The rig geologist should note the type(s) of logs run, the logging conditions, the distribution of log copies and originals, and any observed problems on the appropriate forms. Oversight of geophysical logging activities should follow requirements in applicable Shaw E & I technical SOPs and the project work plans.

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- If the borehole is to be abandoned once drilling is completed, the abandonment should follow procedures outlined in applicable Shaw E & I technical SOPs and the project work plans. The abandonment will be supervised by the rig geologist.
- Mud rotary boreholes may be used for monitoring, extraction, or injection well installation. Installation and development of a well constructed through drilling mud requires more time and an experienced driller. A mud rotary drilled well will require significant time for development and possibly the use of chemicals to break down the drilling mud. If a monitoring, extraction, or injection well is to be installed in the borehole, the appropriate Shaw E & I technical SOPs and project-specific requirements/procedures should be followed. The well installation will be supervised by the rig geologist.

6.5 Demobilization

After drilling, sampling, and well installation or borehole abandonment is completed, the drill pipe and tools are laid down, the mast is lowered, and the rig is moved off of the location. Demobilization/site restoration will be supervised by the rig geologist or appropriate designee. Additional demobilization requirements/procedures are as follows:

- All debris generated by the drilling operation should be removed and appropriately disposed of.
- The site should be cleaned, the ground washed as necessary, and the site conditions restored as specified by the project work plans.
- All abandoned borings should be topped off and completed in accordance with the project work plans. All wells should also have their surface completions finished as specified by the project work plans.
- Any hazards remaining as a result of drilling activities should be identified and appropriate barriers and markers put in place, in accordance with the project health and safety plan.
- All soil cuttings and fluids should be properly contained, clearly labeled, and maintained in compliance with the project work plans and/or other applicable requirements.

6.6 Technical Review

All mud rotary drilling specifications, procedures, and results (e.g., reports, forms, etc.) should undergo technical review. It is recommended that the technical reviewer also provide review/oversight of the actual field implementation of mud rotary drilling activities. This may include aiding in troubleshooting drilling problems. The technical reviewer should be an experienced senior geologist or hydrogeologist. At a minimum, the technical reviewer should be a person capable of planning and supervising mud rotary drilling and associated sampling and well installation programs. Individuals needing assistance in finding qualified technical reviewers may consult internal Shaw technical listings for experts in drilling or mud rotary drilling.

Any issues raised during the technical review shall be resolved between the reviewer and the staff planning, conducting, or preparing results of mud rotary drilling activities as follows:

- Comments/issues raised relative to planning and developing detailed procedures for mud rotary drilling should be resolved before mobilization and drilling commences
- Comments/issues raised relative to results of drilling activities should be resolved before external (i.e., outside of Shaw E & I) use or submission of the results.

The technical review comments and issues, and corresponding resolution, shall be documented and filed with the project records. Such records should be maintained until project closeout.

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7. ATTACHMENTS

None

8. FORMS

None

9. RECORDS

- Project Specific Work Plan
- Tailgate Safety Meeting Records
- Site Clearance Documents
- Documentation of Drilling Progress
- Boring Log
- Technical review comments and issues, and corresponding resolution
- Drilling Specifications
- Procedures
- Results

10. REVISION HISTORY AND APPROVAL

Revision Level / Revision Date	Revision Description	Responsible Manager
00 08/07/2003	Initial Issue.	John E. Sciacca
01 03/01/2007	Changed from Standard to Procedure, procedure number changed from SOP-T-GS-018 to EI-GS018, edited ASTM reference numbers, replaced reference to the Insider with ShawNet in Section 5.1, revised Project Responsibility in Section 5.2, added reference to HS308 to Section 6.2	Gary Gaillot
02 01/02/2013	Modified format only to align with Governance Management framework.	Scott Logan

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1. PURPOSE

This procedure provides the standard practice for air rotary drilling. This procedure includes the minimum required steps and quality checks that employees and subcontractors are to follow when performing the subject task.

This procedure may also contain guidance for recommended or suggested practice that is based upon collective professional experience. Recommended practice goes beyond the minimum requirements of the procedure, and should be implemented when appropriate.

2. SCOPE

Geosciences Standard Operating Procedure (SOP) EID-GS-019 describes standards for air rotary drilling, and discusses how such drilling activities will be conducted for projects executed by Shaw Environmental & Infrastructure, Inc. (Shaw E & I). The SOP addresses technical requirements and required documentation. Responsibilities of individuals performing the work are also detailed. Additional project-specific requirements for air rotary drilling may be developed, as necessary, to supplement this procedure and to address project-specific conditions and/or objectives.

3. REFERENCES (STANDARD INDUSTRY PRACTICES)

Air rotary drilling should follow accepted industry practices. These industry practices are as presented in the latest version of the following ASTM Standards:

ASTM D 5782	Standard Guide for Use of Direct Air-Rotary Drilling for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
ASTM D 5872	Standard Guide for Use of Casing Advancement Drilling Methods for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices
ASTM D 6286	Standard Guide for Selection of Drilling Methods for Environmental Site Characterization

Additional reference materials that are useful for planning and conducting air rotary drilling activities include the following:

Aller, Linda, B.W. Truman, G. Hackett, R.J. Petty, J.H. Lehr, H. Sedoris, D.M. Nelson, J.E. Denne, 1989, *Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells*, National Water Well Association, Dublin, Ohio.

Driscoll, Fletcher G., 1995, *Groundwater and Wells*, Johnson Division, St. Paul, Minnesota.

Shuter, Eugene, W.E. Teasdale, 1989, "Application of Drilling, Coring and Sampling Techniques to Test Holes and Wells," *Techniques of Water Resource Investigations*, U.S. Geological Survey, Book 2 Chapter F1.

U.S. Environmental Protection Agency, 1986, RCRA *Ground-Water Monitoring Technical Enforcement Guidance Document*, OSWER-9950.1.

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4. DEFINITIONS

The following definitions are applicable to air rotary drilling and this SOP.

- **Air Rotary Drilling**—Any method of drilling that employs a rotating drill pipe and bit to advance the borehole and uses air as a circulating medium. Air is forced down through the center of the drill pipe, out through the bit at the bottom of the borehole, and then upward in the annular space between the borehole wall and drill pipe. The upward return stream removes cuttings from the bottom of the borehole.

- **Air Rotary Casing Hammer Drilling**—This drilling method is similar to the air rotary method in that it uses an air rotary drill string (drill pipe and bit) contained inside a slightly larger diameter drive casing. The drive casing is a heavy-walled, threaded pipe that allows for pass-through of the rotary drill bit inside the center of the casing. The drive casing is used to maintain borehole stability, to temporarily isolate multiple contaminated zones, and to reduce lost circulation of the subsurface air stream.

  This method is highly useful in drilling coarse unconsolidated sediment and soils. Consequently, it is used more commonly in environmental projects than the air rotary method above. The method is also commonly used to install monitoring wells, as it provides good depth control, and the drive casing can be progressively pulled as well construction materials are placed in the borehole.

- **Cleanout depth**—The depth to which the end of the drill string (bit or core barrel cutting end) has reached after an interval of cutting. The cleanout depth (or drilled depth as it is referred to after clean-out of any sloughed material in the bottom of the borehole) is usually recorded to the nearest 0.1 feet (0.03 m).

- **Drawworks**—A power-driven winch, or several winches, usually equipped with a clutch and brake system(s) for hoisting or lowering a drill string.

- **Drill hole, Boring, or Borehole**—A cylindrical hole advanced into the subsurface by mechanical means (e.g., drilling).

- **Drill string**—The complete direct air-rotary drilling assembly under rotation including bit, sampler/core barrel, drill pipe, collars, stabilizers, and connector assemblies (subs). The total length of this assembly is used to determine drilling depth by referencing the position of the top of the string to a datum near the ground surface.

- **Hoisting line or Drilling line**—Wire rope used on the drawworks to hoist and lower the drill string.

- **Mast**—A load-bearing structure on a drilling rig used for supporting the crown block, top drive, pulldown chains, hoisting lines, and so forth. It must be constructed to safely carry the expected loads encountered in drilling and completion of wells of the diameter and depth for which the rig manufacturer specifies the equipment. To allow for contingencies, it is recommended that the rated capacity of the mast be at least twice the anticipated weight load or normal pulling load.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Geosciences Discipline Lead is responsible for the development, maintenance, and revision of this procedure. Any questions, comments, or suggestions regarding this technical SOP should be directed to the Geosciences Discipline Lead. The Geosciences Discipline Lead's location and associated contact information can be found on the Shaw Group intranet site, ShawNet.

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5.2 Project Responsibility

Employees planning or supervising air rotary drilling activities are responsible for meeting the requirements of this procedure. Employees conducting technical review of air rotary drilling activities are also responsible for following appropriate portions of this SOP. Project participants are responsible for recording information in sufficient detail to provide objective documentation (field notes, logs, forms, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURES (TECHNICAL REQUIREMENTS AND STANDARDS)

Air rotary drilling is generally limited in environmental projects to drilling in hard consolidated rock for coring and installing wells. It may at times be used to drill consolidated sediment or soil. Air rotary drilling achieves some of the fastest penetration rates, compared to other drilling methods, in hard rock formations.

Air rotary drilling commonly has problems in drilling loose unconsolidated coarse sediment or soil. The air does not provide sufficient density or viscosity to keep the borehole open while drilling through these deposits and the borehole collapses, binding the bit in the hole. In addition the air circulation is lost through invasion into coarse permeable beds.

Foam additives have been developed to combat these problems but are generally not allowed by regulatory agencies for use on environmental projects. The air rotary casing hammer drilling method was developed to address these problems and is covered below.

A variety of drilling bits may be used to penetrate various formations encountered. Cone-type bits and down-hole hammers with button bits are typically used to drill through consolidated rock and granular soils. Drag (fishtail)-type bits are commonly used to progress through clayey and silty soils.

Cuttings produced by this method are typically disaggregated, making bedding and fabric determination difficult at best. Soil samples can be obtained from the bottom of the hole; however, this typically requires removing (“tripping”) the entire drill string.

Additional considerations in using air rotary drilling techniques include the potential for pushing vapor-phase contaminants into the surrounding soil/rock matrix and for flushing samples with air, and introducing the possibility of vapors exiting the borehole.

6.1 Air Rotary Casing Hammer Drilling

This section contains basic requirements and procedures for air rotary casing hammer drilling. Air rotary casing hammer method is more commonly used for environmental projects than air rotary alone. Consequently, the remainder of this document covers air rotary casing hammer drilling. The procedures and requirements for air rotary drilling would essentially be similar to those outlined for the air rotary casing hammer technique.

For the air rotary casing hammer method of drilling, the hole is deepened with the air rotary drill string. The drive casing is advanced simultaneously with the air rotary bit, using a rig-mounted hydraulic or air hammer. The drive casing is not rotated.

Air is forced down through the center drill pipe to the bit, and then upward through the space between the drive casing and the drill pipe. The upward return stream removes cuttings from the bottom of the borehole.

Cuttings produced by this method are typically disaggregated, like with the air rotary method above. Soil samples can be obtained from the bottom of the hole; however, this typically requires removing the entire inner rotary drill string for each sample run.

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The selection and implementation of air rotary casing hammer drilling techniques must incorporate knowledge of site-specific conditions and requirements. Consequently, the project-specific work plans should identify the following:

- The purpose of each borehole (e.g., to install a monitoring well, to collect soil samples, to conduct soil vapor sampling, etc.)
- The specific methodology for drilling, including equipment to be utilized and cuttings/fluid containment requirements
- Specific locations, depths, and diameters of boreholes
- The type of sampling and/or logging of boreholes to be conducted
- Details of mobilization/demobilization and decontamination of equipment
- Appropriate health and safety guidelines and personal protective equipment requirements
- Additional procedures or requirements beyond those covered in this SOP

6.2 Basic Equipment Requirements and Considerations

Basic equipment requirements and considerations include the following:

- Drill rigs should be of sufficient horsepower, torque, and hoisting capacity to drill boreholes of the anticipated diameter to anticipated maximum depths, as specified in the project work plans. Each rig should be equipped with a water injection pump.
- Drill rigs should preferably be self-propelled or capable of accessing anticipated site field conditions.
- Rigs used for air rotary casing hammer drilling should have the hammer handling system integrally built into the mast assembly. Retrofitted drilling rigs without a swing-out, independently-operated drive hammer should not be used. A rig which requires personnel to climb onto the mast to attach or detach the hammer is unacceptable for safety reasons.
- The casing hammer should be a drill-through, pneumatic type (suggested minimum rated energy force of 7,200 foot pounds). The casing hammer should have a rotary drilling rod packing assembly to pressurize the system for an air- and water-tight seal, ensuring that all cuttings, water, and air are discharged through the hammer exit spout to an attached removable discharge hose and cyclone.
- The removable discharge hose should be of sufficient size and length to reach the cyclone when the hammer is raised to the top of the mast. The hose shall be properly anchored and attached to a cyclone that effectively decelerates cuttings from the air stream. The cyclone must be positioned such that the rig geologist or other site personnel can easily collect samples of cuttings as they drop out of the bottom.
- Hydraulic and/or other fluid (air) lines and hoses that can move or whip rapidly in an unsafe manner, when under pressure or variations in pressure, should be restrained with appropriate safety lines or cables (e.g., whip checks).
- An air compressor or combination of compressors must be made available and should meet minimum discharge requirements at specified pressures. An example discharge/pressure combination for 300 foot borings through interbedded cobble and silt strata is 750 cfm at 250 psi. In-line filters must be installed in the air stream from the compressor(s) for reducing oil content. The filters will be inspected and changed on a regular basis to prevent the passage of oil into the subsurface.

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- Drive casings should have a required minimum tensile strength (e.g., 100,000 psi) and have external and internal flush threads on each pin and box for connecting. The use of rope thread drive casing with dissimilar metal threaded end pieces attached to mild steel casing bodies should not be allowed. The drive casing shall have uniform wall thickness, tensile strength, and treaded ends machined directly to the casing. A hardened drive shoe with the same internal and external dimensions as the drive casing will be threaded to the bottom of the first joint of the drive casing.

- Drive casings of various lengths should be provided by the subcontractor to facilitate emplacement of sand pack, bentonite seal, and grout. One 3-foot, two 5-foot, and two 10-foot lengths, in addition to a sufficient number of standard length drive casing joints, are recommended for each rig.

- A hydraulic casing extractor must be used to remove the drive casing from the borehole. Extraction of the casing by “hammering-up” with the casing hammer must not be allowed. The hydraulic casing extractor should have a required minimum pulling capacity (e.g., 250 tons) and be constructed as a single unit with hydraulic cylinders, pulling arms, base plate, valves, hoses, slips and spiders, safety bypass valves, back-up wrench, and break-out tongs. The slips and spiders should be of sufficient size to grip the outside of the drive casing and withstand the lifting force (i.e., the pulling capacity of the casing extractor).

- Only Teflon™-based thread compound may be used to lubricate drill pipe threads. No other compound may be used unless otherwise directed in the project work plans. Such directed use in the project work plans should take into account applicable regulatory agency requirements and/or approval.

- Drill bit bearings, cones, rollers, and teeth should be in top operating condition. Proper types of bits, slips, collars, and subs are to be available at sizes needed to drill the desired diameters in the formation(s) to be encountered.

- During drilling, no foam or other drilling additives (except water) may be added to the circulating air (fluid) stream without securing appropriate regulatory approval and/or meeting project-specific requirements.

- The air rotary casing hammer method is also used to drill through consolidated rock and large boulder beds. For these types of formations, an eccentric underreaming bit assembly (such as the ODEX™ or STRATEX™ systems) is attached to the inner rotary drill string. The eccentric underreamer drills a slightly larger diameter borehole than the drive casing. This allows the casing to be advanced while drilling through boulders and bedrock.

6.3 Health and Safety Requirements

Prior to initiating drilling activities, applicable Shaw E & I and project-specific safety requirements must be reviewed by Shaw E & I site personnel and subcontractors. This review is conducted to familiarize these individuals with specific hazards associated with the site and drilling activities, as well as with health and safety procedures associated with the operation and maintenance of drilling equipment. Such information may be found in the project health and safety plan and other applicable Shaw E & I policies and procedures, including HS316, *Drill Rig Operations*, and HS308, *Underground/Overhead Utility Contact Prevention*. Additional health and safety requirements include the following:

- Tailgate Safety Meetings should be held in the manner and frequency stated in the project health and safety plan. All Shaw E & I and subcontractor personnel at the site should have appropriate training and qualifications as specified by the project health and safety plan. Documentation should be kept readily available in the project files on site.

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- During drilling, all personnel within the exclusion zone should pay close attention to all rig operations. Rapidly rotating drill tools can catch or snag loose clothing, causing serious injury.
- Clear communication signals must be established with the drilling crew since verbal communication may not be heard during the drilling process.
- The entire crew should be made aware to inform the rig geologist when any unforeseen hazard arises or when anyone is approaching the exclusion zone.

6.4 Drilling Site Mobilization

Basic site preparation and mobilization requirements and procedures are as follows:

- All drilling and sampling equipment should be decontaminated before drilling in accordance with applicable Shaw E & I technical SOPs and/or project-specific requirements/procedures.
- The driller and the rig geologist should inspect the drilling equipment for proper maintenance and appropriate decontamination. All clutches, brakes, rotary tables, swivels, kellys, and drive heads should be in proper working order. All cables and hydraulic hoses should be in good condition. All pipe joints and bits should be in good condition with no worn threads, cracked tool joint connections, or excessive wear, etc.
- Any excessive leakage of fluids from the rig or fluid circulation system (e.g., portable mud pits, mud pumps, hoses, etc.) should be immediately repaired and the rig or circulation equipment decontaminated again before it is allowed to mobilize to the site.
- The logistics of drilling, logging, sampling, cuttings/fluid containment, and/or well construction should be determined before mobilizing. The site should be prepared as specified by the project work plans.
- Before mobilization, the Site Superintendent and the rig geologist should assess the drilling site. This assessment should identify potential hazards (e.g., slip/trip/fall, overhead, etc.), and determine how drilling operations may impact the environment (e.g., dust, debris, noise). Potential hazards should be evaluated and corrected, or the borehole location changed or shifted, in accordance with the project work plans.
- The Site Superintendent, or designee, should ensure that all identifiable underground utilities around the drilling location have been marked and the borehole location cleared in accordance with the project work plans. At a minimum, copies of the site clearance documents should be kept on site in a common accessible location.
- Once site preparation is completed, the rig is mobilized to the site and positioned over the identified borehole location. The rig should then be leveled with a set of hydraulic pads at the front and rear of the equipment. Once the rig is leveled, the mast should be raised slowly and carefully to prevent tipping or damaging the rig and to avoid hitting any obstructions or hazards.
- Appropriate barriers and markers should be in place prior to drilling, in accordance with the project health and safety plan. Visqueen (plastic) may be required beneath the rig and mud circulation system.
- Appropriate fluids, cuttings, and other investigation-derived waste containment should be set up on site prior to drilling.

6.5 Basic Drilling Requirements and Procedures

Basic air rotary and air rotary casing hammer drilling requirements and procedures are as follows:

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- Immediately prior to drilling, all safety sampling and monitoring equipment will be calibrated according to manufacturer's specifications and appropriate project-specific requirements/ procedures. The rig geologist should inform the driller of the appropriate equipment (e.g., cookie cutter, etc.) to be used for penetrating the specific surface cover (e.g., asphalt, concrete cement, etc.) at the drilling location.

- The upper or "surface hole" portion (first 5 to 20 feet below ground surface) of an air rotary borehole may be drilled with auger or air rotary drilling methods in order to set a temporary conductor casing. The conductor casing is used to keep the upper portion of the hole open and to prevent drilling fluids from channeling to the surface through shallow unconsolidated soils. The length of the conductor casing depends, in part, on the consolidation and permeability of the shallow subsurface soils. If geophysical logging is planned, the conductor pipe should only be as long as is necessary to keep the upper part of the hole open.

- In the event of breaking ground where a shallow subsurface hazard may exist (e.g., unidentifiable utility, trapped vapors, etc.), the driller should be informed of the potential hazard. Drilling of the surface hole should commence slowly to allow continuous visual inspection and, if necessary, probing. The shallow portion of the hole may be hand excavated to the anticipated maximum depth of any suspected obstructions. Specific requirements for such subsurface hazard clearance should be contained in the project work plans.

- Once the surface hole is drilled to the necessary depth, and the conductor casing set in the borehole, the air rotary or air rotary casing hammer drilling of the borehole may commence.

- During air rotary or air rotary casing hammer drilling operations, as the borehole is advanced beyond the conductor casing, the rig geologist will generally do the following:

  – Observe and monitor rig operations

  – Conduct all health and safety monitoring and sampling, and supervise health and safety compliance

  – Prepare a boring log from cuttings, core, or soil samples in accordance with applicable Shaw E & I technical SOPs and project-specific requirements

  – Document drilling progress and other appropriate observations on appropriate forms

  – Supervise the collection and preparation of any soil, soil vapor, or groundwater samples

  – Supervise any borehole geophysical logging conducted in the borehole

  The field geologist should not leave the drill site while drilling operations are conducted and the borehole is being advanced.

- As drilling progresses, the rig geologist should observe and be in frequent communication with the driller regarding drilling operations. Conditions noted should include relative rates of penetration (as indicated by fast or slow drilling), rotation speeds, chattering and bucking of the rig, lost returns, lost circulation zones, hard or sticky drilling, drilling refusal, etc. These conditions, including penetration rates, should be recorded on the appropriate logs and forms as per applicable Shaw E & I technical SOPs and/or the project work plans. Drilling should not be allowed to progress faster than the rig geologist can adequately observe conditions, compile logs, and supervise safety and sampling activities.

  The rig geologist should also observe the make-up and tightening of connections as additional pipe joints are added to the drill string. Any observed drilling problems and causes, including significant down time, should be recorded on the appropriate forms.

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Cutting and fluid containment during drilling should be observed and supervised by the rig geologist in accordance with the project work plans. The air/water circulation system should be inspected periodically for leaks.

The rig geologist should continue to oversee or conduct appropriate health and safety sampling and monitoring during drilling. If any potentially unsafe conditions are evident from drilling observations or health and safety monitoring, the rig geologist may suspend drilling operations at any time and take appropriate actions in accordance with the project health and safety plan. In the event of a suspension of drilling activities, the following actions shall be taken:

- The Site Superintendent must be informed of the situation.
- Appropriate corrective action must be implemented before drilling may continue.
- The observed problem, suspension, and corrective action must be entered on the appropriate forms

- During drilling, the rig geologist will compile a boring log as per applicable Shaw E & I technical SOPs. The boring log should include the following information:
  - Borehole location
  - Name of the drilling company and driller
  - Dates and times of drilling events, including when drilling began, the total depth and when it was reached, intermediate milestones (additional casing, geophysical logs etc.), and any changes in equipment (bits, drill pipe, tools etc.)
  - Relative drilling rate(s) and presence of drill chatter (these parameters may aid in confirming lithologic boundaries)
  - Lithologic data and descriptions from cuttings, core, or soil samples including depths, frequency, and quality
  - Sampling depths and recovery for core or soil samples
  - Premature total depth due to refusal and the cause of refusal (if known)
  - Any other observed drilling conditions such as lost circulation zones, zones of hard or soft drilling, etc.
- The rig geologist will also enter pertinent information on the appropriate forms (in addition to the boring log) in accordance with the project work plans. The information to be recorded includes but is not limited to the following:
  - The dates and times of drilling events including when drilling began, the total depth and when it was reached, intermediate milestones (additional casing, geophysical logs etc.), and any changes in equipment (e.g., bits, drill pipe, tools, etc.)
  - The dates, times, and causes of any significant down time
  - Premature total depth due to refusal and the cause of refusal
- Subsurface soil sampling with a drive sampler can be conducted at discrete intervals while drilling with air rotary or air rotary casing hammer methods. However, driven samples typically require the removal of the drill pipe to advance the sampler beyond the bit. Drive sampling conducted during air rotary or air rotary casing hammer drilling should follow requirements in appropriate Shaw E & I technical SOPs and/or the project work plans.

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- Borehole geophysical logs may be run at various depths or prior to completing a well. The geophysical logging should be conducted as per applicable Shaw E & I technical SOPs and the project work plans. The rig geologist should note the type(s) of logs run, logging conditions, distribution of log copies and originals, and any observed problems on the appropriate forms.
- If the borehole is to be abandoned once drilling is completed, the abandonment should follow procedures outlined in applicable Shaw E & I technical SOPs and the project work plans. The abandonment will be supervised by the rig geologist.
- Air rotary or air rotary casing hammer boreholes may be used for monitoring, extraction, or injection well installation. If a monitoring, extraction, or injection well is to be installed in the borehole, installation should follow appropriate Shaw E & I technical SOPs and project-specific requirements/procedures. The well installation will be supervised by the rig geologist.

6.6 Demobilization

After drilling, sampling, and well installation or borehole abandonment is completed, the drill pipe and tools are laid down, the mast is lowered, and the rig is moved off of the location. Demobilization/site restoration will be supervised by the rig geologist or appropriate designee. Additional demobilization requirements/procedures are as follows:

- All debris generated by the drilling operation should be removed and appropriately disposed of.
- The site should be cleaned, the ground washed as necessary, and the site conditions restored as per the project work plans.
- All abandoned borings should be topped off and completed as per the project work plans. All wells should also have their surface completions finished as per the project work plans.
- Any hazards remaining as a result of drilling activities should be identified, and appropriate barriers and markers should be put in place, as per the project health and safety plan.
- All soil cuttings and fluids should be properly contained, clearly labeled, and maintained in compliance with the project work plans and/or other applicable requirements.

6.7 Technical Review

All air rotary drilling specifications, procedures, and results (e.g., reports, forms, etc.) should undergo technical review. It is recommended that the technical reviewer also provide review/oversight of the actual field implementation of the air rotary drilling activities. This may include aiding in troubleshooting drilling problems. The technical reviewer should be an experienced senior geologist or hydrogeologist. At a minimum, the technical reviewer should be a person capable of planning and supervising air rotary drilling and associated sampling and well installation programs. Individuals needing assistance in finding qualified technical reviewers may consult internal Shaw technical listings for experts in drilling or air rotary drilling.

Any issues raised during the technical review shall be resolved between the reviewer and the staff planning, conducting, or preparing results of air rotary drilling activities, as follows:

- Comments/issues raised relative to planning and developing detailed procedures for air rotary drilling should be resolved before mobilization and drilling commences
- Comments/issues raised relative to results of drilling activities should be resolved before external (i.e., outside of Shaw E & I) use or submission of the results.

The technical review comments and issues, and corresponding resolution, shall be documented and filed with the project records. Such records should be maintained until project closeout.

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7. ATTACHMENTS

None

8. FORMS

None

9. RECORDS

- Project Specific Work Plan
- Tailgate Safety Meeting Records
- Site Clearance Documents
- Boring Log
- Documentation of drilling progress
- Technical review comments and issues, and corresponding resolution

10. REVISION HISTORY AND APPROVAL

Revision Level / Revision Date	Revision Description	Responsible Manager
00	Initial Issue.	John E. Sciacca
01 03/01/2007	Changed from Standard to procedure, procedure number changed from SOP-T-GS-019 to EI-GS019, Edited ASTM reference numbers, updated reference book in section 3, edited definition for Air Rotary Drilling, shortened definition and moved test to Section 6 Procedures (Technical Requirements and Standards), edited definition for Air Rotary Case Hammer Drilling, shortened definition, moved text to new section 6.1 Air rotary Case Hammer Drilling, replaced reference to the Insider with ShawNet in Section 5.1, revised project responsibility in section 5.2, additional requirement added in section 6.2, added reference to HS308 in section 6.2	Gary Gaillot
02 01/02/2013	Modified format only to align with Governance Management framework.	Scott Logan

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1. PURPOSE

This procedure provides the standard practice for direct push drilling and soil sampling. The procedure provides the minimum required steps and quality checks that employees and subcontractors are to follow when performing the subject task.

This procedure may also contain guidance for recommended or suggested practice that is based upon collective professional experience. Recommended or suggested practice goes beyond the minimum requirements of the procedure and should be implemented when appropriate.

2. SCOPE AND RELATED STANDARDS

Geosciences Standard Operating Procedure (SOP) EID-GS-021 describes standards for direct push drilling and soil sampling, and discusses how such drilling and sampling will be conducted and documented for projects executed by Shaw Environmental & Infrastructure Inc. (Shaw E & I). Responsibilities of individuals performing the work are also detailed. Additional project-specific requirements for direct push drilling and soil sampling may be developed, as necessary, to supplement this procedure and to address project-specific conditions and/or objectives.

This SOP covers requirements for collection of soil and unconsolidated materials by direct push methods primarily for laboratory or other testing and for lithologic description or analysis (logging). It describes basic equipment and procedures and addresses aspects of the process where quality must be maintained. It does not address procedures for specific brands of equipment, or for uncommon purposes of boring or sampling. Other types of soil and rock sampling while drilling are addressed in other Shaw E & I technical SOPs.

3. REFERENCES (STANDARD INDUSTRY PRACTICES)

The methodology for direct push drilling and soil sampling should follow industry standard practices. The latest revision of the following references are relevant and useful for planning and conducting direct push drilling and soil sampling:

ASTM D 6282	Direct Push Soil Sampling for Environmental Site Characterizations
ASTM D 6286	Standard Guide for Selection of Drilling Methods for Environmental Site Characterization

4. DEFINITIONS

The following definitions are applicable to direct push drilling and soil sampling and this SOP.

- **Direct push drilling**—The creation of a boring by the displacement of soil without cutting or grinding and without the production of mechanically-altered soil (cuttings) at the ground surface. In direct push drilling, soil is displaced, primarily laterally, as a pipe or rod is forced vertically downward, creating a cylindrical space (i.e. a boring). Energy to create the boring may be generated from constant pressure (e.g., hydraulically-powered), vibration, or other means.

- **Slough**—Slough is soil or other earth material that has been dislodged from its original location within the boring and displaced elsewhere within the boring (usually to the bottom). The creation and sampling of slough should be avoided, because slough has disturbed

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properties and is typically of uncertain origin with respect to depth. The presence of slough also impedes proper abandonment of borings.

- **Conductor Casing**—Conductor casing is drill pipe that is extended down into the ground as a boring is advanced, to prevent sidewall material from falling into the borehole and covering the in-place soil material that constitutes the bottom of the boring. Conductor casing is usually removed when a borehole is being abandoned.
- **Sample**—A mass of soil or earthen material that has been removed from the boring from a known depth, has had little internal disturbance, and may be considered representative of the in-situ earthen material from a known depth and representative with respect to the intended tests or properties of interest.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Geosciences Discipline Lead is responsible for the development, maintenance, and revision of this procedure. Any questions, comments, or suggestions regarding this technical SOP should be directed to the Geosciences Discipline Lead. The Geosciences Discipline Lead's location and associated contact information can be found on the Shaw Group intranet site, ShawNet.

5.2 Project Responsibility

Employees planning or conducting direct push drilling and soil sampling, or any portion thereof, are responsible for meeting the requirements of this procedure. Employees conducting technical review or oversight of direct push drilling and soil sampling are also responsible for following appropriate portions of this SOP. Project participants are responsible for recording information in sufficient detail to provide objective documentation (field notes, logs, forms, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURES (TECHNICAL REQUIREMENTS)

This section addresses basic requirements and procedures involved with direct push drilling and soil sampling. This section includes information on selection of methods and equipment, planning and preparation requirements, health and safety requirements, drilling and sampling procedures, and key practices for ensuring quality.

Proper drilling and subsurface soil sampling procedures are necessary to ensure the quality and integrity of the samples. The details within this SOP should be used in conjunction with project-specific work plans. The project work plans should generally provide the following information:

- Specific direct push drilling and soil sampling methodologies and equipment to be employed
- Sample collection objectives
- Anticipated locations and total depths of soil borings and target horizons or depths of soil samples to be collected
- Numbers and volumes of samples to be collected
- Types of chemical analyses to be conducted for the samples
- Specific quality control (QC) procedures and sampling requirements
- Detailed direct push drilling and subsurface soil sampling requirements or procedures based upon site-specific conditions and project-specific objectives/requirements

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6.1 Selection of Methods and Equipment

The practice of direct push drilling and soil sampling involves numerous variations in methodology and types of equipment. There are few industry-wide standards for direct push drilling and soil boring. Key aspects of the variations in direct push drilling and sampling are as follows:

- **The use of single-wall or dual-wall sampling systems**. Single-wall systems generally provide lower-quality sampling and higher rates of production than dual-wall systems. Single-wall systems can typically be advanced with lower energy sources (i.e., to greater depth) than dual-wall systems because they have smaller area and hence encounter less sidewall friction and tip resistance during advance.
- **Open-hole or cased boring**. This SOP recommends that borings always be advanced through or with a conductor casing.
- **Open-barrel or closed (sealed)-barrel sampler**. Open-barrel samplers are open at the bottom at all times, and may fill with slough, lose sample material as they are retrieved, or contribute to or be subject to cross-contamination. Closed-barrel samplers are closed at the bottom until being mechanically opened at a target depth. Closed-barrel samplers reduce the potential for sampling of slough or cross-contamination of the sample.
- **Liner or inner-barrel material**. Inner barrel/sampler tubes should be selected based on the need to see or access samples for lithologic evaluation and the need to perform chemical or other analytical testing. Use of lexan or other see-through materials can be beneficial in identifying soil type or visual indications of contamination (such as petroleum saturation). Some liners, such as lexan, can be quickly cut to select certain sample intervals for testing, and the sample may be retained, shipped, and stored directly in the liner. Liners or sample barrel material should generally not be made of materials that include any of the chemical species that are sought during analysis.
- **Energy source for making the boring**. Energy sources may be static or dynamic, and may include vibratory or sonic systems, hydraulic systems, percussion (hammer) systems, or even rotational systems.
- **Energy source for removing the sampler**. Energy sources may be static or dynamic, and are generally one of the following: hydraulically-lifted rod systems, winch and wire rope systems, or percussive systems (backpounding). This SOP recommends against backpounding as a means of removing samplers, as it tends to disturb samples.
- **Use of checkball or open-top tubes for collection of soil**. Checkball systems prevent fluids that are within the sampling barrel, above the sample, from flowing down into the barrel as the sampler is retrieved. Checkball systems are mostly used when sampling granular soils beneath the water table, to minimize the potential for water to dislodge or alter sample material as the barrel is retrieved.
- **Use of catchers or retainers**. Catchers are used to help retain loose soils within the sampling barrel as it is retrieved. Catchers are most commonly used when sampling granular soils beneath the water table, with variable success.

6.2 Planning and Preparation

Planning for direct push drilling and soil sampling activities involves the following:

- Identifying drilling and sample collection objectives and exact methodologies and equipment to be used for sample collection

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- Identifying specific drilling and sampling locations, targeted depths, and specific identification numbers of soil samples to be collected
- Identifying numbers and volumes of samples to be collected
- Specifying types of chemical analyses to be conducted for the samples
- Listing specific quality control (QC) procedures and sampling requirements
- Describing any detailed project-specific sampling requirements or procedures beyond those covered in this SOP, as necessary
- Listing expected soil types, hydrostratigraphy, and/or formations to be encountered (if known)
- Identifying and listing all pertinent health and safety issues and requirements, including those contained in the project-specific health and safety plan(s), relative to work activities (including site utility clearance)
- Compiling main subcontractor requirements for direct push drilling and soil sampling and generating the statement of work to procure subcontractor services

All of the above information and items should be compiled as part of a sampling plan contained within the project work plans. This plan includes detailed, project-specific direct push drilling and soil sampling procedures beyond the basic procedures and requirements in this SOP.

Preparation for direct push drilling and soil sampling activities includes the following:

- Securing all necessary site access, permitting, and plan approvals
- Procuring the appropriate direct push drilling and sampling subcontractor
- Completing all necessary underground utility clearance activities at each of the sampling locations; each location should be cleared according to requirements in appropriate Shaw E & I technical SOPs and the project work plans.
- Briefing the rig geologist, subcontractor personnel, and other site personnel on specific information necessary for effective implementation of the sampling effort (e.g., sampling objectives, locations and depths, project-specific sampling requirements and procedures, pertinent health and safety requirements, etc.)
- Verifying that job personnel have proper health and safety training

The Project Manager, or designee, is responsible for appropriately briefing field personnel, as described above.

6.3 Health and Safety Requirements

Prior to initiating drilling and sampling activities, applicable Shaw E & I and project-specific safety requirements must be reviewed by Shaw E & I site personnel and subcontractors. This review is conducted to familiarize these individuals with specific hazards associated with the site and drilling activities, as well as with health and safety procedures associated with the operation and maintenance of drilling equipment. Such information may be found in the project health and safety plan and other applicable Shaw E & I policies and procedures, such as HS316, *Drilling Operations*, and HS-308, *Underground/Overhead Utility Contact Prevention*. Additional health and safety requirements include the following:

- Tailgate Safety Meetings should be held in the manner and frequency stated in the project health and safety plan. All Shaw E & I and subcontractor personnel at the site should have

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appropriate training and qualifications as specified by the project health and safety plan. Documentation should be kept readily available in the project files on site.

- During drilling, all personnel within the exclusion zone should pay close attention to all rig operations. Pushed or driven drill tools can catch or snag loose clothing, causing serious injury.
- Clear communication signals must be established with the drilling crew, since verbal communication may not be heard during the drilling process.
- The entire crew should be made aware to inform the rig geologist when any unforeseen hazard arises or when anyone is approaching the exclusion zone.

6.4 Drilling and Sampling Requirements/Procedures

This SOP cannot present a single, detailed and specific procedure that is applicable to all methods and equipment that are available (Section 6.1) or to the specific sampling objectives of a specific project. An example procedure for direct push drilling and soil sample collection is shown in Attachment 1. The example procedure may be supplemented or customized to provide project-specific requirements and procedures.

Sample quality is easily compromised by poorly selected samples or haphazard drilling and sampling technique. Common problems and suggested solutions include the following:

- Generation of excess slough. Excess sloughing occurs when conductor casing is not used, when soil materials fall out of the sample barrel as it is retrieved, and when soil at or near the ground surface falls into the boring. Slough is excess when the amount that is present hinders the collection of sufficient representative sample volume or mass for the required testing or lithologic analysis.
- Collection of slough for testing or logging. This occurs when a large volume of slough is present in the boring bottom at the time the sampler is emplaced and driven into soil. Because slough is disturbed and from unknown depth, it is unsuitable for logging or testing.
- Disturbance (negatively-biasing) of samples for analysis of Volatile Organic Compounds (VOCs). The act of driving a sampling tube into soil causes compression and some heating of the soil, and can create macroscopic void space, i.e., a microannulus between the soil and sampling tube. Heating, compression of soil, and creation of void space contribute to the migration of gaseous fluids as well as the partitioning of VOCs, such as gasoline or solvent vapors. Although some heating, compression, and formation of microannular space are unavoidable, care should be taken to minimize these phenomena to the extent that is reasonably possible. Some sampling devices and methods are more suitable for analysis of samples for VOCs than others.
- Improper abandonment of borings. Excess slough or caving (the dislodgement and falling of a significant volume of sidewall material) hinders the proper abandonment of a boring. Where this occurs, the borehole should be cleaned out prior to grouting. A tremmie pipe should be used to conduct grout to the bottom of the borehole if a conductor casing is not in place prior to and during grouting.

Additional key practices that will ensure the quality of the samples collected and proper/efficient abandonment of the borings, include the following:

- Drill with a Conductor Casing. Various equipment, systems, and methods exist for direct push drilling and soil sampling. Some systems are open-hole (i.e., do not use conductor casing), hence borings made with these systems are at high risk for slough-related difficulties in logging, sampling, and abandonment. Most systems have provisions for driving down a

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conductor casing, to keep the boring open and relatively free of slough when the sampler or a plug or drive-point is not present at the bottom of the casing system. This SOP recommends the use of a method of direct push drilling that integrally includes the advancement of conductor casing as the boring is made, and further recommends that the conductor casing remain in place during sampling and into the abandonment process.

- Measure the Boring Depth. A weighted tape should be used to verify the depth of the boring within the conductor casing. Measurement should be made with reference to the ground surface. It is important to measure depth at the start of sampling intervals and at total depth (TD) of the boring.
- Clean-Out Excessive Slough. If slough is present, it should be removed by forcing a sampler into it and retrieving and emptying the sampler of slough.
- Identify Slough and Avoid Sampling it or Logging it as In Situ Material. Slough is generally easy to identify based on jumbled internal textures, lighter density, macroscopic and unmineralized void spaces, greater softness and malleability, and decreased cohesion, as compared to in situ material that has not been dislodged prior to the sampling process.
- Grout Through a Conductor Casing. Grouting through a conductor casing prevents any significant accumulation of slough in the boring and ensures that grout will be the predominant material in the borehole, thereby minimizing any potential for vertical migration of fluids in the filled borespace. This minimizes potential liability.

6.5 Documentation

Accurate documentation of the boring, sampling, and abandonment activities is important for interpreting sample results, interpreting boring conditions and lithologic information, and conceptually reconstructing events. Appropriate forms (including boring logs) should be completed in accordance with appropriate Shaw E & I technical SOPs and project-specific requirements/procedures.

6.6 Technical Review

All direct push drilling and soil sampling specifications, procedures, and results (e.g., reports, forms, etc.) should undergo technical review. It is recommended that the technical reviewer also provide review/oversight of the actual field implementation of direct push drilling and soil sampling activities. This should include aiding in troubleshooting for drilling and sampling problems. The technical reviewer should be an experienced senior geologist or hydrogeologist. At a minimum, the technical reviewer should be a person capable of planning and supervising direct push drilling and associated sampling and well installation programs. Individuals needing assistance in finding qualified technical reviewers may consult internal Shaw technical listings for experts in drilling or direct push drilling and sampling.

Any issues raised during the technical review shall be resolved between the reviewer and the staff planning, conducting, or preparing results of direct push drilling and soil sampling activities, as follows:

- Comments/issues that arise relative to planning and developing detailed procedures for direct push drilling and soil sampling should be resolved before mobilization and drilling commences.
- Comments/issues that arise relative to the results of drilling and sampling activities should be resolved before external (i.e., outside of Shaw E & I) use or submission of the results.

The technical review comments and issues, and corresponding resolution, shall be documented and filed with the project records. Such records should be maintained until project closeout.

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7. ATTACHMENTS

- Attachment 1, Example Direct Push Drilling and Soil Sampling Procedure

8. FORMS

None

9. RECORDS

- Project Specific Work Plan
- Tailgate Safety Meeting Records
- Boring Log
- Documentation of Sampling Activities
- Technical review comments and issues, and corresponding resolution

10. REVISION HISTORY AND APPROVAL

Revision Level / Revision Date	Revision Description	Responsible Manager
00 08/07/2003	Initial Issue.	John E. Sciacca
01 03/01/2007	Changed from Standard to procedure, procedure number changed from SOP-T-GS-021 to EI-GS021, edited ASTM reference numbers, replaced reference to the Insider with ShawNet in section 5.1, revised Project responsibility in section 5.2, added reference to HS308 in section 6.2	Gary Gaillot
02 01/02/2013	Modified format only to align with Governance Management framework.	Scott Logan

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Attachment 1
Example Direct Push Drilling and Soil Sampling Procedure

The following procedure is provided as an example. It should be customized based on project/site-specific equipment, methodology, and sampling and quality control requirements. This procedure is written for a direct push drilling rig that uses a small-diameter conductor casing with a 3-foot long inner wireline sample barrel (with a 3-foot long acrylic liner) connected to the bottom of the casing. The casing and associated sample barrel are driven, pushed, or vibrated into the ground in 3-foot increments. Soil samples are collected into the acrylic sample tubes as the conductor casing and sample barrel are advanced into the formation. The samples inside the liner and sample barrel are then retrieved with a wireline, leaving the conductor casing in place. Soil samples are thus continuously collected until the total depth of the boring is reached. The example procedure consists of the following:

1. Decontaminate the direct push sampling rig and associated sampling equipment before mobilizing to the first sample location, in accordance with applicable Shaw E & I technical SOPs and/or project-specific requirements/procedures.

2. Inspect the direct push rig to make sure the equipment is properly maintained, adequately decontaminated, and determined capable of achieving the objectives for drilling (equipment advancement), sample collection, and abandonment of the boring (to be done by the driller and rig geologist).

3. Calibrate all field analytical and health and safety monitoring equipment according to the instrument manufacturer's specifications and/or project work plans. Calibration results must be recorded on the appropriate form(s) as specified by the project work plans or health and safety plan.

4. Wear the appropriate personal protective equipment, as specified in the project work plans or health and safety plan. Personal protection will typically include, at a minimum, a hard hat, safety glasses, gloves, steel-toed boots, hearing protection, and coveralls.

5. Remove the surface cover (e.g., concrete, asphalt, etc.) at the drilling/sampling location according to the project work plans.

6. Once the direct push rig is sited at the sampling location, make sure the location is free of underground utilities, as per the project work plans and Shaw Policy and Procedure HS308, Underground/Overhead Utility Contact Prevention. Manually probe or excavate near-surface soils (as required) as an additional step to avoid underground utilities or structures.

7. Learn the drilling equipment heights and dimensions necessary to independently determine the boring or sampler depth while observing the work (to be done by the rig geologist). Such information includes lengths of rods, casing, barrels, and other in-ground equipment; the length of strokes or advances; and the height from ground surface to "full down" stroke of the direct push rig.

8. Between each sampling location and prior to each sampling run, decontaminate the sampling equipment according to applicable Shaw E & I technical SOPs and/or project-specific procedures.

9. Inform the driller of the expected total depth, the first and expected additional sampling depths, the likelihood of encountering groundwater or NAPL, and any contingency or opportunistic decisions that are anticipated (such as contingency-sampling or increased total depth).

10. Record the type of sampler assembly on the appropriate form(s) as specified in appropriate Shaw E & I technical SOPs or the project work plans. To minimize off-gassing of volatiles, the

sampler should not be advanced/pushed until the sampling team is ready to process the sample.

11. Commence drilling and sample collection by advancing the conductor casing and associated sample barrel (with liner) for the first 3-foot increment.

12. Pull the wireline sampling string up from the bottom of the borehole and remove the sample barrel. Make sure that each sample barrel is retrieved as quickly and smoothly as possible. Record the depth interval for each sample drive as the sample barrel is being retrieved.

13. Remove the acrylic liner containing the soil sample from the sample barrel.

14. Observe and record the amount of sample recovery on the appropriate form(s), according to applicable Shaw E & I procedures and/or the project work plans. Any observed field problems associated with the sampling attempt (e.g., refusal) or lack of recovery should be noted on the appropriate form.

15. Select the appropriate portion of the liner containing the sample to be cut and be submitted for laboratory analysis. Such selection should be based on the following factors: (1) judgment that the sample represents relatively undisturbed intact material, not slough; (2) volume/length of sample required for analysis; (3) minimal exposure to air; (4) lithology; and (5) obvious evidence of contamination. The project work plans should specify the volume/length of sample to be submitted for specific analyses and confirm the selection factor(s).

16. Place Teflon™ film over each end of the liner containing the samples to be submitted for chemical analysis and seal each end with plastic end caps. Do not use any type of tape to seal the cap, because tape causes a toluene interference. All samples should be individually stored in resealable plastic bags. Note: Additional project-specific sample preparation steps or modifications may be required as stated in the project work plans.

17. Appropriately label and number each sample to be submitted for analysis according to applicable Shaw E & I technical SOPs and the project work plans. The label will be filled out using waterproof ink and may contain, at a minimum, the following information:

    – Project number
    – Boring number
    – Sample number
    – Bottom depth of sleeve
    – Date and time of sample collection
    – Parameters of analysis
    – Sampler's initials

18. Document the sampling event on the appropriate form(s), as specified in the project work plans. The information listed on the form(s) should, at a minimum, include the following:

    – Project name and number
    – Date and time of the sampling event
    – Sampling methods used – specify sample type

- Sample number
- Sample location
- Sample depth interval
- Sample description (type of matrix)
- Weather conditions
- Unusual events, including lack of water or insufficient water volume in sampler
- Signature or initials of sampler

19. Appropriately preserve, package, handle, and ship the sample in accordance with applicable Shaw E & I technical SOPs and/or project-specific procedures. The samples shall also be maintained under custody. Samples stored on site will be subject to the provisions of applicable Shaw E & I procedures and/or project requirements. All reasonable attempts should be made to ship samples on the date they are collected.

20. Cut/split the remaining acrylic liner to expose the remaining soils for logging. The descriptions of the soil and preparation of a boring log should follow applicable Shaw E & I technical SOPs and project-specific requirements/procedures. The soil boring log should include the following information:

    - Borehole location
    - Name of the drilling company and driller
    - Dates and times when drilling began and when it was completed
    - Lithologic data and descriptions from soil samples
    - Sampling depths and recovery of soil samples

21. Continue to advance the borehole in 3-foot increments and collect soil samples to the total depth. As the borehole is advanced, the rig geologist will generally do the following:

    - Observe and monitor rig operations
    - Conduct all health and safety monitoring and sampling and supervise health and safety compliance
    - Prepare a boring log from cuttings or soil samples according to applicable Shaw E & I technical SOPs and project-specific requirements
    - Document drilling progress and other appropriate observations on appropriate forms
    - Supervise the collection and preparation of any soil, soil vapor, or groundwater samples

    The rig geologist should not leave the drill site while drilling operations are being conducted and the borehole is being advanced.

22. As drilling progresses, the rig geologist should observe and be in frequent communication with the driller regarding drilling operations. Conditions noted should include relative rates of penetration, flowing sands, drilling refusal, changes in equipment, etc. These conditions should be recorded on the appropriate logs and forms in accordance with applicable Shaw E & I technical SOPs and/or the project work plans. Drilling should not be allowed to progress

faster than the rig geologist can adequately observe conditions, compile logs, and supervise safety and sampling activities.

23. The rig geologist should also observe the make-up and tightening of connections as additional conductor casing joints are added to the drill string. Any observed drilling problems and causes, including significant down time, should be recorded on the appropriate forms.

24. Cuttings (i.e., left over soil samples) and fluid containment during drilling should be observed and supervised by the rig geologist as per the project work plans.

25. Periodically measure the boring depth with a weighted tape to verify its depth. If it cannot be directly measured, then count rods or pipe lengths that have been inserted into the ground or take other action to verify depth (in a manner that is independent of asking the driller the boring depth).

26. If the borehole is to be abandoned once drilling and sampling is completed, follow procedures outlined in applicable Shaw E & I technical SOPs and the project work plans. The abandonment will be supervised by the rig geologist. If the borehole contains slough, the slough should be removed prior to abandonment.

27. If a monitoring well is to be installed in the borehole, follow appropriate Shaw E & I technical SOPs and project-specific requirements/procedures. The well installation will be supervised by the rig geologist.

28. After drilling, sampling, and well installation or borehole abandonment is completed, lay the conductor casing down and move the rig off of the location. The rig geologist or appropriate designee will supervise demobilization/site restoration. Additional demobilization requirements/ procedures are as follows:

    – All debris generated by the drilling operation should be removed and disposed of appropriately.

    – The site should be cleaned, the ground washed as necessary, and the site conditions restored according to the project work plans.

    – All abandoned borings should be topped off and completed as specified by the project work plans. All wells should also have their surface completions finished as specified by the project work plans.

    – Any hazards remaining as a result of drilling activities should be identified and appropriate barriers and markers put in place, as specified by the project health and safety plan.

    – All soil cuttings and fluids should be properly contained, clearly labeled, and maintained in compliance with the project work plans and/or other applicable requirements.

29. Complete all appropriate forms and documentation as required in the project work plans.

1. PURPOSE

This procedure provides the standard practice for soils logging (the description of soils). The procedure includes the minimum required steps and quality checks that employees and subcontractors are to follow when performing the subject task.

This procedure may also contain guidance for other recommended or suggested practice that is based upon collective professional experience. Recommended practice goes beyond the minimum requirements of the procedure, and should be implemented when appropriate.

2. SCOPE

Geosciences Standard Operating Procedure (SOP) EID-GS-025 describes standards for the description and field classification of engineering soils by visual-manual methods for projects executed by Shaw Environmental & Infrastructure, Inc. (Shaw E & I). It applies to soils logging for generation of boring logs, trench logs, and any other type of descriptive soil log generated by visual observation and manual tests performed in the field. This procedure does not cover all of the requirements or standards for generation and completion of boring logs. (Standards for boring log generation can be found in Shaw Procedure No. EID-GS-027) This SOP does not include nor cover the use of laboratory or field geotechnical tests to identify/classify and describe soils, although descriptions may be augmented by data from such tests, when available.

The SOP addresses technical requirements and required documentation. Responsibilities of individuals performing the work are also detailed. Additional project-specific requirements for soils logging may be developed, as necessary, to supplement this procedure and address project-specific conditions and/or objectives.

3. REFERENCES

The description and classification of soil should follow accepted industry practices. These are presented in the latest version of the following American Society for Testing and Materials (ASTM) Standards:

ASTM D 653 Standard Terminology Relating to Soil, Rock, and Contained Fluids

ASTM D 2487 Standard Test Method for Classification of Soils for Engineering Purposes

ASTM D 2488 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)

Additional reference materials that are useful for planning and conducting soils logging include the following:

- United States Army, 1997, *Field Manual (FM) 5-410, Military Soils Engineering,* Revised, June 1997. Available on line at: http://www.adtdl.army.mil/cgi-bin/atdl.dll/fm/5-410/toc.htm
- United States Bureau of Reclamation (USBR), 1998, *Engineering Geology Field Manual, Second Edition*. Available on line at: http://www.usbr.gov/pmts/geology/fieldman.htm
- United Stated Department of Agriculture (USDA), 1993, *Soil Survey Manual, Soil Conservation Service*. Available on line at: http://soils.usda.gov/procedures/ssm/main.htm
- American Geological Institute, AGI Data Sheets

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- US Army Corps of Engineers, 1953, *The Unified Soil Classification System; US Army Technical Memorandum, No.3-357*.
- Compton, Robert R., 1962, *Manual of Field Geology*, John Wiley and Sons Inc.
- US Department of the Interior, 1974, *Earth Manual*, a Water Resources Technical Publication.

4. DEFINITIONS

The following definitions are applicable to the logging of soils and this SOP.

- **Clay**—Soil passing a No. 200 (75µm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or fine-grained portion of a soil, with a plasticity index equal to or greater than 4.
- **Coarse Grained Soils**—Soils composed of greater than 50% sand and gravel or larger sized particles.
- **Fine Grained Soils**—Soils composed of 50% or more silt and clay-sized particles.
- **Gravel**—Particles of rock that will pass through a 3-inch (75mm) sieve and be retained on a No. 4 (4.75mm) sieve.
- **Sand**—Particles of rock that will pass a No. 4 (4.75mm) sieve and be retained on a No. 200 (75µm) sieve.
- **Silt**—Soil passing a No. 200 (75µm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4.
- **Soil**—All unconsolidated materials above bedrock.
- **Standard Penetration Test**—ASTM D 1586 method for the collection of soil samples.
- **USCS**—Unified Soil Classification System.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Geosciences Discipline Lead is responsible for the development, maintenance, and revision of this procedure. Any questions, comments, or suggestions regarding this technical SOP should be directed to the Geosciences Discipline Lead. The Geosciences Discipline Lead's location and associated contact information can be found on the Shaw Group intranet site, ShawNet.

5.2 Project Responsibility

Employees planning or conducting soils logging are responsible for meeting the requirements of this procedure. Employees conducting technical review or oversight of such efforts are also responsible for following appropriate portions of this SOP. Project participants are responsible for recording information in sufficient detail to provide objective documentation (logs, forms, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURES (TECHNICAL REQUIREMENTS)

This section addresses the process and procedures necessary for the preparation of soil descriptions based on the field classification of soils by visual-manual methods. Objective,

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quantitative and accurate observations are necessary to ensure the quality and scientific integrity of soil descriptions. The guidance contained within this SOP should be used in conjunction with project-specific work plans to prepare soil descriptions.

All personnel required to log soil for Shaw Technical Services should follow the guidelines presented in this SOP unless project, contract, or client requirements specify otherwise. The guidance provided in this SOP is based primarily on the procedures contained in the most recent version of American Society for Testing and Materials (ASTM) D 2488, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*. The logging/description of rock is discussed in Shaw Procedure No. EID-GS-026, *Standards for Rock Logging*. Preparation of boring logs should follow Shaw Procedure EID-GS-027, *Standards for Generation of Boring Logs* and/or the project work plans. Personnel involved in describing soil and preparing soil boring logs should be familiar with these documents.

Field soil descriptions prepared for soils collected from boreholes may be recorded on the Visual Classification of Soils Form (Section 8) unless project, contract, or client requirements specify otherwise. Descriptions will focus on making and recording objective, concise, quantitative, and accurate observations. The field geologist conducting the logging should refrain from providing subjective, interpretative, diagnostic, or genetic comments and observations until the soil is completely and accurately described following the guidance contained in this SOP.

6.1 Soils Description

The standard method for classification of soil is the Unified Soil Classification System (USCS). This system and classification method is presented in ASTM D 2488-00, *Standard Practice for Description and Identification of Soils (Visual Manual Procedure)*. When classifying soils using this method, a representative soil sample is obtained. The soil sample is then attributed to one of two broad groups: 1) fine-grained soils, or 2) coarse-grained soils. Fine-grained soils are composed of 50% or more silt and clay sized particles. Coarse-grained soils are composed of greater than 50% sands and gravels. Flow charts for determining the USCS symbol and associated name are provided on Figures 1a, 1b, and 2 in ASTM D 2488-00. A summary chart of the groups and USCS symbols is provided in Attachment 1. The soil description for each group should be prepared to contain the information and follow the sequence provided below.

6.1.1 Fine Grained Soils (Silts and Clays) Description Format

The standard description format for a fine-grained soil is as follows:

SOIL GROUP NAME; color; moisture state; consistency; plasticity; percentage of fines; percentage and size-range of coarse fraction; maximum particle size; evidence of contamination (visual evidence/odors); other terms (see below).

6.1.2 Coarse Grained Soils (Sands and Gravels) Description Format

The standard description format for a coarse-grained soil is as follows:

Grading term, **SOIL GROUP NAME;** color; moisture state; density; percentage and size-range of coarse fraction; maximum particle size; angularity; shape; percentage and plasticity of fines; evidence of contamination (visual evidence/odors); other terms (see below).

6.1.3 Other Terms to Include in Description

Additional information useful for describing the characteristics of a soil include the following:

- Hardness of coarse sand and larger particles
- Surface coating on coarse-grained particles
- Bedding and other soil structures

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- Organic soil or presence of organic material
- Cement, caliche
- HCl reaction
- Mineralogy/petrology of grains/clasts
- Debris; metal, concrete, plastic, etc.
- Evidence of fill
- Evidence of disturbance

6.2 Descriptive Terms (Explanation and Use)

Brief explanations and use of the above descriptive terms are provided in the following text. Specific criteria and field methods used to assign the proper term in a soil sample description are provided in ASTM D 2488-00 and other references listed above. These terms should be included in the descriptions of the soil units.

- **Soil Group Name:** The primary criterion used to assign the soil group name is the percentage of each soil particle size fraction. The soil group name will be assigned based on the percentage and size-range distribution of soil particles using Figures 1a, 1b, and 2 in ASTM D 2488-00 and/or the classification chart in Attachment 1. Following determination of the soil group name, the USCS group symbol should be assigned to the soil unit. The group name and USCS group symbol for fine-grained soils will also need to be determined following the procedure in Section 14 of ASTM D 2488-00.

- **Grading term:** (Coarse-grained soils) Gradation is the proportion by mass of a soil distributed in a specified particle-size range. Coarse-grained soils are described as poorly graded or well graded. Note that grading is the opposite of sorting; a well-graded soil is poorly sorted and vice versa. Grading is described in Sections 15.3.1 and 15.3.2 of ASTM D 2488-00.

- **Color:** Color is an especially important property in identifying organic soils and is often important in identifying other types of soils. Within a given locality, color may also be useful in identifying materials of similar geologic units. Color should be described for moist samples. Note in the description if the color represents a dry condition. If the sample contains layers or patches of varying colors (i.e., mottled), this should be noted, and representative colors should be described.

  The Munsell Soil Color System should be used for consistent color descriptions and identification. This is because a given color will often be given different names by different people conducting the logging. A given color may also appear differently to people when next to other colors.

- **Moisture state:** Describe as dry, moist, or wet according to the following:

  – Dry Absence of moisture, dusty, dry to touch

  – Moist Damp but no visible water

  – Wet Visible free water, usually soil is below the water table

- **Density (coarse-grained soils):** Describe density (degree of firmness) for coarse-grained soils as very loose, loose, medium dense, dense, or very dense, as indicated by the criteria below. This observation is inappropriate for fine-grained soils. Terminology is as follows:

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Density	Standard Penetration Resistance (SPT)
Very loose	0 – 4
Loose	5 – 10
Medium dense	11 – 30
Dense	31 – 50
Very dense	> 50

- **Consistency (fine-grained soils):** Describe consistency (degree of firmness) for intact fine-grained soils as very soft, soft, firm, hard, or very hard, as indicated by the criteria below. This characteristic should not be used for soils with significant amounts of gravel. Classification is as follows:

Consistency	Thumb/Thumbnail Test	Standard Penetration Resistance (SPT)
Very soft	Thumb penetration > 1in. (25 mm)	< 2
Soft	Thumb penetration ≈ 1 in. (25 mm)	2 – 4
Firm	Thumb penetration ≈ ¼ in. (5 mm)	5 – 15
Hard	Thumb will not indent, but thumbnail will	16 – 30
Very hard	Thumbnail will not indent.	> 30

- **Plasticity (fine-grained soils):** Describe as nonplastic, low, medium, or high. To determine plasticity, shape into an elongated thread about 1/8-inch in diameter. Describe plasticity based on the following:
  - **Nonplastic:** A 1/8-inch thread cannot be rolled at any water content.
  - **Low:** The thread can barely be rolled, and a lump cannot be formed when drier than the plastic limit.
  - **Medium:** The thread is easy to roll and little time is needed to reach the plastic limit. The thread cannot be re-rolled when the plastic limit is reached and the lump crumbles when drier than the plastic limit.
  - **High:** It takes a considerable amount of time to reach the plastic limit when rolling the sample. The thread can be re-rolled several times once the plastic limit is reached and the lump can be formed without crumbing when drier than the plastic limit.
- **Percentage of fines:** Estimate (to the nearest 5%) the percentage of silt and clay-sized particles combined, or the percentage of silt and clay individually to the nearest 10%.
- **Percentage of coarse fraction:** Estimate (to the nearest 5%) the percentage of sand and gravel-sized particles.

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- **Size-range of coarse fraction:** Describe the size-range as fine sand, medium sand, coarse sand, fine gravel, coarse gravel, cobble-sized, or boulder-sized.
- **Maximum particle size or dimension:** Describe the maximum particle size of the course fraction.
- **Angularity:** Angularity is a description for coarse-grained materials only. The angularity of coarse sand, gravel, cobbles, and boulders is described as angular, subangular, subrounded, or rounded as indicated by the criteria below. A range of angularity may be stated, as such: sub-rounded to rounded. The criteria are as follows:
  - **Angular**—Particles have sharp edges and relatively planar sides with unpolished surfaces.
  - **Subangular**—Particles are similar to angular description but have rounded edges.
  - **Subrounded**—Particles have nearly planar sides but well-rounded corners and edges.
  - **Rounded**—Particles have smoothly curved sides and no edges.
- **Shape:** Describe the shape of the gravel, cobbles, and boulders as “flat”, “elongated,” or “flat and elongated” if they meet the criteria below. Indicate the fraction of the particles that have the shape, such as “one-third of gravel particles are flat”; note any unusually shaped particles.

  The particle shape is classified/described as follows, where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively:
  - **Flat**—Particles with width/thickness ratio >3
  - **Elongated**—Particles with length/width ratio >3
  - **Flat and elongated**—Particles that meet criteria for both flat and elongated
- **Evidence of contamination (visual/olfactory):** Describe any visual signs (i.e., staining) or odors that may indicate that contamination is present.
- **Other Terms:** (see below).

6.3 Other Terms

Other geologic observations should be included to describe soils. These other observations and terms are just as important as the descriptive terms in Section 6.2. These other terms need to be carefully considered, observed, and included in the soil descriptions, as applicable. Such terms include the following:

- **Hardness:** Indicate the hardness of coarse sand or larger particles as hard, or state what happens when the particles are hit by a hammer; (e.g., “gravel-size particle fractures with considerable hammer blow,” “some gravel-size particles crumble with hammer blow”). Hard particles are those that do not fracture or crumble when struck with a hammer. Remember that the larger the particle, the harder the blow required to fracture it. A good practice is to describe the particle size and the method that was used to determine the hardness.
- **Surface coating:** On coarse-grained particles.
- **Bedding**: Describe thickness, orientation, and/or grading.
- **Soil Structure:** Describe as stratified, laminated, fissured, slickensided, blocky, lenses, or homogeneous. The descriptors presented are for soils only; they are not synonymous with descriptions for rock.

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- **Stratified**—Alternating layers of varying material or color; note thickness.
- **Laminated**[1]—Alternating layers of varying material or color with layers less than 6 mm thick; note thickness.
- **Fissured**[1]—Breaks along definite planes with little resistance to fracturing.
- **Slickensided**[1]—Fracture planes appear polished or glossy, sometimes striated.
- **Blocky**[1]—Cohesive soil that can be broken down into small angular lumps which resist further breakdown.
- **Lenses**—Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thicknesses.
- **Homogeneous**—Same color and textural or structural appearance throughout.

[1]Do not use for coarse-grained soils with the exception of fine sands, which can be laminated.

- **Organic soil:** Note the presence and type of organic particles; change in color upon exposure to air or odor.
- **Cementation:** Describe the cementation of intact soils as weak, moderate, or strong, as indicated by the criteria below:
  - **Weak**—Crumbles or breaks with handling or little finger pressure
  - **Moderate**—Crumbles or breaks with considerable finger pressure
  - **Strong**—Will not crumble or break with finger pressure.
- **HCl reaction:** Calcium carbonate is a common cementing agent in soils. The reaction with dilute hydrochloric acid is useful in determining the presence and abundance of calcium carbonate. Describe the reaction with HCl as none, weak, or strong, as indicated by the criteria below:
  - **None**—No visible reaction
  - **Weak**—Some reaction, with bubbles forming slowly
  - **Strong**—Violent reaction, with bubbles forming immediately
- **Mineralogy/petrology of grains/clasts:** Describe the specific minerals (e.g., mica, gypsum, etc.) and/or lithologies of clasts and relative percentages.
- **Evidence of fill:** Describe debris such as metal, concrete, plastic, etc.
- **Evidence of disturbance:** Describe visual evidence and degree of disturbance. Classify as natural (biological, tectonic, etc.) or manmade (e.g., construction).
- **Sedimentary structures:** Describe sedimentary structures or lack of structures in soil samples (includes root tubes).

6.4 Boring Log Preparation

Soil descriptions prepared following the guidance in this SOP should be recorded on a boring log according to the provisions and requirements of Shaw Procedure No. EID-GS-027, *Standards for Generation of Boring Logs*. The soil descriptions should be recorded on the log in waterproof and smear-proof blue or black ink. Additional information may also be included on the log to supplement the soil descriptions as described in Procedure No. EID-GS-027. An example Visual Classification of Soils field log form is included in this SOP (Section 8).

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6.5 Technical Review

All soil descriptions (logging results) should undergo technical review and approval before internal or external distribution (i.e., outside of Shaw E & I). The technical reviewer should be an experienced senior geologist or hydrogeologist and capable of logging and describing soils following the requirements of this procedure. For logging/soil descriptions prepared for a site in a state that requires review and approval of such work products by a registered or licensed geologist, the individual conducting the technical review should hold appropriate registration or licensing in that state.

The technical reviewer should be given appropriate information on the geology of the site, the scope of associated site activities, any and all assumptions used in the logging and any other important information regarding site conditions or issues affecting soil descriptions. The technical reviewer must also be given sufficient time to conduct a sound and thorough review.

Certain states require the logging of soils and generation of boring logs under the supervision of a registered or licensed geologist. For sites and projects in such states, an appropriately registered or licensed geologist should be identified during the planning/preparation phase of the project. The registered/licensed geologist will meet with the field geologist(s) that will be conducting the soils logging. The registered/licensed geologist will brief the field geologist(s) regarding applicable requirements for soils logging and boring log generation, including the requirements in this SOP and Shaw Procedure No. EID-GS-027, *Standards for Generation of Boring Logs.* The registered/licensed geologist may also observe/review the logging conducted by the field geologist(s) at the site during drilling and logging operations.

Any issues raised during the technical review should be resolved between the reviewer and employees generating the soil descriptions before internal distribution or external submission of the boring logs containing the descriptions. The technical review comments and issues and corresponding resolution should be documented and filed with the project records. Such records should be maintained until project closeout.

7. ATTACHMENTS

- Attachment 1, ASTM Soil Classification & USCS Group Symbols
- Attachment 2, Example Visual Classification of Soils Form

8. FORMS

None

9. RECORDS

- Boring Logs
- Visual Classification of Soils Form
- Technical review comments and issues, and corresponding resolution

10. REVISION HISTORY AND APPROVAL

Revision Level Revision Date	Revision Description	Responsible Manager
00 08/27/2003	Initial issue	John E. Sciacca
01	Procedure number changed from SOP-T-GS-025 to EI-GS025, reference to	Gary Gaillot

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Revision Level / Revision Date	Revision Description	Responsible Manager
01/30/2007	SOP-T-GS-027 was updated to EI-GS027, edited ASTM reference numbers, replaced reference to the Insider with ShawNet, revised project responsibility section, changed reference to SOP-T-GS-026 to EI-GS026 in Procedures (Technical Requirements) section.	
02 01/02/2013	Modified format only to align with Governance Management framework.	Scott Logan

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Attachment 1
Attachment 1, ASTM Soil Classification & USCS Group Symbols

					Group Symbol				Group Name
>50% Sand & Gravel	GRAVEL % gravel > % sand	≤5% fines	Well-graded		GW	<15% sand			Well-graded GRAVEL
						≥15% sand			Well-graded GRAVEL with Sand
			Poorly-graded		GP	<15% sand			Poorly graded GRAVEL
						≥15% sand			Poorly graded GRAVEL with Sand
		10% fines	Well-graded	fines - ML or MH	GW-GM	<15% sand			Well-graded GRAVEL with Silt
						≥15% sand			Well-graded GRAVEL with Silt and Sand
				fines - CL or CH	GW-GC	<15% sand			Well-graded GRAVEL with Clay
						≥15% sand			Well-graded GRAVEL with Clay and Sand
			Poorly-graded	fines - ML or MH	GP-GM	<15% sand			Poorly graded GRAVEL with Silt
						≥15% sand			Poorly graded GRAVEL with Silt and Sand
				fines - CL or CH	GP-GC	<15% sand			Poorly graded GRAVEL with Clay
						≥15% sand			Poorly graded GRAVEL with Clay and Sand
		≥15% fines		fines - ML or MH	GM	<15% sand			Silty GRAVEL
						≥15% sand			Silty GRAVEL with Sand
				fines - CL or CH	GC	<15% sand			Clayey GRAVEL
						≥15% sand			Clayey GRAVEL with Sand
	SAND % sand > % gravel	≤5% fines	Well-graded		SW	<15% gravel			Well-graded SAND
						≥15% gravel			Well-graded SAND with Gravel
			Poorly-graded		SP	<15% gravel			Poorly graded SAND
						≥15% gravel			Poorly graded SAND with Gravel
		10% fines	Well-graded	fines - ML or MH	SW-SM	<15% gravel			Well-graded SAND with Silt
						≥15% gravel			Well-graded SAND with Silt and Gravel
				fines - CL or CH	SW-SC	<15% gravel			Well-graded SAND with Clay
						≥15% gravel			Well-graded SAND with Clay and Gravel
			Poorly-graded	fines - ML or MH	SP-SM	<15% gravel			Poorly graded SAND with Silt
						≥15% gravel			Poorly graded SAND with Silt and Gravel
				fines - CL or CH	SP-SC	<15% gravel			Poorly graded SAND with Clay
						≥15% gravel			Poorly graded SAND with Clay and Gravel
		≥15% fines		fines - ML or MH	SM	<15% gravel			Silty SAND
						≥15% gravel			Silty SAND with Gravel
				fines - CL or CH	SC	<15% gravel			Clayey SAND
						≥15% gravel			Clayey SAND with Gravel
50% or More Fines	Low-Plasticity Clay				CL	<30% sand & gravel	<15% Sand and Gravel		Lean CLAY
							15-25% sand & gravel	% sand ≥ % gravel	Lean CLAY with Sand
								% sand < % gravel	Lean CLAY with Gravel
						≥30% sand & gravel	% sand ≥ % of gravel	< 15% gravel	Sandy lean CLAY
								≥ 15% gravel	Sandy lean CLAY with Gravel
							% sand < % gravel	< 15% sand	Gravelly lean CLAY
								≥ 15% sand	Gravelly lean CLAY with Sand
	Low-Permeability Silt				ML	<30% sand & gravel	15% sand & gravel		SILT
							15-25% sand & gravel	% sand ≥ % gravel	SILT with Sand
								% sand < % gravel	SILT with Gravel
						≥30% sand & gravel	% sand ≥ % of gravel	< 15% gravel	Sandy SILT
								≥ 15% gravel	Sandy SILT with Gravel
							% sand < % gravel	< 15% sand	Gravelly Silt
								≥ 15% sand	Gravelly Silt with Sand
	Plastic Clay				CH	<30% sand & gravel	< 15% sand & gravel		Fat CLAY
							15-25% sand & gravel	% sand ≥ % gravel	Fat CLAY with Sand
								% sand < % gravel	Fat CLAY with Gravel
						≥30% sand & gravel	% sand ≥ % of gravel	< 15% gravel	Sandy fat CLAY
								≥ 15% gravel	Sandy fat CLAY with Gravel
							% sand < % gravel	< 15% sand	Gravelly fat CLAY
								≥ 15% sand	Gravelly fat CLAY with Sand
	Plastic Silt				MH	<30% sand & gravel	< 15% sand & gravel		Elastic SILT
							15-25% sand & gravel	% sand > % gravel	Elastic SILT with Sand
								% sand < % gravel	Elastic SILT with Gravel
						≥30% sand & gravel	% sand ≥ % of gravel	< 15% gravel	Sandy elastic SILT
								≥ 15% gravel	Sandy elastic SILT with Gravel
							% sand < % gravel	< 15% sand	Gravelly elastic SILT
								≥ 15% sand	Gravelly elastic SILT with Sand
	Organics (Peat or Bay Mud)				OL/OH	<30% sand & gravel	< 15% sand & gravel		Organic SOIL
							15-25% sand & gravel	% sand ≥ % gravel	Organic SOIL with Sand
								% sand < % gravel	Organic SOIL with Gravel
						≥30% sand & gravel	% sand ≥ % of gravel	< 15% gravel	Sandy Organic SOIL
								≥ 15% gravel	Sandy Organic SOIL with Gravel
							% sand < % gravel	< 15% sand	Gravelly Organic SOIL
								≥ 15% sand	Gravelly Organic SOIL with Sand

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Attachment 2
Example Visual Classification of Soils Form

PROJECT NUMBER:	PROJECT NAME:	
BORING NUMBER:	COORDINATES:	DATE:
ELEVATION:	GWL: Depth Date/Time	DATE STARTED:
ENGINEER/GEOLOGIST:	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS:		PAGE: OF

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER PER ( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	MEASURED CONSISTENCY (TSF)	WELL CONSTRUCTION	REMARKS

NOTES:

Drilling Contractor: _____

Drilling Equipment: _____

Driller: _____

_____

1651-9-02

Shaw a world of Solutions	Title: Standards for Soils Logging	No: EID-GS-025 Attachment No. 2

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CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNCONFINED COMPRESSIVE STRENGTH (TONS PER SQUARE FOOT)
VERY SOFT	LESS THAN 0.25
SOFT	0.25 to 0.50
FIRM	0.50 to 2.0
HARD	2.0 to 4.0
VERY HARD	MORE THAN 4.0

DENSITY OF GRANULAR SOILS

DENSITY	STANDARD PENETRATION RESISTANCE (1)
VERY LOOSE	0-4
LOOSE	5-10
MEDIUM DENSE	11-30
DENSE	31-50
VERY DENSE	OVER 50

(1) STANDARD PENETRATION RESISTANCE IS THE NUMBER OF BLOWS REQUIRED TO DRIVE A 2-INCH O.D. SPLIT BARREL SAMPLER 12 INCHES USING A 140-POUND HAMMER FALLING FREELY THROUGH 30 INCHES. THE SAMPLER IS DRIVEN 18 INCHES AND THE NUMBER OF BLOWS RECORDED FOR EACH 6-INCH INTERVAL. THE SUMMATION OF THE FINAL TWO INTERVALS IS THE STANDARD PENETRATION RESISTANCE.

GRAIN SIZE IN MM

USCS CLASSIFICATION FOR SOILS

COARSE-GRAINED SOILS

CLEAN GRAVELS (LITTLE OR NO FINES)	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
	GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
CLEAN SANDS (LITTLE OR NO FINES)	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM	SILTY SANDS, SAND-SILT MIXTURES
	SC	CLAYEY SANDS, SAND-CLAY MIXTURES

FINE-GRAINED/HIGHLY ORGANIC SOILS

SILTS AND CLAYS LIQUID LIMIT (LESS THAN 50)	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS SILTY CLAYS, LEAN CLAYS
	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
SILTS AND CLAYS LIQUID LIMIT (GREATER THAN 50)	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS
	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS	PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

1. PURPOSE

This procedure provides the standard for the generation of boring logs. The procedure includes the minimum required steps and quality checks that all employees are to follow when performing the subject task.

This procedure may also contain guidance for recommended or suggested practice that is based upon collective professional experience. Recommended practice goes beyond the minimum requirements of the procedure, and should be implemented when appropriate.

2. SCOPE

Geosciences Standard Operating Procedure No. EID-GS-027 describes standards for the generation of boring logs and how such activities will be conducted for projects executed by Shaw Environmental & Infrastructure, Inc. (Shaw E & I). The SOP addresses technical requirements and required documentation. Responsibilities of individuals performing the work are also detailed.

The SOP presents the minimum mandatory data requirements for a boring log as well as basic field/quality practices relevant to logging. The concepts presented herein are relevant to both soil and rock borings. Additional project-specific requirements for generation of logs may be developed, as necessary, to supplement this procedure and to address project-specific conditions and/or objectives.

This SOP does not cover the specific technical methodology for logging (describing) soil or rock from samples, cuttings, or cores. That methodology is discussed in Procedure Nos. EID-GS-025, *Standards for Soils Logging*, and EID-GS-026, *Standards for Rock Logging*.

3. REFERENCES

The latest version of the following references are useful and relevant to developing a boring log and to this SOP:

ASTM D 2487	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
ASTM D 2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
ASTM D 653	Standard Terminology Relating to Soil, Rock, and Contained Fluids.
ASTM D 5434	Standard Guide for Field Logging of Subsurface Exploration of Soil and Rock.

4. DEFINITIONS

The following definitions are applicable to the generation of boring logs and this SOP:

- **Boring Log**—A detailed written record of the site-specific lithology and geologic units encountered while drilling a borehole.
- **Blows**—The number of blows from the drill rig drop hammer required to drive a split-spoon sampler a vertical distance of six inches.

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- **Percent Recovery**—The amount of sample material (rock or soil) recovered from a borehole at a given depth. Derived by dividing the length of material recovered by the total length of the sampler.
- **Rock Quality Designation (RQD)**—A measure of the quality of the undisturbed rock mass (i.e., how unbroken a drilled rock mass is). Expressed as the percent of the length of the core that consist of pieces that exceed 4 inches in length, or are judged to have exceeded 4 inches in length prior to drilling, divided by the total length of the core run (measured along the central axis of the core).

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Geosciences Discipline Lead is responsible for the development, maintenance, and revision of this procedure. Any questions, comments, or suggestions regarding this technical SOP should be directed to the Geosciences Discipline Lead. The Geosciences Discipline Lead's location and associated contact information can be found on the Shaw Group intranet site, ShawNet.

5.2 Project Responsibility

Employees generating/constructing boring logs are responsible for meeting the requirements of this procedure. Employees conducting technical review of boring logs are also responsible for following appropriate portions of this SOP. Project participants are responsible for recording information in sufficient detail to provide objective documentation that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURES

The purpose of the boring log is to accurately record observations and tests made of the recovered soil or rock material. Interpretations must also be accompanied by the underlying observations that were used to make the interpretations.

The following forms should be used to document the work:

- A daily field report
- A boring log

The Example Visual Classification of Soils and Visual Classification of Rock field log forms are included in this procedure (Section 8).

6.1 Documentation

A number of basic logging forms are available, and no firm guidelines exist on what style should be used. Two example field logs are included with this SOP. Whatever form is chosen, the log should be structured to allow easy recording of the minimum data requirements (below) as well as any project-specific requirements. The log will become part of the official project file and should be prepared assuming that other, non-Shaw E & I geologists may review it.

Other minimum requirements for logging forms include the following:

- The log should be on 8.5" × 11" standard white paper with additional pages numbered sequentially.
- All data should be recorded in waterproof and smear-proof black or blue ink. A fine-point "Sharpie" is ideal.
- All log entries shall be legible and printed.

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- If an error is made, a single line shall be drawn through the mistake and the corrected value written next to it. The correction shall be initialed by the logger. Never use “white-out” or heavy scribbles to correct a log.
- The log should be considered a legal document. If the client or site ever becomes involved in litigation, the log could become evidence.
- The log should be protected while in the field. Attach it to a clipboard and use rubber bands or binder clips to secure the edges. Keep the log dry when drilling in inclement weather. If necessary, erect a shade-type structure at the site to ensure that samples can be handled and logged in a dry setting.
- When the project is complete, the original (field) log shall be kept in the official project file. Photocopies can be made for the project report, but the original should always stay in the file until returned to the client.

6.2 Minimum Data Requirements

The following data should be collected and recorded, at a minimum:

- The project name and site location
- The Shaw project number
- The borehole name/number
- An approximate ground surface elevation
- Coordinates of surface location of the borehole (if known)
- The name of the drilling company and the name of the driller
- The name of the geologist making the log
- The date drilling began and the date drilling ended
- Drilling equipment, including the drill rig make and model; drill type; downhole equipment dimensions; bit type; quantity and type of any drilling fluids used; and drive sampler or coring (sample collection) equipment types and dimensions
- A detailed lithologic description of soil or rock from samples, cuttings, or cores according to Procedure No. EID-GS-025*, Standards for Soils Logging,* and/or Procedure No. EID-GS-026, *Standards for Rock Logging*
- Number of hammer blows on the sampler per 6-inch interval (for drive samples)
- An estimate of the percent of material recovered from the sampler (see “percent recovery” in Section 4)
- Soil or rock color according to Procedure No. EID-GS-025, *Standards for Soils Logging,* and/or Procedure No. EID-GS-026, *Standards for Rock Logging*
- USCS soil classification symbol (soil logs only); lower case for field classifications, upper case if laboratory classifications are made.
- Depth groundwater is encountered during drilling; depth water is encountered in the borehole if left over night
- An estimate of the rock quality designation (rock logs only)

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- An estimate of the amount of joint spacing (rock logs only)
- Observed drilling conditions (e.g., hard drilling, soft drilling, rig chattering, sticky drilling, lost circulation zones, circulation points, etc.)

There may be additional site- or project-specific data collection or logging requirements. These requirements should be specified in the project-specific work plans.

6.3 Technical Review and Approval

All boring logs should undergo technical review and approval before internal or external (i.e., outside of Shaw E & I) distribution. The technical reviewer should be an experienced senior geologist or hydrogeologist and capable of the construction and interpretation of boring logs. For logs prepared for a site in a state that requires review and approval of such work products by a registered or licensed geologist, the individual conducting the technical review and sign-off as "approved by" should hold appropriate registration or licensing in that state.

The technical reviewer should be given appropriate information on the geology of the site, the scope of associated site activities, any and all assumptions used in the generation of the log, and any other important information regarding site conditions or issues affecting the generation of the log(s). The technical reviewer must also be given sufficient time to conduct a sound and thorough review.

Certain states require the logging of borings and generation of logs under the supervision of a registered or licensed geologist. For sites and projects in such states, an appropriately registered or licensed geologist should be identified during the planning/preparation phase of the project. The registered/licensed geologist will meet with the field geologist(s) that will be logging the borings. The registered/licensed geologist will brief the field geologist(s) regarding applicable requirements for logging and log generation, including the requirements in this SOP and Shaw E & I technical SOPs EID-GS-025, *Standards for Soils Logging,* and/or EID-GS-026, *Standards for Rock Logging*. The registered/licensed geologist may also observe/review the logging conducted by the field geologist(s) at the site during drilling and logging operations.

Any issues raised during the technical review should be resolved between the reviewer and the employees generating the logs before internal distribution or external submission of the boring logs. The technical review comments and issues and corresponding resolution should be documented and filed with the project records. Such records should be maintained until project closeout.

7. ATTACHMENTS

- Example Visual Classification of Soils (Field) Log Form
- Example Visual Classification of Rock (Field) Log Form

8. FORMS

None

9. RECORDS

- Boring Logs
- Technical review comments and issues, and corresponding resolution

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10. REVISION HISTORY AND APPROVAL

Revision Level / Revision Date	Revision Description	Responsible Manager
00 08/25/2003	Initial issue	John E. Sciacca
01 01/30/2007	Procedure number changed from SOP-T-GS-027 to EI-GS027, reference to SOP-T-GS-025 and SOP-T-GS-026 was changed to EI-GS025 and EI-GS026 respectively all references updated to reflect change, edited ASTM reference numbers, replaced reference to the Insider with ShawNet, revised project responsibility section.	Gary Gaillot
02 01/02/2013	Modified format only to align with Governance Management framework.	Scott Logan

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Attachment 1
Example Visual Classification of Soils (Field) Log Form

PROJECT NUMBER:	PROJECT NAME:	
BORING NUMBER:	COORDINATES:	DATE:
ELEVATION:	GWL: Depth Date/Time	DATE STARTED:
ENGINEER/GEOLOGIST:	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS:		PAGE: OF

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER PER ( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	MEASURED CONSISTENCY (TSF)	WELL CONSTRUCTION	REMARKS

NOTES:

Drilling Contractor: _____

Drilling Equipment: _____

Driller: _____

_____

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Attachment 2
Example Visual Classification of Rock (Field) Log Form

PROJECT NUMBER:_____
PROJECT NAME:_____
_____
APPROX. ELEV:_____
DRILLING METHOD:_____
_____
COORDINATES:_____
_____

FIELD GEOLOGIST:_____
_____
CORING/SAMPLING METHOD:_____
_____
CORE SIZE/DIA:_____
DRILLER:_____
_____

PAGE:_____OF:_____
BORING NO.:_____
DATE:_____
DATE STARTED:_____
DATE COMPLETED:_____

RUN NUMBER	DEPTH ( )	RECOVERY ( )	% RECOVERY	% ROD	DESCRIPTION	JOINT SPACING			REMARKS
						MAXIMUM	MINIMUM	AVERAGE	

1. PURPOSE

This procedure provides the standard practice for groundwater monitoring well design and installation. The procedure provides the minimum required steps and quality checks that employees and subcontractors are to follow when performing the subject task.

This procedure may also contain guidance for recommended or suggested practice that is based upon collective professional experience. Recommended or suggested practice goes beyond the minimum requirements of the procedure and should be implemented when appropriate.

2. SCOPE

Geosciences Standard Operating Procedure (SOP) EID-GS-031 describes standards for the design and installation of groundwater monitoring wells, and how such design and installation will be conducted and documented for projects executed by Shaw Environmental & Infrastructure Inc. (Shaw E & I). Responsibilities of individuals performing the work are also detailed. Additional project-specific requirements for monitoring well design and installation may be developed, as necessary, to supplement this procedure and address project-specific conditions and/or objectives.

This SOP covers requirements for basic monitoring well design and installation. The following types of well design and installations are <u>not</u> covered specifically in this SOP:

- Any well that is not primarily intended for groundwater monitoring.
- Wells with multiple screen interval completions.
- Multiple wells or casings within a single boring.
- Instrumented wells (e.g. wells with inclinometers).
- Driven wells.

Individuals needing assistance in the design and installation of monitoring wells and/or these other types of wells/completions may consult internal Shaw E & I technical listings for experts or may contact the Geosciences Discipline Lead (see Section 5.1).

3. REFERENCES (STANDARD INDUSTRY PRACTICES)

The design and installation of groundwater monitoring wells should follow industry standard practices. These are discussed in the latest version of the following ASTM Standards:

ASTM D 5092	Design and Installation of Groundwater Monitoring Wells in Aquifers
ASTM D 5787	Practice for Monitoring Well Protection

The following references are also useful for the planning, design, and installation of groundwater monitoring wells:

ASTM D 6286	Selection of Drilling Methods for Environmental Site Characterization

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ASTM F 480 — Standard Specification for Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDRs), SCH 40 and SCH 80.

Smith, S. A., 1995, *Monitoring and Remediation Wells: Problem Prevention, Maintenance and Rehabilitation*, CRC Press.

U. S. Army Corps of Engineers, 1998, *Monitoring Well Design, Installation and Documentation at Hazardous, Toxic and Radioactive Waste Sites, Engineer Manual EM 1110-1-4000*, November 1. http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-1-4000/.

4. DEFINITIONS

The following definitions are applicable to monitoring well design and installation and this SOP.

- **Monitoring Well**—An engineered structure made for the purposes of accurately recording the depth to free water within the ground and for the repeated collection of liquid samples that are representative of the conditions of the groundwater within the vicinity of the screened portion of the well.
- **Installation**—The construction of a groundwater monitoring well within the ground.
- **Water Table**—The surface or level in the saturated zone at which the hydraulic pressure is equal to atmospheric pressure.
- **Well Casing String (System)**—Monitoring well components consisting of blank casing (riser), well screen, well sump (optional), and top and bottom caps that are connected together and placed in the well boring for construction of the well.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Geosciences Discipline Lead is responsible for the development, maintenance, and revision of this procedure. Any questions, comments, or suggestions regarding this technical SOP should be directed to the Geosciences Discipline Lead. The Geosciences Discipline Lead's location and associated contact information can be found on the Shaw Group intranet site, ShawNet.

5.2 Project Responsibility

Employees designing or installing groundwater monitoring wells, or any portion thereof, are responsible for meeting the requirements of this procedure. Employees conducting technical review or oversight of monitoring well design or installation are also responsible for following appropriate portions of this SOP. Project participants are responsible for recording information in sufficient detail to provide objective documentation (e.g., field notes, completion diagrams, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURES

Groundwater monitoring wells are constructed to facilitate reliable, repeatable, representative, and cost-effective sampling of groundwater with minimal disturbance of the aquifer. The degree of representativeness of samples depends upon both the well installation and the sampling procedures. Poor well design or construction may result in samples that are unrepresentative of the groundwater quality for the strata or formation in which the wells are screened. Well sampling procedures are addressed in other Shaw E & I technical SOPs.

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This SOP presents procedures for monitoring well design and installation that will facilitate collection of representative samples and be protective of the environment, in manners consistent with accepted practice and with most regulatory requirements.

6.1 Planning

The planning phase for monitoring well design and installation is an important function and includes the following:

- Identifying and addressing conceptual design issues/parameters (see Section 6.1.1)
- Selecting the drilling and well construction methods to be used (see Section 6.1.2)
- Identifying key approvals necessary for site access and installation of monitoring wells (see Section 6.1.3)
- Listing key Health and Safety requirements (see Section 6.1.4)
- Identifying and listing key requirements of subcontractor(s) used for well installation (see Section 6.1.6)

All planning, design, and installation of monitoring wells shall meet applicable federal, state, or local agency regulations/requirements. Additional program/project-specific requirements may also need to be addressed. Design elements and specifications, drilling methods, health and safety requirements, and detailed site- or project-specific installation procedures should be described in the project-specific work plans.

6.1.1 Conceptual Design

The expected stratigraphic interval for completion, the approximate total depth of the well, and the expected drilling conditions need to be known/developed. This information is necessary in order to complete the design for the well(s) (see Section 6.2), select methods for the drilling and construction of a well, and determine appropriate site-specific installation procedures.

The following are critical issues that must be identified and addressed during conceptual design:

- Monitoring and sampling objectives for the well(s) (e.g., collect groundwater samples, monitor position of the water table, measure thickness of non-aqueous phase liquid (NAPL), collect NAPL samples, etc.)
- Specific hydrostratographic interval or zone targeted for monitoring (e.g., base of unconfined unit A, top of confined aquifer B, first water-bearing fractured interval in unit X, water table in unconfined unit C, etc.)
- Any expectations for other future uses of the well(s) (e.g., groundwater extraction, NAPL [product] recovery, fluid injection for remediation, etc.).
- Expected top and bottom depths of the targeted zone (screen interval) of monitoring and total depth of the well(s).
- The type(s) of sampling that are to be performed in the well.
- Contaminant and groundwater chemistry and relation to composition of well materials.
- Current and expected use of the drill site area during the lifetime of the well.
- Expected long-term range or fluctuation in the position of the water table, or water level in the well(s).

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- Expected grain size gradations of the zone that is to be filter-packed.
- Expectations for the presence of light or dense NAPL.
- Rough diameter of well casing and screen to be installed.
- "Drillability" of the geologic formations and/or type of drilling method(s) appropriate for penetrating formations to be encountered and installing the well(s) (see Section 6.1.2).
- Need for telescoped casing, including shallow permanent casing.
- Requirements for collecting formation fluid, cuttings, or intact formation samples as the well boring is advanced (drilled).
- Requirements for geophysical logging of the wellbore or completed well.

Additional project-specific critical issues may also need to be identified and addressed, and should be described in the project work plans.

6.1.2 Selection of Drilling and Well Construction Methods

The drilling method(s) to be used for constructing the monitoring well will need to be identified. Primary criteria for selecting a drilling method are a follows:

- Ability to drill and maintain a stable wellbore of the desired diameter and depth in the geologic formations at the site and effectively construct the well, as anticipated.
- Ability to avoid more complex constructions such as telescoped casings (deep wells) and shallow permanent casings to prevent communication between water-bearing zones.
- Minimizing formation damage or introduction of drilling fluids into the formation.
- Cost and time factors (budget) for the drilling method and site conditions.
- Flexibility of a drilling method to adapt to unexpected but possible different subsurface conditions or lithology, such as a perched aquifer or bedrock where only alluvium was anticipated.
- Surface access requirements, impacts, and limitations for drilling and sampling equipment (e.g., wildlife areas, archaeology site, buildings, etc.).
- Minimizing and controlling the generation of cutting or fluid wastes produced during the drilling.
- Ability to efficiently and reliably collect samples and data during the drilling process.

The selected drilling method(s) should be specified in the project work plans.

6.1.3 Approvals

Specific approvals for well installation need to be identified and can include notifications, permits, legal access and right-of-entry, and contacting and cooperating with inspection authorities.

Typical or basic pre-work approvals include some or all of the following:

- Permit for Drilling and/or Well Construction. A permit for drilling and/or installation of the well(s) may be required from a government agency (and sometimes also from a client agency) that has appropriate jurisdiction. Fees or accounts for payments of fees for oversite

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are often required by many jurisdictions. Local, State, and Federal agencies may have specific well construction requirements that need to be identified and followed.

- Project work plans. Review and approval of various work plans (containing design specifications and procedures for installing monitoring wells) by a regulatory agency and the client are often required.
- Request/notification for underground utilities. Additionally, Shaw Procedure EIG-HS-308, *Underground/ Overhead Utility Contact Prevention,* shall be followed. Additionally, in nearly every state it is a legal requirement to notify a third-party consortium for the identification and marking of known underground utility structures and features. There may also be client-specific requirements for underground utility identification and clearance.
- Legal Authority to Enter/Construct. Rights of entry and rights to construct must be in hand for any property that is not owned by the Client and under contract.
- Requirements for inspections before, during, or after well installation may exist. Regulatory agencies in urbanized areas and on more sophisticated or larger projects commonly retain and exercise the right to inspect work.

The approvals need to be appropriately planned for and executed in order to effect timely and efficient installation of the monitoring wells.

6.1.4 Health & Safety

All applicable Shaw E & I and project-specific health and safety requirements for drilling and well installation shall be identified and adhered to at a minimum. The Client, regulatory agencies, property owner, or site operator may have additional requirements that must be identified and addressed. All requirements must be listed and described in the project health and safety plan.

6.1.5 Subcontractors & Personnel

Requirements for the subcontractor that is drilling and installing the monitoring well(s) must be identified. The requirements are compiled into a statement of work to procure subcontractor services once the design of the monitoring well(s) is completed.

The drilling subcontractor typically must possess one or more licenses pertaining to its qualifications to perform the type of work, and authority to work in the city or state. This can include a contractor's license, issued by the state, and other specialized licenses, such as for drilling and installation of water wells, to demonstrate expertise and responsibility. Such license requirement should be listed in the project work plans.

6.2 Design Process and Considerations

Monitoring wells may be designed after the approximate completion interval and total depth, drilling conditions, method of drilling, sampling requirements, and relevant understanding of contaminant and groundwater chemistry are known. Additional site- or project-specific conditions may also need to be known. Certain special design or installation conditions require additional evaluation and consideration. Some conditions potentially requiring special design or installation considerations are listed in Attachment 1. The following text discusses the components that need to be evaluated and specified for the monitoring well design. The specific design components and parameters for the well(s) should be described in the project work plans.

6.2.1 Borehole and Casing Diameters

The borehole diameter must be sufficiently wide to construct the well, and the well casing string must be sufficiently wide for use after completion. The borehole diameter should be at least 4

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inches greater than the nominal casing diameter. For deep borings it may be prudent for the boring diameter to be 6 inches greater than the nominal casing diameter. For drilling methods that involve constructing the well within temporary casing (i.e., hollow-stem auger or temporarily driven drill casing), it is common for the boring diameter to be 6 to 7 inches greater than the nominal well casing diameter (i.e., 10 to 12–inch diameter boreholes). The borehole diameter needs to be sufficiently wide such that all the well construction materials may be placed without obstruction.

The well casing should have an interior diameter sufficient to allow passage of all equipment that might plausibly be used within the casing during the lifetime of the well. Monitoring wells are commonly 2- or 4-inch nominal diameter for depths to about 200 feet, and often 6-inch diameter for greater depths.

It is common to select an inside casing diameter that is 1 inch greater than the diameter of any equipment expected to be used within the well casing for shallower wells, and 2 inches greater for deeper wells.

Many monitoring wells are installed in boreholes made by direct push drilling methods. For these wells the casing strings are relatively small diameter, generally <2 inches. The borehole diameters using direct push methods are also relatively small, generally <3 inches. Viable monitoring wells can be constructed using these methods; however, due to the relatively narrow annular space, a pre-pack may be used for the filter pack (see Section 6.2.8).

6.2.2 Length and Position of Well Screen

Only factory-manufactured well screen should be used. Screens are commonly available in lengths of 5, 10, and 20 feet, and sometimes 2.5 feet. Pieces may be joined for greater lengths.

Most monitoring well screens are designed to be 5 or 10 feet long, and many regulatory agencies specify these lengths in their guidance or regulations. The reason for short screen lengths is that well screens and associated filter packs are analogous to elevator shafts within buildings: contaminants and other materials may migrate up and down within them with ease. In addition, there may be stratification of dissolved phase contaminants in the formation that may be diluted during purging and sampling across a long screen interval.

There are a few site-specific situations where well screens of 20 feet or more may be suitable or necessary. Such situations could include wells where the expected range in water levels is 20 feet or more, and the well needs to screen across the water table; or where the target formation is more than 20 feet thick, the contaminant plume is believed to be of great thickness, there is little or no vertical groundwater gradient within the target formation and no potential for a NAPL. In general, the length of screen (and associated length of filter pack) selected for the well should be based upon site-specific objectives, requirements, and conditions, should be designed to meet monitoring/sampling objectives, and should not contribute to enhanced vertical transport of contaminants.

The position or depth of the well screen relative to the water table, or specific target horizon or fracture/stratigraphic interval must be clearly known. Such information should be specified in the project work plans.

6.2.3 Length of Filter Pack

The filter pack should not extend more than 2 to 3 feet above the top of the well screen and no more than 1 to 2 feet below the bottom cap or sump. This is because filter packs typically have much higher vertical permeability than the adjoining native formation, and hence will facilitate the preferential vertical flow of groundwater or contaminants. Excess length of filter packs facilitates the vertical spread of contamination as well as the collection of samples that “average” (i.e., dilute) across a greater thickness of aquifer than anticipated.

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A transition (or secondary) pack may be placed over the primary filter pack. The transition pack is a finer gradation material than the primary pack, and is designed to retard the infiltration of the overlying bentonite and/or cement seal into the primary filter pack. It is appropriately used where the primary filter pack is a coarse gradation with a high potential for the infiltration of the overlying seal material.

6.2.4 Lengths of Seals

A bentonite seal should be placed directly over the uppermost filter pack. It should be 2 to 3 feet thick. A cement annular seal should extend from the top of the bentonite seal to the surface. In deeper wells, the seal may be over 100 feet thick.

The lengths and positions of the bentonite and cement seals may have to be adjusted if the water table is shallow (i.e., <6 feet deep). At times, a thicker bentonite seal may also be prudent when there are uncertainties in the borehole condition. Information on the composition of the seals is provided in Sections 6.2.10 and 6.2.11.

6.2.5 Shallow Permanent Casing

A permanent (larger diameter) shallow casing may be necessary to isolate the wellbore and well casing string (Section 6.2.6) and prevent communication between water-bearing zones. Such casings are commonly steel pipe of large diameter. The inside diameter of such casing should be at least 4 inches more than the exterior well casing diameter, to provide an adequate width for filling with a cement seal. This may require a very large initial boring for the shallow casing, and may necessitate a different drilling method. The use of a shallow casing in well construction will typically double the total cost of well construction.

Permanent shallow casings may be appropriate under the following conditions:

- The shallow or overlying aquifer or zone is highly contaminated and the deeper aquifer or zone of completion may have much lower or no contamination.
- The monitoring well will be screened/filter packed in a zone that has contaminant or natural chemistry distinct from that of an overlying zone of saturation.
- The monitoring well will be screened/filter packed in a zone that has different total head from an overlying zone of saturation, indicating that advection would occur between the two zones via the wellbore.
- Either the screened/filter pack zone or an overlying zone of saturation is an important resource for drinking water supply.
- A NAPL is suspected to exist above the zone that is to be screened/filter packed.

At times, a temporary drive casing may be used in drilling and constructing a well in place of a permanent shallow casing. The use of a permanent shallow casing or temporary drive casing in the installation of the well should be based upon site-specific objectives and conditions or regulatory requirements, and specified in the project work plans.

6.2.6 Well Casing String

This section discusses each component of the well casing string. The components include blank casing (riser), well screen, sump (optional), and top and bottom caps.

Blank Casing or Riser

Blank well casing (or riser) is attached to the top of the well screen and extends from the screen up to, or just above, the ground surface. Blank casing is made from the following materials:

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- PVC. Any PVC well pipe/screen should be manufactured to ASTM F-480 standards. Schedule (SCH) 40 or SCH 80 are typically used; SCH 80 is typically used for total depths greater than roughly 100 feet. Use of SCH 40 PVC at depths roughly greater than 100 to 150 feet; or in environments rich in ketones, esters, or certain aromatic hydrocarbons, may be problematic.

- Stainless Steel. Stainless steel (SS) is commonly used for wells with high concentrations of solvents or other organic compounds. Type 304 is the most commonly used grade and 316 is less commonly used, but more resistant to corrosion/chemical reaction. Use in saline or reducing waters may cause corrosion or leaching of metals.

- PTFE (Teflon). PTFE is very expensive. Its surface is slippery, and it may slip during installation, and it may be difficult for seal material to bond to it. It has higher chemical resistance and lower leachability than PVC or SS.

- Reinforced Fiberglass. The outside surface of reinforced fiberglass casing is slippery, brittle, and easy to crack if not handled with care. It is usually used for monitoring specific remediation applications/techniques.

ABS plastic, high density polyethylene (HDPE), and low carbon steel pipe are other materials that are sometimes used for blank well casing.

Well casing material should be selected based upon the following factors:

- The expected total well depth and expected depth of water during construction. For wells deeper than roughly 100 feet, the selection of casing material must consider the potential for the casing to collapse or tear apart as it is being hung in the well bore.

- The natural and contaminant groundwater chemistry. Saline waters and pH<7 are conditions which will likely degrade stainless steel or other metal well casings. Certain chemical products, or high dissolved concentrations, of non-polarizing organic compounds may cause swelling or even dissolution of PVC, or dissolution of some plasticizers.

- The cost of the well casing material. Well casing materials vary in cost as follows: least expensive – PVC; moderately expensive – stainless steel; most expensive – PTFE (Teflon).

Casing connections should be flush treaded. O-rings of known chemistry and compatible with the water chemistry and sampling objectives may be used to ensure a tight seal. Glued or solvent welded connections are not acceptable as the glues or solvents can alter the chemistry of the groundwater samples. Connections held together with slip couplings and sheet metal screws are also not acceptable. The screws can easily fail and can also damage sampling equipment.

Well Screen

Well screens are composed of the same materials as the blank casing and should be factory-manufactured. For monitoring wells, the dominant criterion for selection of the screen should be sizing to exclude approximately 90% of the filter or sand pack particles. Sizing and selection of well screen and filter pack is covered in Shaw E & I technical SOP EID-GS-033, *Standards for Filter Pack and Well Screen Selection*.

Common screen types are slotted (milled) or wire-wrap. Slotted (milled) screen has the least open area (typically 2-6%) and is the least expensive. The most common widths of the cut slots used are 0.010 and 0.020-inch. Wire-wrap screen typically has 5-15% open area and comes in various grades of spacing between the wraps. Teflon and fiberglass screens are usually only available as slotted screen.

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Well screens do not have to be of the same material as the blank casing. For example, a well could be constructed of SCH 80 PVC blank casing and 304 stainless well screen. If different materials are used, care should be taken to ensure that the screen and blank casing can be securely connected, and that the use of dissimilar metals does not create problems with corrosion/cathodic reaction at the connection. Individuals needing help in designing well casing string configurations should find a senior geologist/hydrogeologist with monitoring well design and installation experience.

Well Sump (Foot)

A well sump consists of a short piece (i.e., 1 to 3 feet) of blank well casing with a bottom cap that is attached to the bottom of the screen section. A sump is used when dense non-aqueous phase liquid (DNAPL) is expected to enter the well (and is to be sampled and/or removed from the well), or a significant amount of sediment may enter the well over time.

The use of a foot or sump results in the expenditure of more resources during installation, development, and well purging. It is a practice that carried over from the installation of water supply wells, and is generally of little benefit for monitoring wells. The use of a sump may not be practical where the bottom of the well screen is to be set at the top of a lower confining unit. Consequently, the current trend is to avoid the use of sumps in monitoring wells.

Top and Bottom Caps

The well screen or sump should have a firmly attached bottom cap to prevent formation material from entering the well during installation and after completion. The top cap is usually either a slip cap that is placed over the top of the blank casing, or a rubber (expansion) gasket cap that is used to seal the top of the casing. The purpose of the top cap is to prevent entry of surface water into the well casing.

6.2.7 Centralizers

Centralizers are concentric devices that are designed to keep the well casing centered within the borehole, and to build a well that has an adequate annular space around the sides of the well casing. Centralizers are generally not used for wells less than 20 feet total depth and are typically not used when constructing a well through hollow stem augers or when using direct push drilling methods. The augers maintain space between the well casing string and borehole wall as the well is constructed.

Drillers generally have to use extra care in installing wells with centralizers. This is because the centralizers may become dislodged during installation of the casing string, hinder emplacement of filter pack or seal material with a tremie pipe, or hinder measuring the depths of filter pack or seal material. Any installation of centralizers should be closely supervised.

Centralizers, if used, are typically placed at intervals of every 20 feet for SCH 40 PVC casings. They may be placed at intervals of every 40 feet for steel or other more rigid casings. Centralizers are also placed just above the top of the well screen and, for certain wells, at the bottom of the screen or sump. The exact spacing to be used should be based on well- and site-specific conditions and specified in the project work plans. Metal centralizers will interface with electrical geophysical logs run inside PVC well casing.

6.2.8 Filter Pack

Filter packs may either be artificial (emplaced engineered material, including pre-packs) or natural (in-place geologic formation). Artificial packs are used most commonly and should be considered the default approach. Natural sand packs are not recommended and should generally only be used when installation of an artificial pack is not feasible (due to subsurface conditions).

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Engineered (Artificial) Filter Pack. Engineered filter packs should consist of chemically inert rounded particles of a defined size distribution. Clean-washed and bagged graded silica sands are usually used for this purpose. Selection of filter pack size should follow appropriate Shaw E & I technical SOPs and/or project-specific requirements. Filter packs are best placed (especially with deeper borings) with a small diameter pipe (tremie) extended to the bottom of the borehole. The tremie is slowly withdrawn as the sand is pumped into the boring.

Pre-Pack. Pre-pack and channel-pack are integral systems of interior casing, filter pack, centralizers, and exterior casing. They are commonly used for small diameter (i.e., 1-inch casing diameter) wells and may be preferable for larger diameters wells where heaving or caving formation is prevalent. Filter pack gradations and screen opening sizes can be designed or selected from several off-the-shelf products.

Natural Sand Pack. Use of a natural pack may be appropriate if the following criteria are met: an engineered filter pack cannot be installed and the natural formation in the vicinity of the proposed well screen is well characterized, homogeneous, composed predominantly of grains that will not enter the well screen, sufficiently permeable, and loose enough that it will collapse around the well screen. The use of a natural sand pack will usually require prior regulatory agency and client approval. Such approval should be documented, as required for the project, and the documentation maintained as project records.

6.2.9 Transition (Secondary) Filter Pack

A transition (or secondary) sand pack may be placed above the primary filter pack. This transition pack may be used where the filter pack is sufficiently coarse-grained and graded such that there is potential for the bentonite seal to migrate significantly into it. Such migration may result in bentonite entering the well screen. An optional upper transition filter pack may also be placed between the bentonite seal and the cement seal. Transition sand packs are typically 2 to 3 feet thick and composed of a graded, engineered silica sand with smaller grain size than the primary filter pack.

6.2.10 Bentonite Seal

The bentonite seal serves to separate the sanitary seal from the filter pack and provides extra protection against any migration of fluid up or down the wellbore from the screen/filter pack interval. It is typically 2 to 3 feet thick and may be composed of bentonite chips or pellets that are emplaced and then hydrated in-place, or it may be composed of a mechanically-mixed bentonite powder-water slurry that is tremied into place.

6.2.11 Cement Annular Seal

The cement seal constitutes the bulk of the annular fill in a deep well. Its primary purpose is to prevent fluids from migrating up or down the wellbore above the filter pack. To do this it must have low permeability, fill the entire annular space, and not shrink.

The seal is composed of a grout mixture of Portland cement and water, with or without a bentonite additive. An admixture of about 5% bentonite powder, added to a cement-water slurry, is used to minimize shrinkage of the seal after it has been emplaced and is setting. Some regulatory agencies have guidance, requirements, or specifications for using or not using bentonite in the grout. Such guidance and/or requirements need to be known and incorporated into the well design.

The use of quick-setting or other additives is not recommended as they can affect the chemistry of the groundwater samples. At times such additives may be necessary in highly permeable formation, but should only be used after appropriate regulatory approval. Such approval should be documented in the project files. Proper mixing and installation are important. The seal material should be mechanically mixed. It should be emplaced into the borehole in a way that

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prevents contact with the boring sidewall until it is in place, so that it does not pull sidewall material with it as it falls. The use of a tremie pipe, as with the sand pack placement, will facilitate completing the annular seal, especially in deeper borings. This helps to prevent voids or bridging of the cement. Additional information on the composition and mixing of the cement seal is presented in ASTM D 5787.

Cement generates heat as it sets. It is possible for deformation or failure of thermoplastic (i.e., PVC or ABS) well casing to occur from the heat generated during setting of the cement seal. This problem is exacerbated by more-rapidly-setting cements and thicker annular spaces. At times, the thickness of the annular space is greater than designed, for example if the formation washes out during drilling or cleaning of the wellbore. In such cases the potential for softening and sagging of the well casing is great as the cement sets. If this occurs, the well must be abandoned and replaced. Changing the design of the well may also be necessary.

6.2.12 Above-Grade or Flush-Mount Surface Completion

Selection of an above-grade or flush-mount surface completion is largely determined by the likelihood of vehicle traffic at the site surface, or other client/property owner requirements (e.g., visual aesthetics, etc.). Flush-mount completions are default practice where there is vehicle traffic, the ground surface is stable, and flooding is not anticipated. Above-grade completions are commonly used in areas of little or no vehicle traffic, where the ground surface is unstable (loose or muddy), where high grasses are present, or where a likelihood of standing water exists. There may be strict regulatory requirements for the design and construction of surface completions. Such requirements must be identified and incorporated into the well design.

The following are the primary design criteria for every surface completion:

- Preventing hazard to/from vehicles.
- Preventing damage to the well.
- Preventing inflow of surface waters.
- Preventing unauthorized access and/or tampering. (requires some form of locking or securing the wellhead)
- Ease of use.
- Client/property owner requirements.

The exact type and components of the surface completion to be used should be described in the project work plans.

Above-Grade Completions

The primary components of an above-grade completion are the surface pad, protective casing, locking lid, drain hole, and bollards. Information on each of these components is provided in the following text.

Surface Pad. The surface pad is a concrete pad that stabilizes the protective casing, provides a firm surface for workers, and directs surface waters away from the well casing. The protective pad should be at least 2 feet by 2 feet and at least 4 inches thick; however, it is recommended that it be somewhat larger and at least 6 inches thick. The surface pad should have a slight slope away from the protective casing to drain water away from the well.

Protective Casing. The protective casing should be weather- and tamper-resistant, capable of keeping rainfall from reaching the well casing, and resistant to opening without use of significant force. It is set around and over the well casing, extending from at least 6 inches above the well

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casing to at least 2 feet below grade (~30 inches below top of surface pad). There should be cement all the way around the protective casing, to its full depth.

Lid. The protective casing should have a locking, hinged lid that will protect the wellhead from rain, tampering, animals, and ultraviolet damage.

Drain hole. A small hole should be drilled through the protective casing, a short distance above the top of the surface pad (higher if flooding is anticipated).

Bollards. Bollards (a.k.a. bumpers, traffic guards) are emplaced around the protective casing to hinder the destruction of the well from vehicles. Bollards are often made of six-foot long, 4- to 6-inch diameter iron (black) pipe, filled with concrete. Bollards should be painted in a weather-resistant and highly-visible color paint.

Bollards should be set to a depth of at least 30 inches. They should be placed in an oversized, slough-free borehole or excavation that is filled with concrete. The borehole or excavation for the bollard should be at least 6 inches greater diameter than the bollard. Bollards are typically placed 3 to 6 feet from a well, usually 4 per well. At times, the bollards are embedded in the surface pad.

Bollards are easily knocked over when the momentum (speed and/or weight) of an impacting vehicle is great. For wells that are deeper or otherwise significantly expensive to replace, more robust bollards may be made as follows:

- Use a wider-diameter, thicker walled pipe for the bollard.
- Use a longer pipe. Bury it more deeply yet maintain enough height that any portion of a vehicle will strike the bollard before striking the protective well casing.
- Bury the pipe in a wider excavation. A wider and heavier concrete base is more difficult to dislodge than a narrow, shallow and light base.
- Space the bollards further out from the well. This may require use of 6 or more bollards.

Bollards should not be placed as to completely prevent a development, workover, or sampling rig from accessing the well.

Flush-Mount Completions

Flush-mount completions are constructed for monitoring wells that need to be secured from damage when driven over by vehicles, constructed in locations that have very low likelihood of flooding, and need to be resistant to entry of rainfall or sheetflow. A locking protective street box or vault is the main component of the flush-mount completion. The box needs to have the following characteristics:

- Sufficient strength to not break, crack, significantly sag, or permanently deform when the greatest expectable vehicle wheel weight is upon it
- A lid that is snuggly fitting and securely bolted to the frame
- Minimal potential for rainfall or sheetflow to enter it

The box should be set slightly above surface grade and placed in concrete. The concrete should completely surround the box and be sloped from the top edge of the box to surface grade. The top of the blank well casing should be positioned inside the box to provide sufficient clearance to install a top cap on the casing.

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6.3 Monitoring Well Installation

The basic process for monitoring well installation consists of drilling and preparing the well boring or borehole (includes setting permanent shallow protective casing [if required] and drilling borehole to total depth [TD]); decontaminating the well material (as necessary); connecting the components of the well casing string; carefully placing the well casing string in the borehole; placing/setting the annular materials (filter pack, transition pack [optional], bentonite seal, and cement seal); and constructing the surface completion. The procedures for installation (construction) of a monitoring well depend upon a variety of site-specific conditions and factors discussed in Sections 6.1 and 6.2.

Detailed site-specific procedures for monitoring well installation should be developed and described in the project work plans and be based on the site-specific conditions and factors. Drilling of the borehole for the well should also follow applicable Shaw E & I technical SOPs and project-specific requirements/procedures. An example of a basic monitoring well installation procedure is included as Attachment 2. It is not possible for this SOP to present a detailed, specific procedure that would be applicable to the wide range of well designs, drilling methods, and installation methods available or applicable to specific conditions for a particular project. The example procedure may be customized and supplemented to address site- or project-specific conditions and requirements. Monitoring well installation should be supervised by the rig geologist.

6.4 Documentation

Accurate documentation is important to demonstrate that the monitoring well was installed appropriately and to help ensure the usability of monitoring and sampling results from the well. Appropriate forms should be completed as per applicable Shaw E & I technical SOPs and project-specific requirements/procedures. Such forms can consist of a well construction form and a boring log. An example well construction form is included with this SOP (see Section 8). Basic requirements for generation of boring logs are presented in Shaw E & I technical SOP EID-GS-027, *Standards for Generation of Boring Logs*.

Additional aspects of work may be addressed on separate appropriate forms. Such items to be entered on the appropriate forms include the following:

- Observations or measurements pertaining to health and safety
- Times of starting and completion of tasks and any significant down time
- Any problems or issues related to installing a particular well
- Exact counts (footages, weights, bags, piece numbers, etc.) of materials, as required for payment purposes.

In addition, the regulatory agencies may have specific documentation requirements for monitoring well installations. These requirements should be known and planned for in advance to ensure timely and effective compliance.

6.5 Acceptance

Shaw E & I or client QC programs may have specific requirements for the acceptance of a monitoring well. These requirements may include submittals of documentation (see above discussion) and/or field tests. The following are examples of field QC tests.

<u>Straightness of Well Casing</u>

A well casing must be sufficiently straight that any instrument/equipment used within the casing can freely pass through it. As many instruments/equipment have lengths of 3 feet, 10 feet, or

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even more, a casing that is not straight can cause an instrument or equipment to become stuck or prevent it from passing the area of constriction. Methods to help ensure a straight casing are to drill a straight boring (if possible) and, once the boring is complete, to hang or suspend the casing (using slips, etc.) while constructing the well.

Sediment Content or Turbidity

A client or oversight agency may have a maximum measured turbidity allowed for water samples produced from a monitoring well. They may refuse to accept a well that does not adequately clean up of sediment and turbidity during development. Careful design and construction of the well help ensure that the initial sedimentation rate and turbidity within the well can be reduced to acceptable limits during subsequent development of the well.

At times, monitoring wells are required to be designed and installed in fine-grained non-aquifer units. In such cases, the required maximum turbidity standards may not be achieved even with careful design and well installation practices.

6.6 Technical Review

All monitoring well design and installation specifications, procedures, and results (e.g., reports, forms, etc.) should undergo technical review. It is recommended that the technical reviewer also provide review/oversight of the actual field implementation of monitoring well installation activities. This should include aid in troubleshooting drilling and installation problems. The technical reviewer should be an experienced senior geologist or hydrogeologist. At a minimum, the technical reviewer should be a person capable of planning and supervising monitoring well installation programs. Individuals needing assistance in finding qualified technical reviewers may consult internal Shaw E & I technical listings for experts in well design and installation.

Any issues raised during the technical review shall be resolved between the reviewer and staff planning, conducting, or preparing results of monitoring well installation activities as follows:

- Comments/issues raised relative to planning, designing, and developing detailed procedures for monitoring installation should be resolved before mobilization and drilling/well installation commences.
- Comments/issues raised relative to results of well installation activities should be resolved before external (i.e., outside of Shaw E & I) use or submission of the results.

The technical review comments and issues, and corresponding resolution should be documented and filed with the project records. Such records should be maintained until project closeout.

7. ATTACHMENTS

- Attachment 1, Conditions Potentially Requiring Special Design or Installation Considerations
- Attachment 2, Example Monitoring Well Installation Procedure
- Attachment 3, Example Monitoring Well Construction Form

8. FORMS

None

9. RECORDS

None

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10. REVISION HISTORY AND APPROVAL

Revision Level / Revision Date	Revision Description	Responsible Manager
00 / 08/27/2003	Initial issue	
01 / 01/30/2007	Procedure number changed from SOP-T-GS-031 to EI-GS031, edited ASTM Reference numbers, replaced reference to the Insider with ShawNet, revised Project Responsibility in Section 5.2, added reference to HS308 in Section 6.1.2, changed reference from SOP-T-GS-033 to "EI-GS033 in section 6.2.6, updated description for Engineered (Artificial) Filter Pack in Section 6.2.8, changed reference to SOP-T-GS-027 to EI-GS027	Gary Gaillot
02 / 01/02/2013	Modified format only to align with Governance Management framework.	Scott Logan

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Attachment 1
Conditions Potentially Requiring Special Design or Installation Considerations

Installation over 100 feet total depth – potential for casing failure during installation of well. Careful selection of casing materials and drilling techniques; careful handling of well materials during installation recommended.

Installation in waters with polar organic chemicals at concentrations > approximately 25% of solubility limit – potential for damage to PVC casing, screen, and components. Literature research and possibly using material other than PVC is recommended.

Installation in reducing waters or low pH waters with hydrogen sulfide – potential for corrosion of steel casing components and leaching of metals such as Ni and Cr into well waters. Use of non-metal casing may be recommended.

Drilling through a confining zone between two saturated zones – high potential for advective flow of contaminated water through borehole. Use of a conductor casing or temporary drive casing may be required.

Extremely unstable formation/flowing sands – necessitates careful consideration and implementation of drilling and installation techniques, including use of mud rotary drilling methods and/or temporary drive casing. Use of water to flood hollow stem augers to construct wells in flowing sands is another technique. However, issues may arise with possible chemicals in the water supply used. May also require prior regulatory acceptance/concurrence; some agencies may not allow use of this technique.

Installation at the water table – careful review of range in depth to water is recommended. Recommend for well screen that is high enough and low enough to capture all expected depths of water.

Installation through uncased borehole – a high potential exists for dislodging of loose sidewall materials during installation, and of bridging of sand or seal materials, or entrainment of sloughed sidewall materials. Use of a tremie pipe is recommended for installing filter pack and seals.

Expected use includes active recovery of liquids – the well screen and filter pack should be more carefully designed to ensure adequate flow of liquids into the well casing.

Monitoring for radionuclides – certain well construction materials (such as bentonite) contain naturally-occurring radioactive components. Discussion of construction materials with geoscience leads at Shaw's U.S. Dept. of Energy Project Offices is recommended.

Attachment 2
Example Monitoring Well Installation Procedure

The following monitoring well installation procedure is provided as an example or basic procedure. It should be customized based on project/site-specific conditions, equipment, methodologies, and quality control requirements. This procedure is written for a generic shallow 2- or 4- inch diameter monitoring well installed inside a mud rotary boring or inside hollow stem augers or temporary drive casing. The rig geologist should supervise drilling of the well boring and installation of the monitoring well. The example procedure consists of the following:

1. The well boring should be drilled to the desired total depth using the methods and procedures specified in applicable Shaw E & I technical SOPs and the project work plans. This includes generation of a boring log by the rig geologist during the advancement of the boring.

2. After the borehole has been successfully drilled to the target total depth, remove all drill cuttings prior to constructing the well. Additional conditioning of the borehole may be required depending upon observed conditions. Review logs and notes with the driller for any zones or depths exhibiting drilling problems that may affect the well installation. Make sure the proposed screen depths will be placed in the proper stratigraphic interval. Identify and plan any other necessary actions mutually agreed upon by the rig geologist, project geologist, and the driller to ensure or aid in effective installation of the well.

3. Remove the drill pipe and bit if using rotary techniques, or remove the center stem, bit, and plug if using the hollow-stem auger technique. The well construction materials will then be installed inside the open borehole or through the center of the drive casing or augers.

4. Measure the total depth of the completed boring using a weighted sounding line. Check the borehole depth to ensure that formation material has not heaved to fill the borehole. If heaving has taken place, options for cleaning, redrilling, or installation in the open section of the boring should be discussed with the project geologist and driller.

5. In the event that the hole was drilled beyond the desired depth, sealant (usually bentonite or as specified in the project work plans) may be added to the bottom of the boring to raise the bottom of the hole to the desired depth. The bentonite should be added gradually to prevent bridging. Bentonite addition should stop when its level has reached approximately 6 inches to 1 foot below the desired base of the well casing string. The bentonite plug should be allowed to hydrate for at least 1 hour before installation of a filter pack or other well materials.

6. Calculate volumes of filter pack, bentonite pellets/slurry, and cement grout required, based on borehole and well casing dimensions.

7. Place a layer of filter pack (6 inches to 1 foot, or as specified in the project work plans) at the bottom of the borehole. The filter pack will be installed through the center of the drive casing/augers. Filter pack will be added slowly while withdrawing the drive casing/augers. Measure and record the depth to the top of the layer.

8. Thoroughly decontaminate the blank casing, well screen, sump (optional), and top and bottom caps to be installed in the well according to applicable Shaw E & I technical SOPs and/or the project work plans.

9. Inspect the blank casing, well screen, sump, top and bottom caps, and any other well construction materials prior to installation to ensure that no damage has occurred during shipment and decontamination activities.

10. Connect the well casing string together. Make sure the top cap is securely positioned on the blank casing to prevent unwanted material from entering the well during construction activities. Carefully lower the well string through the open borehole, drive casing, or inside of the augers until the well

string is at the desired depth. The well string should be suspended by the installation rig and should not rest on the bottom of the boring. The casing string should be vertical and centrally positioned in the borehole. Stainless steel centralizers should be used if necessary and feasible. In the event that the well string was dropped, lowered abruptly, or suspected of being damaged during placement, the string should be removed from the boring and inspected.

In certain instances, the well string may rise after being placed in the borehole due to heaving sands. If this occurs, the driller must not place any drilling equipment (drill pipe, hammers, etc.) to prevent the casing from rising. The rig geologist should note the amount of rise. The rig geologist should then consult with the project geologist for an appropriate course of action.

11. Record the following information on the appropriate forms according to this SOP and/or the project work plans: length of well screen, total depth of well boring, depth from ground surface to top of grout or bentonite plug in bottom of borehole (if present), depth to base of well string and depth to top and bottom of well screen.

12. When using the mud rotary drilling technique, tremie the filter pack into the annular space around the screen. Clean, potable water may be used to assist with the filter pack tremie operation. For all other drilling techniques, the filter pack may be allowed to free-fall or be tremied (deeper boring) according to the project work plans. If using drive casing or augers, the drive casing or augers should be pulled slowly during filter pack installation in increments of roughly 0.5 to 1 foot so that the filter pack can fill the annular space between the well screen and borehole wall.

13. Monitor filter pack settlement by initially measuring the sand level (before beginning to withdraw the drive casing/augers). In addition, repeatedly take depth soundings using a weighted tape to continually monitor the level of the sand. The top of the well casing should also be monitored to detect any movement due to settlement or upward lifting from drive casing/auger removal. If the top of the well casing moves upwards at any time during the well installation process, the driller should not be allowed to set drilling equipment (downhole hammers, drill pipe, etc.) on the top of the casing to prevent further movement.

14. Add filter pack until its height is approximately 2 to 3 feet above the top of the screen (unless otherwise specified in the project work plans), and verify its placement (by sounding). The filter pack may then be gently surged or swabbed in order to settle the pack material and reduce the possibility of bridging.

15. The height of the filter pack should then be re-sounded and additional filter pack placed as necessary. Once the placement of the filter pack is completed, the depth to the top of the pack is measured and recorded on the appropriate forms according to the project work plans. The total volume of filter pack used should be recorded and compared to the pre-installation calculated volume. If the actual volume used is less than the calculated volume, the project geologist should be consulted to help determine if bridging of the sand pack occurred.

16. Install a bentonite seal measuring 2 to 3 feet thick (unless otherwise specified in the project work plans) on top of the filter pack. If pellets or chips are used, they should be added gradually to avoid bridging. Take repeated depth soundings using a weighted tape to ascertain the top of the bentonite seal. The seal should be allowed to hydrate for at least one hour, or as specified in the project work plans, before proceeding with the grouting operation.

17. After hydration of the bentonite seal, place cement grout in the annular space. The grout may be pumped through a tremie pipe and filled from the top of the bentonite seal upward. The bottom of the tremie pipe should be maintained below the top of the grout to prevent free fall and bridging. When using drive casing or hollow-stem auger techniques, the drive casing/augers should be raised in incremental intervals, keeping the bottom of the drive casing/augers below the top of the grout. Grouting will cease when the grout level has risen to within approximately 1 to 2 feet of the ground surface, depending on the surface completion type (flush-mount versus aboveground). The grout

levels should be checked for settlement after a time period specified in the project work plans. If settling has occurred, the grout should be topped off to the original level.

18. For above-grade completions, the protective steel casing should be centered over the well casing (riser) and inserted into the grouted annulus. The bottom of the protective casing should be set at a depth of 2 feet below grade. Prior to installation, a 2-inch deep temporary spacer shall be placed between the PVC well cap and the bottom of the protective casing cover to keep the protective casing from settling onto the well cap.

19. Allow a minimum of 24 hours to elapse after final grouting before installing the concrete pad and steel guard posts for above-grade completions, or street boxes or vaults for flush-mount completions.

20. After the protective casing has set, construct a concrete surface pad (2 feet by 2 feet by 4 inches thick) at ground surface around the protective steel casing. The concrete is sloped away from the protective casing to promote surface drainage from the well.

21. Embed four steel bollards to a depth of approximately 30 inches below surface grade. Install the posts in concrete-filled postholes spaced equally around the well at a distance of approximately 3 feet from the protective steel casing.

22. After the surface pad has set, a drainage hole may be drilled into the protective casing if required by the project work plans. The drainage hole is positioned approximately two inches above ground surface, just above the top of the surface pad.

23. For flush-mount completions, set a street box or vault and cement it in position. The street box or vault will be centered over the well casing (riser). The top of the street box or vault will be positioned slightly above grade and the cement sloped to grade to promote surface drainage away from the well

24. Label the wellhead to identify, at a minimum, the well number, depth, and date of installation. A reference or measuring point for measuring water levels may also be placed or marked at the wellhead.

25. Following well completion and demobilization of the rig, the well site should be cleared of all debris and trash and restored to a neat and clean appearance according to the project work plans. All investigation-derived waste generated at the well site should be appropriately contained and managed according to the project work plans.

26. All measurements should be recorded and all appropriate documentation completed according to this SOP and/or project-specific requirements.

27. The wellhead may be surveyed for location and elevation after completion according to applicable Shaw E & I technical SOPs and/or project-specific requirements.

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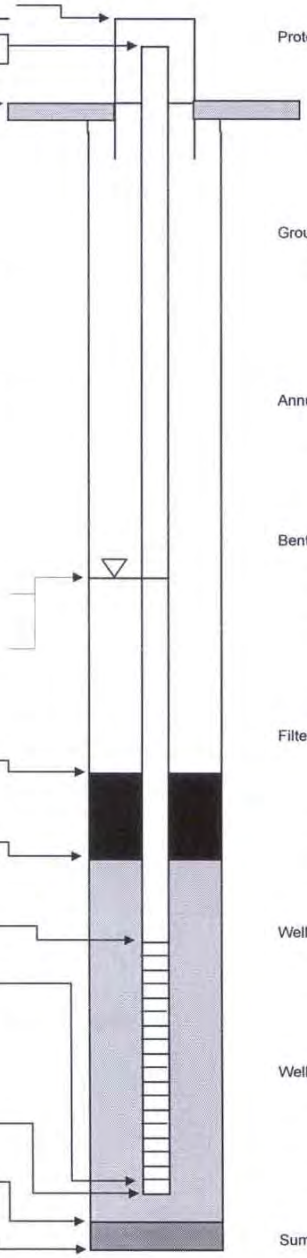
Attachment 3
Example Monitoring Well Construction Form

Monitoring Well Construction Form

Project: _____
Location: _____
Client: _____
Subcontractor: _____
Driller: _____
IT Field Representative: _____

Well Number: _____
Site Location: _____
Installation Date _____
Northing: _____
Easting: _____
NAD: _____ NGVD: _____



Protective Cover Elevation (ft): _____
Top of Casing Elv. (ft): _____
Top of Casing Stickup (ft): _____
Land Surface Elv. (ft): _____

Approximate Diameter of Borehole (in): _____

Well Casing Diameter (in): _____

Depth to Water (ft):
During Drilling: _____
Date: _____
Post Development: _____ TOC
Date: _____

Top of Bentonite Seal (ft): _____

Top of Filter Pack (ft): _____

Top of Screen Interval (ft): _____

Bottom of Screen Interval (ft): _____

Bottom of Well (ft): _____

Bottom of Filter Pack (ft): _____

Bottom of Borehole (ft): _____

Protective Casing:
Type: _____
Dimensions (in): _____
Length (ft): _____
Guard Post: _____

Ground Seal (Surface Pad)
Dimensions: _____
Type: Concrete

Annular Space Seal:
Type: Bentonite-Cement Grout
Installation: Gravity Tremie Pumped

Bentonite Seal:
Manufacturer: _____
Type: Pellets Slurry
Installation: 6-in lifts One Section
Gravity Tremie Pumped
Hydration time (hrs): _____

Filter Pack Material:
Manufacturer: _____
Product Name: _____
Size: _____
Volume Added (ft^3): _____
Installation: Gravity Tremie

Well Casing:
Manufacturer: _____
Type: _____
Diameter (in): _____

Well Screen Casing:
Manufacturer: _____
Type: _____
Slot Size (in): _____ %Open
Slot Type: Continuous wrap Factory slot

Sump/End Cap: _____

Backfill Material: _____

Shaw
Shaw E & I, Inc.

1. PURPOSE

This procedure provides the standard practice for development of monitoring, extraction, and injection wells completed primarily in granular formations. The procedure includes the minimum required steps and quality checks that all employees and subcontractors are to follow when performing the subject task.

This procedure may also contain guidance for recommended or suggested practice that is based upon collective professional experience. Recommended practice goes beyond the minimum requirements of the procedure and should be implemented when appropriate.

2. SCOPE

Geosciences Standard Operating Procedure (SOP) EID-GS-037 describes standards for well development and outlines how such development activities will be conducted for projects executed by Shaw Environmental & Infrastructure, Inc. (Shaw E & I). The SOP addresses technical requirements and required documentation. Responsibilities of individuals performing the work are also detailed. Additional project-specific requirements for well development may be prepared, as necessary, to supplement this procedure and address project-specific conditions and/or objectives.

3. REFERENCES (STANDARD INDUSTRY PRACTICES)

Well development should follow accepted industry practices. These industry practices are presented in the latest version of the following ASTM Standards:

ASTM D 5521	Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers
ASTM D 5092	Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers.
ASTM D 6724	Standard Guide for Installation of Direct Push Ground Water Monitoring Wells
ASTM D 6725	Standard Guide for Installation of Direct Push Ground Water Monitoring Wells

Additional reference materials, which will be useful for planning and conducting well development, include the following:

- Aller, Linda, B.W. Truman, G. Hackett, R.J. Petty, J.H. Lehr, H. Sedoris, D.M. Nelson, J.E. Denne, 1989, *Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells*, National Water Well Association, Dublin, Ohio.
- Driscoll, Fletcher G. 1995, *Groundwater and Wells*, Johnson Division, St. Paul, Minnesota.
- Izraell, Ruth, D. Yeskis, M. Collins, K. Davies, B. Zavala, 1992, *Monitoring Well Development Guidelines for Superfund Project Managers*, U.S. EPA Groundwater Forum, Office of Solid Waste and Emergency Response, April 1992.
- U.S. Environmental Protection Agency, 1986, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, OSWER-9950.1.

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Additional reference materials on well development may be found in regulatory or other governmental links on the Internet.

4. DEFINITIONS

The following definitions are applicable to well development and this SOP.

- **Airlift Pumping**—A method of well development for groundwater production wells. It utilizes an airlift pump consisting of two pipes, with one (the air line) inside the other (the eductor pipe) used to withdraw water from a well. The lower ends of the pipes are submerged, and compressed air is delivered through the inner pipe to form a mixture of air and water. This mixture rises in the outer (eductor) pipe to the surface because the specific gravity of this mixture is less than that of the water column. This method of pumping is not usually recommended by regulatory agencies for development of monitoring wells, since volatile organics may be stripped from the groundwater and since the introduction of air can change formation and groundwater chemistry.

- **Backwashing**—The reversal of water flow (due to the addition of water to a well) that causes water to move through the well screen, through the sand pack, and into the formation to loosen bridges and facilitate the removal of fine-grained materials. Only formation water and a pump without a check valve are used for this process. Water is first discharged from the well and then the pump is shut down. The corresponding water column in the eductor line then flows back down through the pump and into the well, causing the flow reversal.

- **Bailer**—A cylindrical steel, stainless steel, Polyvinyl Chloride (PVC), or Teflon container with a valve at the bottom, and sometimes open at the top, for admission of fluid and sediment. The bailer is attached to a wire line or string and used in recovering and removing water, cuttings, mud, sand, or debris from the bottom of a well.

- **Bailing**—A technique whereby a bailer is lowered to the bottom of a well and then raised to recover and remove water, cuttings, mud, sand, or debris from the well.

- **Eductor Pipe**—The pipe used to transport water discharged to the surface from a pump (during pumping or air lifting).

- **Hydraulic Jetting**—A well development method that employs a jetting tool with nozzles and a high-pressure pump to force water outwardly through the well screen, through the filter pack, and into the adjacent formation to dislodge fine sediment and sand bridges and rehabilitate formation damage from drilling.

- **Overpumping**—Pumping at rates generally greater than those used during sampling, well purging, or general groundwater extraction. Commonly combined with backwashing or surging of the well as part of development.

- **Suction Bailer (Also referred to as a Double Bailer or Moran Bailer or Sand Pump)**—A suction bailer is a specially built bailer that can remove sediment or other foreign objects from the bottom of a monitoring or extraction well. The upward and downward movement of the bailer may also help to surge the well. A suction bailer is one of the tools used by a well development subcontractor.

- **Surge Block**—A plunger-like tool consisting of leather or rubber discs sandwiched between steel or wooden discs that may be solid or valved (vented surge block) that is used in well development. (See “Surging” below.)

- **Surging**—A well development technique using a number of different types of equipment or methods to create a strong inward and outward movement of water through the well screen, through the sand pack, and into the formation.

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- **Turbidity**—The state, condition, or quality of opaqueness or reduced clarity of a fluid due to the presence of suspended matter. Also, a measure of the ability of suspended material to disturb or diminish the penetration of light through a fluid; commonly measured as nephelometric turbidity units (NTUs).

- **Washing**—The addition of water to a well to conduct development. This is usually done for wells with the water level in the middle of the well screen interval. That is, part of the sand pack and formation is not saturated. The water is added to develop the unsaturated portion of the well screen, sand pack, and adjoining formation. Potable water from a domestic water supply is commonly used; however, most regulatory agencies do not like the use of this technique for monitoring wells. Any water added to the well must be of known and acceptable chemistry. The effects of the wash water on the formation groundwater chemistry must also be ascertained.

  Well water may also be used to wash the well cap and inside of the casing (above the static water level) of sediment from the development process. This application of washing is usually acceptable to the regulatory community.

- **Well Development**—The use of any number of mechanical techniques to remove fine-grained materials, drilling fluids, and sand bridges from the well screen, sand pack, and adjacent formation to provide sediment-free representative groundwater samples, enhance well yields, and help restore natural hydraulic conditions in the formation.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Geosciences Discipline Lead is responsible for the development, maintenance, and revision of this procedure. Any questions, comments, or suggestions regarding this technical SOP should be directed to the Geosciences Discipline Lead. The Geosciences Discipline Lead's location and associated contact information can be found on the Shaw Group intranet site, ShawNet.

5.2 Project Responsibility

Employees conducting well development are responsible for meeting the requirements of this procedure. Employees conducting field technical review of well development activities are also responsible for following appropriate portions of this SOP. Project participants are responsible for recording information in sufficient detail to provide objective documentation (field notes, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURES (TECHNICAL REQUIREMENTS AND STANDARDS)

This section presents information on basic considerations and methods, planning and preparation, basic procedures and requirements, and technical review requirements for well development.

6.1 Basic Considerations and Methods

Well development is conducted to help restore natural hydraulic conditions in the formation, enhance well yields, and provide sediment-free water samples from the wells that are representative of groundwater in the formation. The development process involves use of one or a combination of mechanical methods to 1) recover fluids introduced into the formation and sand pack during drilling; 2) remove fine-grained materials and sand bridges from the sand pack and adjacent formation; 3) remove the "skin" from the borehole wall; and 4) help repair damage to the formation from drilling.

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Well development should be conducted on all newly installed wells, after a specified period of time (e.g., a minimum of 48 hours and not more than 7 days after sealing the annular space of the well). State or local regulatory agencies may specify the time period; individuals planning well development activities should be aware of such requirements relative to their specific site(s). Monitoring wells may also be redeveloped after they have not been used for a period of time, when they show evidence of sediment buildup in the bottom of the well, or when they start yielding turbid water samples. Extraction/injection wells may also be redeveloped to restore or improve yield and specific capacity, and after rehabilitation efforts.

Many well development methods are currently in use within the industry. These include surging, bailing, pumping, overpumping, airlifting, washing, backwashing, and jetting. Descriptions and information on these methods are provided in Driscoll (1986) and ASTM D 5521. Some combination of methods are specifically planned and implemented for development of wells relative to specific construction parameters and subsurface conditions at a particular site. For instance, monitoring wells can be developed by surging and pumping; surging and bailing; bailing, pumping, and backwashing; etc. The focus of developing monitoring wells is generally towards cleaning the filter pack to provide representative groundwater samples, though some monitoring wells are used for slug and specific capacity testing and may require more aggressive development. Development methods should be selected to reflect the main objective.

The focus of extraction/injection well development is generally towards restoring the natural hydraulic conditions in the formation and enhancing well yields. Many extraction/injection wells are installed using mud rotary methods. Consequently, development of such wells tends to commonly be a multi-staged process utilizing several different and “aggressive” methods. These methods and operations are utilized to clean the filter pack, breakdown the mud cake, and repair the formation at the filter pack/formation interface. Polyphosphates and/or surfactants may be used to remove drilling mud from the well. Example combinations of methods for extraction/injection well development include airlifting, jetting, and mechanical surging; jetting, pumping, and overpumping; bailing, mechanical surging, and pumping; etc.

The specific combination used should include a method that imparts a surge or flow of water from the well out thorough the sand pack, into the formation, and back through the sand pack into the well. This surge or flow is necessary to remove fine-grained materials and drilling fluids, and to break up sand bridges in the sand pack and formation.

The exact combination of development methods to be used for wells at a site depends on a variety of project- or site-specific factors that include, but are not limited to, the following:

- Development objectives
- Intended use and type of the well
- Well construction parameters
- Drilling methods used, including type of drilling fluids and volume of fluid loss
- Regulatory requirements
- Type(s) of contaminants present, or potentially present, including non-aqueous phase liquids (NAPLs)
- Type and composition of formation at the well completion interval
- Water level position inside the well
- Other previous well development issues or problems occurring at the site
- Types and relative costs of methods available by local subcontractors

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Certain special well construction and site conditions may require additional evaluation and consideration for the planning and implementation of well development activities. Some conditions potentially requiring special planning and implementation considerations are listed in Attachment 1.

Individuals planning and selecting appropriate development methods/combinations for their particular wells should consider and evaluate the above information. They should look at methods and techniques used for previous similar wells (completed in the same formations) on site or near the site area. They may also seek the aid of an experienced senior geologist or hydrogeologist. Individuals needing assistance in finding qualified technical assistance may consult internal Shaw technical listings for experts in well development.

6.2 Planning and Preparation

Planning and preparation for well development activities involves the following:

- Identifying specific well development objectives and development methods to be used (including possible limitations to the development methodologies)
- Determining specific well(s) to be developed, locations of the wells, and specific identification numbers for the wells
- Securing construction details and information on the expected condition of each of the wells to be developed
- Listing known or assumed hydrogeologic conditions for each well, e.g., high yield, low yield, potential for presence of non-aqueous phase liquid (NAPL)
- Identifying and listing exact equipment to be used (simple or complex)
- Determining type, duration, and frequency of field parameter measurements to be made during development
- Identifying and listing exact criteria to be used to determine when a well has been sufficiently developed
- Describing the estimated duration(s) of the development effort per well
- Specifying water and sediment handling and disposal requirements
- Identifying site access and restrictions on equipment layout
- Determining and listing expected hardcopy and electronic work products to be generated from the development activities
- Listing all pertinent Health and Safety issues and requirements, including those contained in the project-specific Health and Safety Plan(s), relative to work activities
- Identifying applicable requirements of this and other SOPs and pertinent project-specific requirements for the well development effort
- Determining and describing detailed project-specific procedures for the well development effort
- Identifying all main subcontractor requirements for well development to be compiled into subsequent Statement of Work to procure subcontractor services
- Procuring the appropriate well development subcontractor

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The above information is necessary for effective implementation of the well development effort and should be presented in the project work plans, especially the detailed project-specific development procedures.

Prior to initiating well development activities in the field, site personnel and subcontractors should be briefed on the above information and any additional information contained in the project work plans, along with project or corporate health and safety requirements. This is done to familiarize personnel with specific objectives, requirements, procedures, and hazards associated with the site as well as health and safety procedures associated with the field operation. The Project Manager or designee is responsible for ensuring that the briefing is conducted.

6.3 Basic Procedures and Requirements

This text describes the basic method or process for conducting well development. It is not possible to write a single specific procedure for well development applicable to the wide range of sites encountered and methods available. Attachments 2 and 3 provide example general procedures for monitoring well and extraction/injection well development, respectively. These example procedures should be modified or customized, as appropriate, to address specific site conditions and requirements. These detailed project-specific procedures should be presented in the project work plans.

The basic process for monitoring well development is as follows.

- Decontaminate the development rig and all development equipment, including pumps, bailers, riser pipes, etc., in accordance with appropriate Shaw E & I technical SOPs and/or project-specific requirements/procedures.
- Calibrate all field measuring and testing equipment (e.g., pH, temperature, conductivity, turbidity, dissolved oxygen meters, etc.) according to the instrument manufacturer's specifications, and appropriate Shaw E & I technical SOPs and/or project-specific requirements.
- Access the wellhead according to the project work plans; visually inspect the well to ensure that it is undamaged, properly labeled, and secured (locked). Any observed problems with the wellhead should be noted on the appropriate forms and reported to the Site Superintendent.
- Unlock the well and obtain a depth to water level measurement according to applicable Shaw E & I technical SOPs or project-specific procedures/requirements. Sound the total well depth and compare that value with the value shown on the well completion diagram or form. In addition, observe and record any unusual conditions such as possible obstructions or tight-spots as the well tape is lowered or removed from the well. (Do not insert bailers, pumps, or surge blocks into the well if obstructions, parting of the casing, or other damage to the well are suspected. Instead, report the conditions to the Site Superintendent and Project Manager and obtain approval to continue or cease well development activities, as appropriate.)
- Calculate the volume of water in the well (well volume). The equation for the calculation is shown on the Example Well Development Record (Section 8).
- Collect an initial sample of the well water and measure and record field parameters on the appropriate forms according to the project work plans.
- Compare the measured total well depth to the well construction diagram. If sand or sediment is present inside the well, it should be first removed. This is usually done by bailing; however, airlifting may also be used for extraction/injection wells. (Note: during the initial lowering of the bailer into the well, direct the subcontractor to lower the bailer <u>slowly</u>, and not drop the

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bailer to the bottom of the well. Failure to do this may cause the bailer to stick, break, or dislodge the well bottom cap or sump, resulting in costly repair/replacement of the well).

- Periodically measure the depth to water and check to see that the well recovers sufficiently during and immediately after sediment removal.
- Begin developing by applying the development method or combination of methods as specified in the project work plans. Begin gently at first and then progress as appropriate and specified.
- While development progresses, take periodic water level measurements (as specified in the project work plans) (at least one every 5 to 10 minutes) to determine if drawdown is occurring, and record the measurements on the appropriate forms.
- While development progresses, measure the water discharge and calculate the rate at which water is being removed from the well. Record the volume, time, and rate on the appropriate forms. Record any observations made regarding general well yield and/or recovery.
- While developing, periodically collect water directly from the pump, eductor pipe, or bailer discharge and measure for specified parameters. The time intervals for collection and measurement (e.g., every 15 minutes, etc.) should be listed in the project work plans. The parameters measured usually include temperature, pH, conductivity, and turbidity. Dissolved oxygen (DO) and oxidation/reduction potential (ORP) are optional parameters that may also be measured. All measurements and associated times should be recorded on the appropriate form(s).
- Development should continue until a predetermined set of conditions are met. The exact conditions and criteria should be specified in the project work plans. These can include the following:
  - The well water appears clear and sediment-free to the unaided eye
  - The sediment thickness remaining in the well is less than 1 percent of the screen length
  - A predetermined number of well volumes (previously calculated) of water, usually from three to five, have been removed from the well
  - The final turbidity goal (usually 5 or 10 NTUs) has been attained
  - The measured indicator parameters have stabilized. Stabilization is defined where three or more readings are within tolerances specified in the project work plans. Example tolerances and indicator parameters include 0.1 units for pH; 1 degree F or less for temperature; and 10 percent or less for conductivity.
  - Drilling fluids have been sufficiently removed from the formation, as determined by a review of measured parameters
  - Sand production during pumping is less than or equal to a specified value (e.g., 3 parts per million [ppm])

Terminating development prior to attaining the required water removal and stabilized parameters will require the concurrence of the Project Geologist/Hydrogeologist. The Project Geologist/ Hydrogeologist is responsible for ensuring that development activities are appropriately planned and implemented. The individual selected as the Project Geologist/Hydorgeologist should be a senior professional with experience in planning, implementing, and evaluating well development programs.

- Once development is considered complete, obtain a final water level and turbidity measurement and record on the appropriate form(s). Collect a 1-pint sample of the well water for storage and photographing.

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- Remove all equipment from the well and decontaminate appropriately for storage or development of another well according to the project work plans.
- Complete documentation of the well development event on the appropriate form(s). At a minimum, the following information should be recorded:
  - Project name/client name
  - Project number
  - Well I.D. number
  - Location
  - Start and end dates
  - Developer/subcontractor
  - Well diameter
  - Total depth of well as installed and at end of development
  - Top and bottom depth of screen/sand pack
  - Static water level
  - Development method(s) used
  - Equipment used; decontamination method and calibration method
  - Record of water levels, volumes removed, measured parameters, measurement times, and any observations
- Collect and appropriately transport and dispose of water removed from the well in accordance with the project work plans and regulatory requirements.
- Allow the well to recover for a time period specified in the project work plans prior to sampling (generally 24 to 48 hours - check for local and/or regulatory requirements).

6.4 Technical Review

All well development procedures, data analysis, and results (e.g., reports, etc.) should undergo technical review. It is recommended that the technical reviewer also provide review/oversight of the actual field implementation of well development activities. The technical reviewer should be an experienced senior geologist or hydrogeologist. At a minimum, the technical reviewer should be a person capable of planning, conducting, and evaluating well development activities and results. Individuals needing assistance in finding qualified technical reviewers may consult internal Shaw technical listings for experts in well development.

Any issues raised during the technical review should be resolved between the reviewer and staff conducting the well development activities before external (i.e., outside of Shaw) use or submission of the results. The technical review comments and issues, and corresponding resolution, shall be documented and filed with the project records. Such records should be maintained until project closeout.

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7. ATTACHMENTS

- Attachment 1, Conditions Potentially Requiring Special Well Development Considerations
- Attachment 2, Example Monitoring Well Development Procedure
- Attachment 3, Example Extraction/Injection Well Development Procedure
- Attachment 4, Example Well Development Record

8. FORMS

None

9. RECORDS

- Well Development Record

10. REVISION HISTORY AND APPROVAL

Revision Level / Revision Date	Revision Description	Responsible Manager
00 11/25/2003	Initial issue.	John E. Sciacca
01 02/08/2007	Procedure number changed from SOP-T-GS-037 to EI-GS037, Section 3 edited ASTM reference numbers and reference books, Section 5.1 added reference to ShawNet, Section 5.2 revised project responsibility, Section 6.1 edited ASTM reference number.	Gary Gaillot
02 01/02/2013	Modified format to align with Governance Management framework. Corrected example well development record for m (Attachment 4).	Scott Logan

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Attachment 1
Conditions Potentially Requiring Special Well Development Considerations

Wells completed in fine-grain-dominated formation materials (i.e., in units dominated by clay, silt, or fine sand); not in an aquifer – For some of these formations, no well design or development technique can reduce the turbidity of the water or improve the well efficiency or hydraulic conductivity of the formation. Aggressive development of such wells can actually damage the wells or substantially increase the turbidity of the water. Suitable objectives and methods will need to be compiled for the development effort and possibly discussed with the client and regulatory agencies beforehand. Development of such wells should be conducted and progress carefully.

Wells with a minimal height of water column (e.g., less than 2 feet) inside the well screen – Such wells should not be surged, but can be developed with bailing and pumping, and may need to be developed again in stages; that is, come back in the wet season when the water level may be higher. These wells may be developed by bailing (to remove sediment) and pumping, and could also be developed by washing; however, any water added to the well must be of acceptable and known chemistry. The effect of such water on the formation groundwater chemistry must also be ascertained. Such use will also likely require prior regulatory approval. All water added to the well should be removed; this is not always possible.

Damaged wells – Damaged or obstructed wells should never be developed or redeveloped. Such wells first need to be repaired or replaced.

Use of surge blocks in PVC wells/well screens – The use of surge blocks in such wells has a high potential to collapse or damage the PVC well screens. A vented surge block may help. The development subcontractor should use the surge block carefully in a slow and gentle manner when starting to surge a well. When sediment is first removed from the well by bailing, pumping, or airlifting it is important to monitor the water level to see if the well recharges sufficiently. A well that does not recharge sufficiently has a sediment-blocked screen or sand pack; this will result in collapsing of the screen during surging if the blockage isn't removed first.

Small diameter wells (i.e. < 2 inches in diameter) – Such wells are commonly installed using direct-push methods and usually cannot be developed with a surge block. They are commonly developed by bailing and pumping. Because many of these wells are installed in fine-grain-dominated formations, development should be conducted carefully and initially at low discharge rates.

Use of long or heavy bailers with power winch systems – Long stainless steel bailers are commonly used by development subcontractors with power winch systems. At times, the subcontractor lowers the bailer too quickly and the bailer hits and dislodges the bottom cap or well sump. The subcontractor must be instructed to first carefully lower the bailer to the bottom of the well and mark the cable appropriately. Thereafter the subcontractor must lower the bailer carefully, noting when the bailer is approaching the bottom of the well and slowing the winch down appropriately.

Attachment 2
Example Monitoring Well Development Procedure

This text provides an example monitoring well development procedure by bailing, pumping, and back-washing. Other projects and sites may have different conditions and requirements and use different development methods. This example procedure may therefore be modified or customized, as appropriate, to address specific site conditions, requirements, and methods.

The example procedure is as follows:

1. Develop the well no less than 2 days and not more than 7 days after well installation is complete.

2. Decontaminate the development rig and all downhole equipment (e.g., pumps, bailers, discharge pipes, etc.) in accordance with the project work plans and Shaw E & I SOPs. This includes steam cleaning with unchlorinated water from an approved source followed by thorough rinsing with 100-PPM unchlorinated, organic-free water.

3. Inspect the equipment to ensure that it is in good working order. Repair or replace damaged or malfunctioning equipment and decontaminate appropriately.

4. Calibrate and test all measuring and testing equipment prior to use according to manufacturer's specifications and appropriate project-specific requirements and procedures.

5. Access the wellhead according to the project work plans; visually inspect the well to ensure that it is undamaged, properly labeled, and secured (locked). Any observed problems with the wellhead should be noted on the appropriate forms and reported to the Site Superintendent.

6. Unlock the well and obtain a depth-to-water level measurement according to applicable Shaw E & I technical SOPs or project-specific procedures/requirements. Then sound the total well depth and record the measurements on the appropriate forms specified in the project work plans. (If LNAPL or DNAPL is expected, use an interface probe for monitoring according to applicable Shaw E & I technical SOPs.)

   In addition, observe and record any unusual conditions such as possible obstructions or tight-spots as the well tape is lowered or removed from the well. (Do not insert bailers or pumps into the well if obstructions, parting of the casing, or other damage to the well are suspected. Instead, report the conditions to the Site Superintendent and obtain approval to continue or cease well development activities, as appropriate.)

7. Calculate the volume of water in the well (well volume). (The equation for the calculation is shown on the Example Well Development Record [Section 8].)

8. Slowly lower a bailer into the well to mid-screen and collect a water sample. Empty the sample into a vessel and measure and record field parameters on the appropriate forms according to the project work plans and as discussed below.

9. Compare the measured total well depth to the well construction diagram. If sand or sediment is present inside the well, it should be first removed by bailing. After the bailer is initially placed on the bottom of the well, check to make sure that the subcontractor marks the wire line as to the total depth of the well. Bail the sediment from the bottom of the well.

10. Periodically measure the depth to water and check to see that the well recovers sufficiently during and immediately after sediment removal via bailing.

11. Once sediment removal is complete, measure the water level. Allow sufficient equalization of the water level to commence pumping.

12. Lower a decontaminated electric-powered submersible pump (without check valve) into the well and pump the well.

13. Periodically during pumping, the well will be backwashed by turning the power of the pump off and allowing the water in the pump pipe to flow back into the well. (This creates a surging action of water into the screen, sandpack, and formation.) Additionally, the pump will be periodically lifted up and down inside the well screen while the pump is operating. Water will not be added to the well to aid in development, nor will any type of airlift techniques be used.

14. While developing, periodically collect water directly from the pump eductor pipe or bailer discharge every 15 minutes and measure for the following parameters: temperature, pH, conductivity, turbidity, and possibly dissolved oxygen (DO) and oxidation/reduction potential (ORP). Record all measurements and associated times on the appropriate form(s).

15. Rinse the cap and all internal components of the well casing above the water table with well water to remove all traces of soil/sediment/cuttings. Washing will be conducted before and/or during development.

16. Development will proceed until the following conditions are met:

    - The well water appears clear to the unaided eye.
    - The measured turbidity is $\leq$ 5 NTU.
    - The sediment thickness remaining in the well is less than 1 percent of the screen length (the depth to the water/sediment interface will be measured with a weighted tape and the percentage of sediment height to screen length will be calculated).
    - At least three well volumes (including the saturated filter material in the annulus), plus the volume of water/drilling fluid lost during the drilling process has been removed from the well.
    - The pH, temperature, and conductivity of the development water have stabilized. Stabilization is defined as successive readings in which the pH has changed $\leq$ 0.1 pH units, temperature has changed $\leq$ 1 degree F, and conductivity has changed by less than 10%.

17. Once development is considered complete, obtain a final water level and turbidity measurement and record the measurement on the appropriate form(s). Collect a 1-pint sample of the well water; label the jar with the well number and development date. Agitate the sample and immediately photograph with a 35-millimeter camera in a backlit setting so that the clarity of the water is visible. Prepare the sample for storage according to the project work plans.

18. Remove all equipment from the well; if the equipment is to be stored, decontaminate appropriately according to the project work plans.

19. Cap and secure the wellhead.

20. Complete documentation of the well development event on the appropriate form(s). At a minimum, the following information should be recorded:

    - Project name/client name
    - Project number
    - Well I.D. number
    - Location
    - Date of well installation.

- Start and end dates of development
- Developer/subcontractor
- Well diameter
- Height of well casing above ground surface
- Quantity of water lost during drilling
- Total depth of well as installed and at end of development
- Top and bottom depth of screen/sand pack
- Static water Level
- Development method(s); description of pumping technique
- Type and size/capacity of pump used
- Equipment used, decontamination method, and calibration method
- Record of water levels, volumes removed, measured parameters, and measurement times
- Any observations including physical character of removed water and changes in clarity, color, particulates, and odor during development

21. Collect and appropriately transport and dispose of water removed from the well in accordance with the project work plans and regulatory requirements.
22. Allow the well to recover for at least 48 hours prior to sampling.

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Attachment 3
Example Extraction/Injection Well Development Procedure

This text provides an example extraction/injection well development procedure by airlifting, jetting, surging, pumping, and overpumping. Other projects and sites may have different conditions and requirements and use different development methods. This example procedure may therefore be modified or customized, as appropriate, to address specific site conditions, requirements, and methods. Extraction and injection well development is a multi-staged process whereby different operations and techniques are utilized to clean the filter pack, breakdown the mud cake, and repair the formation at the filter pack/formation interface.

During extraction/injection well development, chemical additives may need to be used, with prior regulatory agency approval, to assist in breaking down mud cake built up during mud rotary drilling. Drilling mud can be a polymer mud (e.g. Polygel), a bentonite-based mud, or a combination of both (e.g. Quikgel). An example of an additive for the dispersal of polymer drill mud is sodium hypochlorite (which will release free chlorine into the well). An example of using an additive to disperse bentonite mud or other clays is the addition of polyphosphates. Polyphosphates should be added in accordance with the manufacturer's specifications. Whenever using chemical additives, care must be used to remove all chemical additives. Over-pumping of the well is recommended to remove the chemical additives.

The example procedure is as follows:

1. Develop the well no less than 2 days and not more than 7 days after well installation is complete.

2. Decontaminate the development rig and all downhole equipment (e.g., pumps, bailers, surge blocks, jetting tools, discharge pipes, etc.) in accordance with applicable Shaw E & I technical SOPs and project-specific requirements/procedures. This includes steam cleaning with unchlorinated water from an approved source followed by thorough rinsing with 100-ppm unchlorinated, organic-free water.

3. Inspect the equipment to ensure that it is in good working order. Repair or replace any damaged or malfunctioning equipment and decontaminate appropriately.

4. Calibrate and test all measuring and testing equipment prior to use according to manufacturer's specifications and appropriate project-specific requirements and procedures.

5. Access the wellhead according to the project work plans; visually inspect the well to ensure that it is undamaged, properly labeled, and secured (locked). Any observed problems with the wellhead should be noted on the appropriate forms and reported to the Site Superintendent.

6. Unlock the well and obtain a depth-to-water level measurement according to applicable Shaw E & I technical SOPs or project-specific procedures/requirements. Then sound the total well depth and compare that value with the value shown on the well completion diagram or form. In addition, observe and record any unusual conditions such as possible obstructions or tight-spots as the well tape is lowered or removed from the well. (Do not insert bailers, pumps, jetting tools, or surge blocks into the well if obstructions, parting of the casing, or other damage to the well is suspected. Instead, report the conditions to the Site Superintendent and obtain approval to continue or cease well development activities, as appropriate.)

7. Obtain a water level depth measurement and sound the bottom of the well. (If LNAPL or DNAPL is expected, use an interface probe for monitoring according to applicable Shaw E & I technical SOPs.)

8. Calculate the volume of water in the well (well volume). (The equation for the calculation is shown on the Example Well Development Record [Section 8].)

9. Collect an initial sample of the well water and measure and record field parameters on the appropriate forms according to the project work plans and as discussed below.

10. Compare the measured total well depth to the well construction diagram. If sand or sediment is present inside the well, they should be first removed by airlifting. (Note: if the air supply is from an air compressor and the well will be sampled for petroleum hydrocarbons, an appropriate filter will need to be placed between the airline and the compressor.) Periodically measure the depth to water and check to see that the well recovers sufficiently during and immediately after sediment removal via airlifting.

11. Periodically measure the depth to water and check to see that the well recovers sufficiently during and immediately after sediment removal.

12. Once sediment removal is complete, the entire screen shall be jetted with water using a jetting tool (see page 516 of Driscoll [1995]). The jetting velocity shall be between 150 and 300 feet per second, or using a pressure not to exceed screen manufacturer's recommendations. The Sediment should then be removed from the bottom of the well via airlifting. Two cycles of jetting should be required.

13. Mechanically surge the entire length of the well screen with an approved appropriate-sized surge block to remove sediment from the filter pack. The surging should start slowly at first in the blank casing just above the screen, then get progressively stronger to be effective.

14. The surging shall proceed in 10-foot intervals from just above the top of the screen and working down. Each 10-foot section should be surged for 10 minutes. The rate of ascent and descent of the surge block within the 10-foot section should be increased to about 3 feet per second, or as directed. The section of screen should then be isolated with a shell-catcher, or other device, and pumped at a predetermined rate (the rate will be increased up to the maximum allowable rate) until the return water is clear. The surging shall be repeated until the working section pumps clear after surging. This process shall be continued down the entire length of the well's screened interval. Depending upon the amount of material pulled through the screen into the well, airlifting should be incorporated at any point in this stage of well development to remove sediment and prevent the surge block from becoming sand-locked.

15. Following jetting and surging, a submersible pump will be installed approximately 10 feet below the expected maximum drawdown. The well will be pumped at progressively higher rates until the discharge water is visually clear and sediment free. The pumping rate will be stepped up from the design flow rate to a maximum flow rate of approximately 2 to 5 times higher.

16. While developing, periodically collect water directly from the pump eductor pipe discharge every 15 minutes and measure for the following parameters: temperature, pH, conductivity, turbidity, and possibly dissolved oxygen (DO) and oxidation/reduction potential (ORP). Record all measurements and associated times on the appropriate form(s).

17. Rinse the cap and all internal components of the well casing above the water table with well water to remove all traces of soil/sediment/cuttings. Washing will be conducted before and/or during development.

18. Development will proceed until the following conditions are met:

    - The well water appears clear to the unaided eye.
    - The sediment thickness remaining in the well is less than 1 percent of the screen length (the depth to the water/sediment interface will be measured with a weighted tape and the percentage of sediment height to screen length will be calculated).
    - At least five well volumes (including the saturated filter material in the annulus), plus the volume of water/drilling fluid lost during the drilling process, has been removed from the well.
    - The measured turbidity is $\leq$ 10 NTU.

- The pH, temperature, and conductivity of the development water have stabilized. Stabilization is defined as successive readings in which the pH has changed ≤ 0.1 pH units, temperature has changed ≤ 1 degree F, and conductivity has changed by less than 10%.
- Sand production during pumping is less than 3 parts per million (ppm).

19. Once development is considered complete, obtain a final water level and turbidity measurement and record on the appropriate form(s). Collect a 1-pint sample of the well water; label the jar with the number and development date. Agitate the sample and immediately photograph with a 35-millimeter camera in a backlit setting so that the clarity of the water is visible. Prepare the sample for storage according to the project work plans.
20. Remove all equipment from the well and decontaminate appropriately for storage according to the project work plans.
21. Cap and secure the wellhead.
22. Complete documentation of the well development event on the appropriate form(s). At a minimum, the following information should be recorded:
    - Project name/client name
    - Project number
    - Well I.D. number
    - Location
    - Date of well installation
    - Start and end dates of development
    - Developer/subcontractor
    - Well diameter
    - Height of well casing above ground surface
    - Quantity of water lost during drilling and fluid purging
    - Total depth of well as installed and at the time of development
    - Top and bottom depth of screen/sand pack
    - Static water level
    - Development method(s); description of surging, jetting, and pumping technique
    - Type and size/capacity of pump used
    - Equipment, decontamination method, and calibration methods used
    - Record of water levels, volumes removed, measured parameters, and measurement times
    - Any observations including physical character of removed water and changes in clarity, color, particulates, and odor during development
23. Collect and appropriately transport and dispose of water removed from the well in accordance with the project work plans and regulatory requirements.

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24. Allow the well to recover for at least 24 hours prior to sampling.

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Attachment 4
Example Well Development Record

Project Name: _____

Location: _____ Well/Piez. No.: _____

Personnel: _____ Date Installed: _____

Date (Start/End): _____ Csg. Diameter (I.D.): _____

Method of Development: _____ Total Depth (ft. TOC): _____

❑ Surging ❑ Bailing ❑ Pumping ❑ Other (State Method) _____

❑ Original Development ❑ Redevelopment Development Date: _____

Depth to water before developing well: _____

		Volume (V)		Purge Factor		Volume To Purge
Height of Water Column: _____ feet _____	=	_____ gal.*		_____	=	_____

$$V = (B * r_c^2 * L_c * 7.48)+(B*(r_w^2-r_c^2)*L_s*ø_s*7.48)=_____ \text{ gallons (See Notes below)}$$

Depth purging from: _____ feet Time purging begins: _____

Weather: _____ Screened Interval (ft. BGL): _____

Equipment Nos.: pH Meter_____ EC Meter_____ Turbidity Meter_____

Equipment decontaminated prior to development Y _____ N _____

Describe _____

Date	Time	Water Level (ft. below TOC)	Volume Removed (gal.)	Temp (C or F)	pH	EC	Turbidity	D.O.	Comments

Notes:

- Water levels – Reported to the nearest 0.01 foot.
- pH – Reading rounded to 0.1 pH units
- Electrical conductivity (EC) – Reported to the nearest 10% mhos/cm or
- µmho/cm @25 C or in mS/cm of instrument set range
- Water temperature – Reported to the nearest 0.1 C or F
- Dissolved oxygen (D.O.) report in 0.1 mg/L
- Turbidity report in NTV nearest whole #

Where:

B=3.14
$ø_s$=porosity of the sand pack
r_c =radius of the well casing and screen in feet
L_c=length of water column inside the casing and screen in feet
r_w =radius of the well bore in feet
L_s =length of saturated portion of the sand pack in feet
7.48 gallons/cubic foot=conversion from cubic feet to gallons

Shaw® a world of Solutions™	Document Type: **Discipline-Specific Procedure**	Level: 3 Owner: Applied Science & Engineering Origination Date: 6/5/2003 Revision Date: 8/25/2011
Group: E&I	Title: Decontamination of Contact Sampling Equipment	No: EID-FS-014 Revision No.: 2 Page 1 of 3

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1. PURPOSE

This procedure is intended to provide minimal guidelines for the decontamination of contact sampling equipment. Contact sampling equipment is equipment that comes in direct contact with the sample or the portion of a sample that will undergo chemical analyses or physical testing.

2. SCOPE

This procedure applies to all instances where non-disposable direct contact sampling equipment is utilized for sample collection and no project-specific procedure is in place. This procedure is not intended to address decontamination of peristaltic or other sampling pumps and tubing. The steps outlined in this procedure must be executed between each distinct sample data point.

3. REFERENCES

- U.S. Environmental Protection Agency, Region 4, 2001, *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual*, 980 College Station Road, Athens, Georgia. November.
- US Army Corp of Engineers, Washington, D.C., 2001, Requirements for the Preparation of Sampling and Analysis Plans (EM-200-1-3), February.

4. DEFINITIONS

- **Soap**—A standard brand of phosphate-free laboratory detergent, such as Liquinox®.
- **Organic Desorbing Agent**—A solvent used for removing organic compounds. The specific solvent would depend upon the type of organic compound to be removed. See Attachment 1 for recommendations.
- **Inorganic Desorbing Agent**—An acid solution for use in removing trace metal compounds. The specific acid solution would depend upon the type of inorganic compound to be removed. See Attachment 1 for recommendations.
- **Tap water**—Water obtained from any municipal water treatment system. An untreated potable water supply can be used as a substitute for tap water if the water does not contain the constituents of concern.
- **Distilled Water**—Water that has been purified via distillation. Distilled water can be purchased in most stores and is acceptable as a final rinse in non-trace analytical decontamination processes. Examples would include disposal profiling, HazCat, and other gross screening applications.
- **Analyte-free water**—Water that has been treated by passing through a standard deionizing resin column, and for organics either distillation or activated carbon units. At a minimum, the finished water should contain no detectable heavy metals or other inorganic compounds, and/or no detectable organic compounds (i.e., at or above analytical detection limits). Type I and Type II Reagent Grade Water meet this definition as does most laboratory-supplied blank water.

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5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be sent to the Field Sampling Discipline Lead.

5.2 Project Responsibility

Shaw employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURE

Wear appropriate eye protection including safety goggles when working with corrosive liquids, especially when diluting concentrated materials to create low-percentage solutions and follow all project Health and Safety requirements. Decontamination wastes are to be recovered and handled as impacted project waste materials and must be disposed of in accordance with regulatory requirements.

A decontamination area should be established. Implements can either be immersed in a 5-gallon bucket containing each solution/rinse or the solutions can be contained in hand-held units made of an inert and compatible material; such as a Teflon™ wash bottle. The analyte-free water needs to be placed in a container that will be free of any compounds of concern.

Consult Attachment 1 for the decontamination solutions/solvents appropriate to the task. The minimum steps for decontamination are as follows:

1. Remove particulate matter and other surface debris by brushing and/or dipping in the soap solution.
2. Rinse thoroughly with tap water.
3. If necessary, rinse with other applicable solutions/solvents. If hexane is used, be sure to follow it with isopropyl alcohol to allow for the final water rinses to properly mix and contact the surface.
4. Final rinse three times to make sure all residual solutions/solvents are removed.
5. Place decontaminated equipment on a clean surface appropriate for the compounds of concern and allow to air dry.

7. ATTACHMENTS

- Attachment 1, Recommended Decontamination Procedures.

8. FORMS

None

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9. RECORDS

None

10. REVISION HISTORY AND APPROVAL

Revision Level / Revision Date	Revision Description	Responsible Manager
00 / 06/05/2003	Initial issue	N/A
01 / 09/08/2006	Updated template and updated numbering of procedure, Sections 1 and 2 minor edits, added definition for Distilled Water, Section 6- extensive content changes	Guy Gallello
02 / 08/25/2011	Modified format only to align with Governance Management Framework	Scott Logan

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Attachment 1
Recommended Decontamination Procedures

Compound	Detergent Wash	Tap Water	Inorganic Desorbing Agent	Tap Water	Organic Desorbing Agent1	Final Water Rinse4	Air Dry
Organic Constituents							
Volatile Organic Compounds	✓	✓			Methanol Purge & Trap grade	✓	✓
Base Neutrals/Acid Extractables/PCBs/Pesticides	✓	✓			Hexane followed by Isopropyl Alcohol	✓	✓
Organic Bases[2]	✓	✓	1% nitric acid	✓	Isopropyl Alcohol	✓	✓
Organic Acids[3]	✓	✓	1% nitric acid		Isopropyl Alcohol	✓	✓
Inorganic Constituents							
Trace Metals and Radio Isotopes	✓	✓	10% Nitric acid -Trace metals grade	✓		✓	✓
Cations/Anions	✓	✓				✓	✓
Acidic Compounds	✓	✓				✓	✓
Basic Compounds (caustic)	✓	✓	1% nitric acid	✓		✓	✓

1 – All organic solvents must be Pesticide Grade or better. The selection of appropriate solvent rinses should first consider if a *known or suspected* contaminant requires removal from sampling equipment. Secondly, identify whether the subsequent analytical protocol would be impacted by the proposed solvent or an impurity thereof (e.g., residual acetone present in isopropyl alcohol would be measured with certain volatile organics analysis).

2 - Organic bases include amines, hydrazines.

3 - Organic acids include phenols, thiols, nitro and sulfonic compounds.

4- Use a grade of water appropriate to the application. For trace level analysis this must be Analyte Free Water. For non-trace applications store-bought distilled water is sufficient

Adapted from: Appendix E, Requirements for the Preparation of Sampling and Analysis Plans (EM-200-1-3), February 2001. US Army Corp of Engineers, Washington, D.C.

Shaw a world of Solutions	Document Type: **Discipline-Specific Procedure**	Level: 3 Owner: Applied Science & Engineering Origination Date: 12/08/2003 Revision Date: 8/25/2011
Group: E&I	Title: Roll-Off Sampling	No: EID-FS-107 Revision No.: 2 Page 1 of 4

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1. PURPOSE

The purpose of this procedure is to provide general information about the sampling of roll-off containers and preparatory requirements for completing the task safely. Roll-off containers are often used to store excavated/treated soil, trash, and other solid materials on project sites.

2. SCOPE

This procedure applies to all instances where roll-off containers require sampling for characterization and there is no project and/or regulatory agency specified procedure in force.

The procedure presents two sampling protocols with differing statistical designs and objectives for characterization of roll-offs depending upon the end use of the material or known disposition.

- Procedure A is designed to provide limited characterization information for those instances where the properties of the material are not in question from site/process knowledge; such as trash/debris from a non-hazardous site or hazardous wastes where the disposition method is pre-determined.
- Procedure B provides a more representative sampling design and should be used in those instances where the material properties are in question or the material is to be reused. Examples include characterization of staged overburden, confirmation that treated materials meet criteria, comparison of material constituent concentrations to differing disposition deciding regulatory concentrations (such as in listed waste situations), and determination of non-hazardous nature of trash/debris from known or suspect hazardous sites.

3. REFERENCES

- U.S. Environmental Protection Agency, 2002, *RCRA Waste Sampling Draft Technical Guidance, Planning, Implementation, Assessment*, EPA/530-D-02-002, August.

4. DEFINITIONS

- **Roll-off**—A metal container used to store and transport bulk materials such as soil and debris. The container has wheels on the bottom and can be loaded/unloaded from its transport vehicle by way of a track mechanism on the truck. Roll-offs are typically open-top containers and range from 10 to 20 cubic yards in volume. For purposes of this procedure, a roll-off is any container used to store bulk wastes such as soil or debris.
- **Composite Sample**—A sample created by the mixing of several discrete samples into one sample representative of the average characteristics of the entity sampled.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be directed to the Field Sampling Discipline Lead.

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5.2 Project Responsibility

Shaw employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURE

Safety Note: *Roll-off containers may contain shifting and physically hazardous loads and are considered to be a confined space. No personnel shall enter a roll-off container without first obtaining a confined-space permit. Personnel should not enter a roll-off containing soil or treatment residuals unless the site ECP deems it safe to do so. At* ***no time*** *shall personnel enter a roll-off containing debris. If a roll-off container cannot be entered, all sampling must be performed either by accessing with a trier or similar implement or by using the assistance of heavy equipment.*

6.1 Procedure A—For Limited Characterization Applications

This procedure uses a five-point composite design to collect a limited representation of the material in the roll-off. If sampling for VOCs, one additional location is randomly selected and sampled for VOCs only. *This procedure should not be used in applications where VOC concentrations are central to the decision.*

- Obtain the five grab samples from as close to the corners and the center of the container as possible.
  - If using a trier or collecting from within the container, collect each grab from the full depth below the first foot of material into the containerized material load. Place the entire length of material into the composite-creation container (bowl or other implement).
  - If heavy equipment is assisting in the sampling effort, instruct the operator to scoop material at differing depths for each of the grab locations. Each “grab” sample should consist of the material from three spots in the loader/backhoe bucket.
  - If collecting debris samples, place a piece of each type of waste at the selected sample location into the mixing bowl. Debris pieces should also be cut or reduced to a manageable size (1 to 2 inches square) before being mixed. Some debris may be light, and larger volumes may need to be sampled and submitted in order to provide adequate sample mass. This is especially true of PPE and other low-weight waste materials
  - If collecting a sample for VOCs, select one randomly determined additional location and collect a VOC sample at a particular depth, below one foot from the surface material. If heavy equipment is assisting, direct the operator to scoop from one location at a depth beyond one foot and fill the appropriate VOC sample containers directly from the material in the bucket.
- Mix and homogenize the material collected from the five locations prior to filling sample containers. If the sample is debris, be sure to fill each container with similar material types. Label and document all containers and prepare for shipment.

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6.2 Procedure B—For Applications Requiring More Intense Characterization

This procedure uses a more involved composite design based upon the collection of four "quadrant composites" and VOC grabs. The quadrant composites can be further combined to reduce analytical costs and provide a gross-average representation of the material properties, or, if more data points are desired, the composites can be analyzed separately to provide data on each quadrant of the material load.

- Divide the roll-off container into quadrants using string and/or stakes. The divisions should be across the middle on both the long and short axis to result in four sections of equal size.
- Sample each quadrant in five randomly selected locations. In addition, collect one VOC grab from one of the five selected locations at a randomly selected depth.
  - If using a trier or collecting from within the container, collect each grab from the full depth below the first foot of material into the containerized material load. Place the entire length of material into the quadrant composite-creation container (bowl or other implement).
  - If heavy equipment is assisting in the sampling effort, instruct the operator to scoop material at differing depths for each of the grab locations. Each "grab" sample should consist of the material from three spots in the loader/backhoe bucket.
  - If collecting debris samples, place a piece of each type of waste at the selected sample location into the mixing bowl. Debris pieces should also be cut or reduced to a manageable size (1 to 2 inches square) before being mixed. Some debris may be light, and larger volumes may need to be sampled and submitted in order to provide adequate sample mass. This is especially true of PPE and other low-weight waste materials
  - If collecting a sample for VOCs, select one of the locations in each quadrant and collect a VOC sample at a particular depth, below one foot from the surface material. If heavy equipment is assisting, direct the operator to scoop from the location at a depth beyond one foot, and fill the appropriate VOC sample containers directly from the material in the bucket.
  - Mix and homogenize the quadrant composite, and place the material into appropriate labeled sample containers. The VOC sample should always remain discrete.
- Repeat the process for each of the other quadrants.
- If multiple data points are desired, package and submit each of the quadrant composites for analysis along with the four quadrant VOC samples.
- If a container average is needed, form a composite by mixing and homogenizing half of each quadrant composite into a single sample and submitting the VOC samples separately. In some cases the laboratory may be instructed to create a VOC-lab composite by combining medium/high level extracts or even combining 5g core sampler aliquots into a TCLP/VOC-(ZHE) test.
- Place the labeled composite and VOC samples into a cooler with the project-required coolant (ice or dry ice), complete all required documentation, and ship the cooler to the laboratory per the project plans.

7. ATTACHMENTS

None

8. FORMS

None

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9. RECORDS

None

10. REVISION HISTORY AND APPROVAL

Revision Level / Revision Date	Revision Description	Responsible Manager
00 / 12/08/2003	Initial issue	N/A
01 / 09/11/2006	Updated template and numbering of procedure, minor edit to Section 2-Scope, reference added, definition of Composite Sample added, minor edits to content in Sections 6.1and 6.2.	Guy Gallello
02 / 08/25/2011	Modified format only to align with Governance Management framework	Scott Logan

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Shaw a world of Solutions	Document Type: **Project Procedure**	Level: 2 Owner: Quality Services Origination Date: 10/1/2007 Revision Date: 8/25/2011
Group: E&I	Title: Field Activities Documentation	No: EIP-G-005 Revision No.: 1 Page 1 of 6

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1. PURPOSE

The purpose of this procedure is to establish a uniform method of documenting field activities so that the resultant documentation is accurate, complete, and sufficient to withstand scientific and legal scrutiny.

2. SCOPE

This procedure applies to all personnel involved in the documentation of field activities on behalf of Shaw Environmental & Infrastructure, Inc. (Shaw E & I). The minimum requirements for documenting field activities are included and apply to various types of projects including, but not limited to, construction, demolition, environmental, active facilities, and closed facilities.

3. REFERENCES

- Shaw E & I Procedure No. EID-FS-001, *Field Logbook*
- Shaw E & I Procedure No. EID-FS-002, *Field Logsheet*
- Shaw E & I Procedure No. EIP-G-004, *Records Generation, Management, and Control*

4. DEFINITIONS

None

5. RESPONSIBILITIES

5.1 Shaw E & I Director of Quality

The Director of Quality is responsible for establishing and maintaining this SOP current with applicable requirements.

5.2 Project Responsibility

Responsibility at the project level for implementing and maintaining this SOP lies with the Project Manager, Site Supervisor, and field personnel as described below.

5.2.1 Project Manager

The Project Manager is responsible for the overall management of project records, including site-specific records unless otherwise dictated by contract or client requirements. At a minimum, a Project Manager (or authorized designee) shall do the following:

- Ensure project work plans adequately address specific records requirements.
- Ensure that project personnel have read and understand project work plans, which address documentation requirements.
- Ensure review of field-generated records to verify compliance with project plans, specifications, and applicable procedures; and implement corrective action in accordance with the appropriate procedure, if needed.

5.2.2 Site Supervisor

The site supervisor is responsible for the documentation of site-specific field activities and for training subcontractor personnel in the documentation requirements, for maintaining appropriate

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QC of records when required, and for records maintenance. This responsibility may be shared with the Quality Representative if required by client or contractual requirements. At a minimum, the site supervisor (or authorized designee) shall do the following:

- Review site-specific work plans that address specific documentation requirements.
- Ensure that project personnel have read and understand the project work plans, which address documentation requirements and associated procedures, including this procedure.
- Ensure that the responsibility for the specific documentation has been assigned to the appropriate project personnel.
- Provide training for project field personnel in the requirements and use of forms for site-specific tasks being performed; training records are reviewed during the project readiness review.
- Review field-generated documentation, as appropriate; verify compliance with project and applicable procedure requirements; and implement actions to correct problems, if needed.
- Ensure that project-generated field records are protected from damage or loss and maintained with the project files in a secured location.
- Examine documentation to minimize unnecessary multiple recordings of the same information when multiple types of activities are being performed and documented (e.g., field forms and logbooks).

5.2.3 Quality Representative

The Quality Representative is responsible for oversight of the documentation of field activities. The Quality Representative shall support the Responsible Manager and Site Supervisor with documentation efforts and will share these responsibilities when required by contractual or client requirements.

5.2.4 Field Personnel

Field personnel are responsible for accurately documenting field activities in accordance with this and other applicable procedure(s) and maintaining the records in a protective manner, safeguarding against damage or loss until submitted to the site supervisor or project files. All records are to be accurate, complete, and legible. Field activity records shall be handled in accordance with Procedure No. EIP-G-004, *Records Generation, Management, and Control*.

6. PROCEDURE

Field activity records shall contain sufficient detail to allow future reconstruction of the recorded event by someone other than the originator. Records may be completed electronically or manually. Forms that are prepared and filled out electronically are discussed in Section 6.2.

The user of this procedure shall ensure that appropriate or applicable field records are completed in accordance with the requirements of an approved procedure, set of instructions, or plan that governs the use of such records. Personnel completing records/forms shall observe the following minimum requirements:

- Keep all record entries concise and legible; make all entries in dark blue or black, indelible ink
- Complete all forms in such a manner as to accurately and thoroughly document the activity
- Use the military clock (24-hour) when recording time

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- When using a preprinted form, complete each blank or space. Mark “NA” or equivalent in each space that is not applicable to the activity
- Make any corrections or deletions required by drawing a single line throughout the entry and initialing and dating the correction
- Do not use correction fluid/tape or erasers

6.1 Field Activity Documentation

Field activities shall be documented to provide a chronological record of daily on-site activities. All activities performed must be documented and accounted for in standard, activity-specific forms (as applicable). A field activity daily log, field logbook, or equivalent must also be maintained. If multiple activities will be performed concurrently that cannot be recorded by one individual, the site supervisor will evaluate and determine if multiple field activity logs are required. If multiple field logs are required, a system shall be established to clearly identify the scope of each activity log.

Photographs taken to support project documentation shall be logged using a site-specific form and shall be compiled in accordance with project requirements. Minimum guidance concerning photographic documentation is given in Section 6.3.

All record entries shall be factual, objective, legible, and concise. The person (or responsible preparer) completing the entries must be knowledgeable of site activities.

Documentation of field activities may include the following records:

- Periodic reporting records to include Daily Logs or Weekly Reports
- Sampling or Environmental Records to include Chain of Custody/Request for Analysis, Sample Collection, Equipment Calibration, Environmental Assessment, and Monitoring activities
- Construction Records to include Inspection/Testing; Sampling, Calibration, Performance, and Monitoring activities
- Off-site activities associated with a project (e.g., inspection of equipment fabrication or material sampling at an off-site location)

6.1.1 Forms and Logs

Forms and logs should be used to record on-going or repetitive activities. All forms shall be constructed and completed in a manner to accurately and thoroughly document the activity.

Sufficient header information shall be included on forms, logs, and records to identify the following:

- Title or Subject
- Project number
- Dates
- Inclusive pagination
- Personnel involved or completing the record
- Location or project information

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Any portion or page of a record or form that is intentionally left blank or is not applicable to the field activity must be noted by the preparer as “Intentionally Left Blank” or “NA.” Alternately, the portion or page may have a line struck through the blank portion with the preparer’s initials and date of the entry.

6.1.2 Daily Logs

Daily logs shall be maintained to provide a chronological record of daily on-site activities. At a minimum, the following information (as applicable) shall be recorded in a field activity daily log, field logbook, or equivalent:

- Project name and number
- Date of activity
- General description and purpose or rationale of the field activity
- Chronological description of work activities (include time an event occurred)
- Reference to site-specific forms or records that contain information associated with field activities being documented (e.g., Tailgate Safety Briefing Form, Accident Report, Testing Log, Sample Collection Form, Inspection Log, Tracking Log, Chain-of-Custody Form, etc.)
- Changes to a plan, specification, or procedure and individuals authorizing the change
- Problems/difficulties encountered
- Visitors on site (include organization/firm, purpose of visit, and conversations or instructions regarding work activities)
- Weather conditions
- Shaw and subcontractor personnel on site
- Project-related phone calls
- Project-related meetings
- Health and safety observations, incidences, and accidents
- Individual(s) completing the form

If the responsible preparer of the daily log changes during its completion, then a notation shall be made indicating the individuals relinquishing and assuming responsibility, along with the date and time. When a daily log is completed, a diagonal line shall be drawn across the unused space and signed by the completing person. In the event of multiple shifts, one daily log should be completed for each shift. When using a field logbook, a note should be made at the end of each shift that the logbook has been relinquished, with the name of the responsible individual and the data and time this occurs.

The site supervisor or authorized designee should review field documentation for completeness and accuracy and initial and date field records as appropriate.

6.2 Electronic Records

Electronically produced records may be used to document project activities. Electronic forms may be printed as hard copy for manual completion or may be completed in electronic format. The electronic record author is responsible for all pertinent information included on the form as stated in previous sections of this SOP.

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Electronic records shall include information sufficient to identify the project activity and shall contain information sufficient to thoroughly document the activity. Information shall include, but not be limited to, project name, project number, date, individual completing the form, and a title describing the information the form contains.

Electronic forms and logs shall be printed, signed by the originator, and submitted as hardcopy records following the requirements presented in this procedure. If this is not practical, the person responsible for records shall ensure electronic back-ups of the field records are maintained and archived.

6.3 Hardcopy Records

Records shall be submitted to the records system on a timely basis. Copies of records may be made; however, the original record shall be submitted to the filing system.

It is preferred that only one project be recorded in a log book. However, if a log book is used for multiple projects, relevant pages shall be copied and submitted to the project files.

Records shall be managed in accordance with SOP EIP-G-004, *Records Generation, Management, and Control*.

6.4 Photographic/Video Documentation

As permitted by the client, the project personnel shall ensure that photographs (and videos, as applicable) are taken on a regular basis during field activity to document the work, events, and equipment used. The frequency and number of photos/videos taken will depend upon the activities occurring and the amount of documentation needed will be determined by the Project Manager or Site Supervisor. The following minimum requirements shall be met:

- Photos should be taken using 35-millimeter film or digital medium.
- Each photo shall be date/time stamped (automatically, if camera is capable), and the following information should be documented on a project photo log: photo number, date, time, description of the activity depicted, and the view direction.
- Digital and print media shall be labeled to identify the date and event recorded and shall be included in the project files.
- The photo log should include the appropriate header information as defined in Section 6.1.1.

7. ATTACHMENTS

None

8. FORMS

None

9. RECORDS

None

10. REVISION HISTORY AND APPROVAL

Revision Level Revision Date	Revision Description	Responsible Manager
00	Initial issue	Cheryl Prince

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Revision Level Revision Date	Revision Description	Responsible Manager
10/01/2007		
01 8/25/2011	Modified format only to align with Governance Management framework.	Bryan Koehler

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Shaw a world of Solutions	Document Type: **General Procedure**	Level: 2 Owner: Quality Origination Date: 4/14/2003 Revision Date: 1/6/2012
Group: E&I	Title: Nonconformance Reporting	No: EIG-Q-007 Revision No.: 2 Page 1 of 4

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1. PURPOSE

To establish the system for documentation, processing, disposition, resolution, and control of hardware nonconformances (i.e., component, equipment, material, and processes).

2. SCOPE

This procedure applies to nonconforming product identified during the course of performing project work activities. Nonconformances may be identified during the execution, monitoring and control, or closure phases of a project or activity. The responsibilities and requirements provided in this procedure are applicable for project or programmatic activities. Deviations of program or procedure requirements that do not result in hardware nonconformances or program or process deficiencies that result in a hardware nonconformance should be documented in accordance with EIG-Q-008, Corrective Action Requests.

3. REFERENCES

- EI-MAN-Q001, *Quality Management System Manual*
- EIG-Q-008, “Corrective Action Requests”

4. DEFINITIONS

- **Conformity**—Fulfillment of a requirement.
- **Disposition**—An evaluation or arrangement provided to determine the fate or condition of use of an item, service, or activity.
  - **Rework**—The process by which a nonconformance is corrected and an item made to conform to original requirements.
  - **Repair**—The process of restoring a nonconforming item to a condition such that the item is capable of functioning reliably and safely even though the item does not conform to original specified requirements.
  - **Use-As-Is**—A disposition authorizing a nonconforming item to be used as originally intended without correcting the nonconformance.
  - **Reject/Scrap**—A disposition indicating that the nonconforming item is not fit for its intended use or is uneconomical to correct.
- **Nonconformance/Nonconformity**—A non-fulfillment of a requirement. An item, condition, material, or service that deviates from drawings, specifications, or other project requirements and cannot be corrected readily within the scope of such requirements or that otherwise requires a disposition. A nonconformance is not a deficiency whereby correction is part of the normal course of work outlined in project requirements (e.g., failing density tests that provide an indication of “in-process” work in a given point in time).
- **Correction**—Action to eliminate a detected nonconformity.
- **Corrective Action**—Action(s) to eliminate the cause(s) of a detected nonconformity, or other undesirable situation.

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5. RESPONSIBILITIES

5.1 Responsible Manager

The Responsible Manager of the project, product, or service shall ensure further processing is stopped until a disposition is determined and corrective action is implemented. In addition, the Responsible Manager(s) shall ensure the disposition of nonconforming items to include the segregation of nonconforming products, when practical, to prevent unauthorized use, installation, or delivery.

5.2 Project Quality Representative

The Project Quality Representative is responsible for maintaining a status of nonconformance reports at project or program locations. This includes reviewing nonconformances, logging and tracking nonconformance reports (NCRs), and verifying the satisfactory completion and closure of corrective actions. These activities may be performed by oversight or project personnel independent of the activity.

5.3 All Personnel

Any individual assigned to a project or program location that discovers a nonconforming item, product, or service is responsible for initiating a nonconformance report by describing the condition and for notifying appropriate management. A written description should be provided for legitimate nonconformances.

6. PROCEDURE

6.1 General

Identified nonconformances shall be handled in a controlled system to ensure that the deviating condition is corrected as documented in the flowchart in Attachment 1.

In situations where the Quality Representative, Responsible Manager, or other staff determines that continued work would cause damage, jeopardize the safety of personnel, preclude subsequent inspections, or make corrective actions ineffective, work shall be stopped.

6.2 Identification and Reporting of Nonconformances

The identifying individual shall document the description of the nonconforming condition. The condition description will be clearly written after consultation with the responsible supervisor to ensure that the discrepancy is correctly described. Appropriate project criteria to include specifications, requirements, or codes violated must also be referenced to provide sufficient information to facilitate a proper and complete disposition. Sketches, photographs, reports, or other records may be included to supplement the NCR.

When this section of the NCR is completed, the report is sent to the Project Quality Representative for review. The Quality Representative shall review the NCR to ensure that it is complete and the reported condition(s) meets the criteria for a nonconformance. NCRs that are not complete or do not meet the criteria shall be reviewed with the originator to coordinate resolution. The NCR will be voided and filed if it is determined the criteria is not met. If the NCR is determined to be valid, the Quality Representative will assign a unique number or identifier and forward the NCR to the Responsible Manager for determining and documenting the appropriate corrective actions.

The Project Quality Representative shall maintain a status log of open and closed nonconformances. The log will also serve as the basis for numbering each discrepancy and tracking it through closure.

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6.3 Disposition

The Responsible Manager shall evaluate the nonconforming characteristics of the item or service and determine the disposition. Disposition may include reject/scrap, use as is, rework, and/or repair. If a design change approval is required to disposition an item that deviates from a design document, the approved design change documentation should be referenced or a copy attached to the NCR.

Nonconforming product shall be dispositioned by one or more of the following ways: taking action to eliminate the detected nonconformity; authorizing its use, release or acceptance under concession by a relevant authority and, where applicable, by the client; taking action to preclude its original intended use or application; or by taking action appropriate to the effects or potential effects, of the nonconformity when nonconforming product is detected after delivery or use has started. The determination shall be documented on the NCR and a technical justification provided by an appropriate authority when the disposition is determined to be “repair” or “use as is.” The Quality Representative shall concur with the disposition.

Whenever practical, nonconforming items should be segregated from conforming items to prevent their inadvertent installation or use. When practical, identification tags or markings should be used to aid in this segregation.

When required by the contract or determined appropriate, the client shall be notified of the nonconformance by the Responsible Manager. The client must be promptly notified of technical errors in work previously completed and submitted to them.

6.4 Corrective Action

The Responsible Manager shall evaluate the nonconforming characteristics and determine the corrective actions for nonconforming items or services. The required section of the NCR shall be completed by the Responsible Manager who shall document the following:

- Corrective actions to be taken. Actions taken shall be appropriate for the nonconformance.
- Personnel responsible for implementing corrective actions.
- Date when necessary actions are to be completed.

The NCR shall be forwarded to the Project Quality Representative for review. If corrective actions are determined appropriate, then personnel responsible for implementation shall perform the corrective action in accordance with the scheduled due date. Extensions of time may be granted by the Project Quality Representative for extenuating circumstances.

After the completion of corrective actions, the Responsible Manager shall document the resolution on the NCR form, sign the form, and forward it to the Quality Representative. Any objective evidence of the corrective actions shall be included.

6.5 Verification and Closeout

Satisfactory resolution of nonconformances must be verified by the Quality Representative. The Quality Representative shall do the following to achieve resolution:

- Initiate an inspection and/or a review of objective evidence to verify satisfactory completion of the corrective action
- Sign off the NCR, if the work is satisfactory, and remove identification tags or markings as applicable

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NCRs are not to be closed until the required corrective measures have been completed to the satisfaction of the Quality Representative. Nonconformances will be monitored until the action is verified as complete and closed as documented on the NCR.

6.6 Records

The original, signed NCR form and associated documentation shall be retained in the project records.

7. ATTACHMENTS

- Attachment 1, Nonconformance Process Flowchart

8. FORMS

- EIG-Q-007.01, Nonconformance Report

9. RECORDS

- EIG-Q-007.01, Nonconformance Report

10. REVISION HISTORY AND APPROVAL

Revision Level / Revision Date	Revision Description	Responsible Manager
00 04/14/2003	Initial Issue.	Cheryl Prince
01 02/15/2007	Sections 1 & 2 had minor changes, Section 5 Responsibilities was updated. Major re-write of procedure. Attachment 1, Nonconformance Process Flowchart was added.	Bryan Koehler
02 01/06/2012	Sections 1 & 2 minor changes. Definitions were added for Conformity, Rework, Repair, Use-As-Is, Reject/Scrap, and Correction. Updated Responsibilities. Major re-write of procedure. Modified format to align with Governance Management framework.	Bryan Koehler

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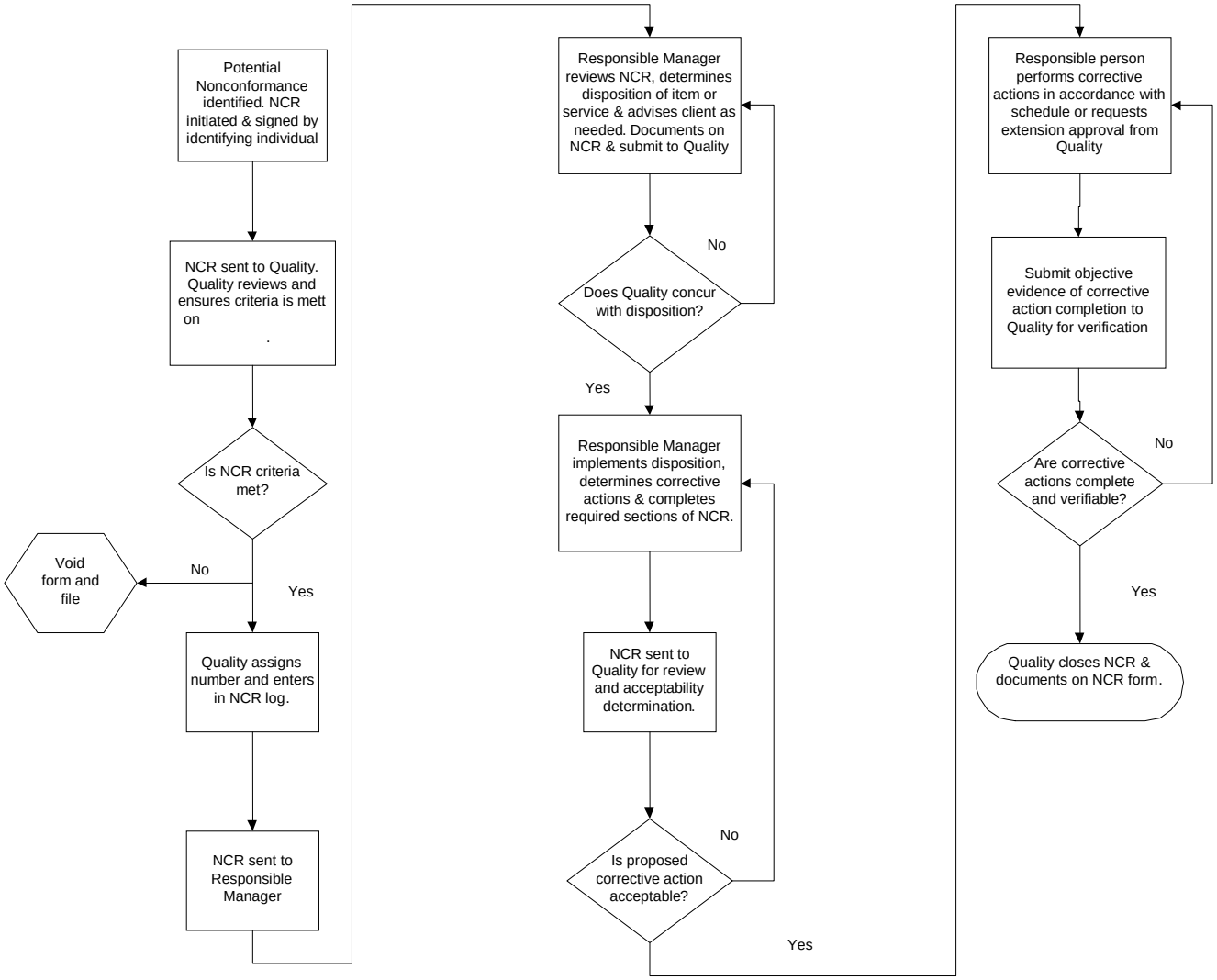
Attachment 1
Nonconformance Process Flowchart



Shaw a world of Solutions	Title: Nonconformance Report	Form No: EIG-Q-007.01_2

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1) NCR Number:	**2) Project Name and Number (include location):**	**3) Date:**

4) Nonconformance Description And Reference: (Specification __ Drawing __ Code __)

Identified by: _____ **Date**_____

Reviewed By: _____ **Date**_____

(Project Quality Representative)

5) Disposition of Nonconforming Condition (Indicate disposition type):
1) Rework, 2) Repair, 3) Use As Is, 4)Reject/Scrap (Note: Use-As-Is or Repair determinations must be technically justified)5)Other (e.g., Return to Supplier)

Evaluated by: _____ **Date**_____

Responsible Manager

Concurrence: _____ **Date** _____

Quality Representative

6) Corrective Action(s) to be taken (include date when action(s) will be complete):

Corrective Action to be Performed by: _____**Due Date**_____

Responsible Manager: _____**Date**_____

Reviewed by: _____ **Date** _____

Quality Representative

7) Client Notification Required: _____ **Yes** _____**No** **Date Notified:** _____

8) Corrective Action Completion

Comments:

Responsible Manager: _____**Date**_____

9) Corrective Action(s) Completion Verification and Date:

Comments:

Reviewed and Closed By: _____ **Date**_____

(Project Quality Representative)

GUIDELINES

Guideline Title:	**Checking of Specifications, Calculations and Drawings**	**CMS Number:**	**CMS-830-03-GL-00002**
Guideline Owner:	**Civil and Structural Engineering**	**Issuing Authority:**	**Department Manager Civil/Structural The Hague, Discipline Manager SPS, Manager Civil & Structural Tyler**

CHECKING OF SPECIFICATIONS, CALCULATIONS AND DRAWINGS

0	Issued for Use	JB / JH / GH	19 Oct 2009
Rev	**Changes**	**Approved**	**Date**

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Checking of Specifications, Calculations and Drawings

CMS Number:	Revision:	Approval Date:
CMS-830-03-GL-00002	0	19 Oct 2009

1.0 PURPOSE

This guideline outlines the activities and responsibilities for checking Specifications, Calculations and Drawings within the Civil and Structural Engineering Group and the Offshore Group and shall be read in conjunction with CMS-830-00-PR-01010, Quality Control of Design Documents.

2.0 SCOPE

This guideline applies to all personnel within the Civil and Structural Engineering and Offshore Groups responsible for checking Specifications, Calculations and Drawings.

3.0 RESPONSIBILITIES

The following personnel have responsibilities defined in this guideline:

- Civil & Structural Engineers
- Initiators
- Checkers
- Approvers

4.0 GUIDELINE

4.1 General

This guideline establishes the minimum checking requirements for specifications, calculations and drawings. It should be read in conjunction with Work Processes CMS-830-03-WP-00002 through 00004 (for drawings) and CMS-720-01-GL-00001 (for specifications).

4.2 Drawings

4.2.1 Drawings are not to be issued IFC <u>unless</u> the documents and the associated calculations have been checked and approved.

4.2.2 At the inquiry stage, calculations may be issued prior to checking. Where this occurs the drawings must be approved by initials or signatures.

4.2.3 Documents shall be checked by someone other than the person who originated the document.

4.2.4 A red, blue or green, colour code system shall be followed as described below:

a. Red – highlights additions to be made
b. Blue or Green – highlights omissions / deletions required
c. Yellow – highlights material reviewed and passing check

4.2.5 In addition, pencil or other coloured marks may be used to highlight notes or other commentary intended for the back-drafters review only.

4.2.6 Check prints shall be retained in accordance with CMS-830-00-PR-00018; Archiving and Storage of Project Documents. (as a record of the evolution of each drawing), and only dispended with upon successful project completion.

4.2.7 Foundation Drawings

These drawings are checked for:

a. Compliance with design calculations
b. Dimensional accuracy
c. Location
d. Orientation
e. Bolts (size, configuration, embedment and projection)
f. Avoidance of clashes with underground services and underground obstructions
g. Compliance with relevant standards and regulations

h. Constructability
i. Full consideration of proper fitness and installation of supported equipment

4.2.8 Underground Layouts

These drawings are checked for:

a. Compliance with design calculations (pipe sizing)
b. Dimensional accuracy
c. Locations of underground lines, manholes, catch basins, cable trenches, draw pits, valve pits, and other sumps and chambers.
d. Avoidance of other U/G obstructions
e. Material selection
f. Interface with electrical and instrument cable requirements
g. Compliance with relevant standards and regulations
h. Constructability

4.2.9 Structural Steel (Layouts)

These drawings are checked for;

a. Compliance with design calculations
b. Dimensional accuracy
c. Avoidance of obstructions and clashes
d. Compliance with relevant standards and mandatory regulations
e. Constructability

4.2.10 Architectural (Layouts)

These drawings are checked for:

a. Dimensional accuracy
b. Interface with heating and ventilation and other services
c. References to schedules and material specifications
d. Means to escape from fire.
e. Compliance with regulations
f. Constructability

4.3 Calculations

4.3.1 Calculations shall only be checked by engineers having the appropriate knowledge and experience.

4.3.2 The checker ensures that calculations are checked for basic principles, arithmetical accuracy, completeness and basis of design. He shall also ensure that the report is produced in the most efficient way and with the least amount of effort.

4.3.3 All appropriate computer input and output data should be checked.

4.3.4 All calculations are approved, after checking, by an authorised engineer, who approves the calculations ensuring that the following criteria are satisfied:

a. That the design approach adopted is viable
b. That the design cases considered are adequate
c. That the arrangement and size of members will transmit the load as calculated
d. That the calculation results are realistic (this is especially important for computerised calculations).

4.3.5 The Approving Engineer may ask for additional calculations, or undertake further checks if considered necessary. The Approving Engineer initials and dates the front sheet of all approved sets of calculations.

4.3.6 It is mandatory that all calculations are checked at all stages prior to issue to Client Approving Authorities, and the 'Issued for Construction (IFC) issue of associated drawings.

4.3.7 With the approval of the Lead Engineer, an alternative to a line by line check of original calculations is permitted as follows:

4.3.8 A full arithmetical check may be replaced by an independent check to confirm results. This check may be manual (using short cuts) or the use of simpler software e.g. “CADSUITE” instead of “STAAD” or “ASAS”.

4.3.9 A check on basic principles, completeness, and design basis remain mandatory. Deviations from the building code requirements are not permitted.

4.3.10 The following check Lists are available to guide the checking of calculations:

a. Piling calculations
b. Concrete calculations
c. Structural steel calculations
d. Architectural – Building calculations

4.4 Specifications and Standards

4.4.1 Project specifications and standards are checked by an Engineer or Architect as appropriate. The documents are approved by the Lead Engineer or Lead Architect. Where the Lead Engineer / Architect has checked a document they may also approve the document.

4.4.2 These documents shall in particular be mindful of:

a. Trade names and trade marks shall not be used.
b. Sentences shall be clear, concise and unambiguous.
c. Requirements shall be indicated by the word “shall”
d. Recommendations shall be indicated by the word “should”
e. Options shall be indicated by the word “may”
f. Parties shall be clearly stated “without ambiguity”:

For example:

- Contractor – CB&I
- Sub-contractor – provider of services
- Owner – client of CB&I

4.5 Vendors Fabrication Drawings (Structural)

4.5.1 It is the responsibility of the project team to ensure that all fabrication drawings are reviewed by competent personnel. Reviews are given priority over normal work load and every effort should be made to achieve a 48- hour turn around period.

4.5.2 Only drawings which have been checked by the vendors are reviewed for approval. Drawings unchecked by the vendors should be returned to the vendor for checking.

4.5.3 The intensity of checking must match the quality of drawings submitted but consistently poor detailing requiring excessive work-hour expenditure must be eliminated.

4.6 Package Units

4.6.1 It is the responsibility of the project team to ensure that civil/structural items contained in package units comply with the company specifications and requirements.

4.6.2 Calculations shall be reviewed to check the basis and adequacy of design.

4.7 Verification of Computer Systems

4.7.1 Civil Engineering Departments’ ‘in house’ software is validated in accordance with the Company procedure CMS-830-00-PR-01060: Engineering Software Quality Control.

4.7.2 Any ‘in house’ software awaiting validation is made available for use but will carry a warning message indicating that the program has not been validated and that all results must be manually checked.

Checking of Specifications, Calculations and Drawings

CMS Number:	Revision:	Approval Date:
CMS-830-03-GL-00002	0	19 Oct 2009

5.0 REFERENCES

CMS-720-01-FM-00020	Business Glossary
CMS-720-01-FM-00021	Technical Glossary
CMS-830-00-PR-01010	Quality Control of Design Documents
CMS-830-00-PR-01060	Engineering Software Quality Control
CMS-830-00-PR-01020	Independent Design Reviews
CMS-810-00-PR-00018	Archiving and Storage of Project Documents
CMS-830-03-GL-00001	Preparation of Specifications, Calculations & Drawings

6.0 TERMINOLOGY

Term	***Definition***
IFC	ISSUED FOR CONSTRUCTION

7.0 EXHIBITS

None

Appendix B
Uniform Federal Policy Quality Assurance Project Plan

UFP-QAPP Worksheet #1 – Title and Approval Page
Former George Air Force Base, California

Site Name/Project Name	OT071 Data Gap Well Installation UFP-QAPP, Former George Air Force Base (GAFB), California
Site Location:	Site OT071 encompasses approximately 900 acres in the southeastern and east-central portion of former GAFB and consists of pesticides in groundwater beneath the former housing areas and the Westwinds Golf Course. The primary pesticide of concern in groundwater at the site is Dieldrin.
Revision Date	None
Document Title	OT071 Data Gap Well Installation UFP-QAPP
Lead Organizations	Air Force Civil Engineer Center (AFCEC)
Preparer's Name and Organizational Affiliation	Mark Unruh, CB&I Federal Services LLC
Preparer's Address, Telephone Number, and E-mail Address	1230 Columbia Street, Suite 1200, San Diego, CA 92101, mark.unruh@cbifederalservices.com
Preparation Date (Day/Month/Year)	11/15/15
Approval Signatures	
Investigative Organization's Project Manager	
	Signature
	David Daftary / CB&I Federal Services LLC
Investigative Organization's Project QA/QC Manager	
	Signature
	Stephen Massey / CB&I Federal Services LLC
Lead Organization's Program Manager	
	Signature
	Joseph Ebert, AFCEC Contracting Officer Representative
Former George AFB Project Manager	
	Signature
	Donald Gronstal, Former George AFB IRP Coordinator

Document Control Number:_____

UFP-QAPP Worksheet #2 – QAPP Identifying Information
Former George Air Force Base, California

Site Name/Project Name	OT071 Data Gap Well Installation UFP-QAPP, Former George Air Force Base (GAFB), California
Site Location	OT071
CB&I Group ID (ERPIMS Site Number/Code)	OT071
Task Order	Task Order (TO) 0018
Contractor Name	CB&I Federal Services LLC
Contractor Number	FA8903-09-D-8580, TO 0018
Contract Title	AFCEC Worldwide Environmental Restoration and Construction 2009 (WERC09)
Work Assignment Number	145981
Guidance used to prepare UFP-QAPP	U.S. Department of Defense (DoD) Quality Systems Manual (QSM), Version 4.2, 2010 Uniform Federal Policy for Quality Assurance Project Plans, Intergovernmental Data Quality Task Force (IDQTF), EPA-505-B-04-900A/DTIC ADA 427785, March 2005 U.S. Environmental Protection Agency (EPA) National Functional Guidelines (NFG) for Inorganic Superfund Data Review, EPA 540-R-013-001, August 2014 EPA NFG for Superfund Organic Methods Data Review, EPA 540-R-014-002, August 2014
Identify Regulatory Program	Regional Water Quality Control Board (RWQCB), Lahontan Region
Approval Entities	AFCEC and RWQCB, Lahontan Region
Indicate whether the QAPP is a generic or a project-specific QAPP	This project-specific Quality Assurance Project Plan (QAPP) was prepared for the Data Gap Well Installation to be conducted at OT071, former GAFB.
List dates of scoping sessions that were held	22 September 2015
List dates and titles of QAPP documents written for previous site work, if applicable	Not applicable
List organizational partners (stakeholders) and connection with lead organization	AFCEC – Lead Organization RWQCB, Lahontan Region – Regulatory Agency
List data users	CB&I Project/Task Lead and AFCEC

UFP-QAPP Worksheet #2 – QAPP Identifying Information (continued)
Former George Air Force Base, California

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Crosswalk to Related Worksheet/ Documents
Project Management and Objectives		
2.1 Title and Approval Page	• Title and Approval Page	• Worksheet (WS) #1 Title and Approval Page
2.2 Document Format and Table of Contents 2.2.1 Document Control Format 2.2.2 Document Control Numbering System 2.2.3 Table of Contents 2.2.4 QAPP Identifying Information	• Table of Contents • QAPP Identifying Information	• The Table of Contents is provided following the QAPP cover page. • WS #2 QAPP Identifying Information
2.3 Distribution List and Project Personnel Sign-Off Sheet 2.3.1 Distribution List 2.3.2 Project Personnel Sign-Off Sheet	• Distribution List • Project Personnel Sign-Off Sheet	• WS #3 Distribution List • WS #4 Project Personnel Sign-Off Sheet • Note: the information from WS # 3 and WS #4 has been combined.
2.4 Project Organization 2.4.1 Project Organizational Chart 2.4.2 Communication Pathways 2.4.3 Personnel Responsibilities and Qualifications 2.4.4 Special Training Requirements and Certification	• Project Organizational Chart • Communication Pathways • Personnel Responsibilities and Qualifications Table • Special Personnel Training Requirements Table	• WS #5 Project Organization Chart • WS #6 Communication Pathways • WS #7 Personnel Roles, Responsibilities, and Qualifications Table • WS #8 Special Personnel Training Requirements Table
2.5 Project Planning/Problem Definition 2.5.1 Project Planning (Scoping) 2.5.2 Problem Definition, Site History, and Background	• Project Planning Session Documentation (including Data Needs tables) • Project Scoping Session Participants Sheet • Problem Definition, Site History, and Background • Site Maps (historical and present)	• WS #9 Project Scoping Session Participants Sheet • WS #10 Problem Definition • General site history and background for former GAFB are provided in Section 1.0 of the QAPP text. • Site maps are provided in the main text of the SSI Work Plan.
2.6 Project Quality Objectives and Measurement Performance Criteria 2.6.1 Development of Project Quality Objectives Using the Systematic Planning Process 2.6.2 Measurement Performance Criteria	• Site-Specific Project Quality Objectives • Measurement Performance Criteria Table	• WS #11 Project Quality Objectives/Systematic Planning Process Statements • WS #12 Measurement Performance Criteria Table (as applicable)

UFP-QAPP Worksheet #2 – QAPP Identifying Information (continued)
Former George Air Force Base, California

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Crosswalk to Related Worksheet/ Documents
2.7 Secondary Data Evaluation	• Sources of Secondary Data and Information • Secondary Data Criteria and Limitations Table	• WS #13 Secondary Data Criteria and Limitations Table
2.8 Project Overview and Schedule 2.8.1 Project Overview 2.8.2 Project Schedule	• Summary of Project Tasks • Reference Limits and Evaluation Table • Project Schedule/Timeline Table	• WS #14 Summary of Project Tasks • WS #15 Reference Limits and Evaluation Tables (as applicable) • WS #16 Project Schedule/Timeline Table
Measurement/Data Acquisition		
3.1 Sampling Tasks 3.1.1 Sampling Process Design and Rationale 3.1.2 Sampling Procedures and Requirements 3.1.2.1 Sampling Collection Procedures 3.1.2.2 Sample Containers, Volume, and Preservation 3.1.2.3 Equipment/Sample Containers Cleaning and Decontamination Procedures 3.1.2.4 Field Equipment Calibration, Maintenance, Testing, and Inspection Procedures 3.1.2.5 Supply Inspection and Acceptance Procedures 3.1.2.6 Field Documentation Procedures	• Sampling Design and Rationale • Sample Location Map • Sampling Locations and Methods/ Standard Operating Procedure (SOP) Requirements Table • Analytical Methods/SOP Requirements Table • Field Quality Control Sample Summary Table • Sampling SOPs • Project Sampling SOP References Table • Field Equipment Calibration, Maintenance, Testing, and Inspection Table	• WS #17a and 17b Sampling Design and Rationale • WS #18a and 18b Sampling Locations and Methods/SOP Requirements Table • WS #19 Analytical SOP Requirements (Sample Containers Preservation and Holding Times) • WS #20a and 20b Field Quality Control Sample Summary Table • WS #21 Project Sampling SOP References Table • WS #22 Field Equipment Calibration, Maintenance, Testing, and Inspection Table More details concerning the sampling procedures (including copies of the field sampling SOPs) can be found in Attachment B (provided electronically).
3.2 Analytical Tasks 3.2.1 Analytical SOPs 3.2.2 Analytical Instrument Calibration Procedures 3.2.3 Analytical Instrument and Equipment Maintenance, Testing, and Inspection Procedures 3.2.4 Analytical Supply Inspection and Acceptance Procedures	• Analytical SOPs • Analytical SOP References Table • Analytical Instrument Calibration Table • Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	• WS #23 Analytical SOP References Table – Lab • WS #24 Analytical Instrument Calibration Table – Lab • WS #25 Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table The analytical SOPs can be found in Attachment C (provided electronically).

UFP-QAPP Worksheet #2 – QAPP Identifying Information (continued)
Former George Air Force Base, California

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Crosswalk to Related Worksheet/ Documents
3.3 Sample Collection Documentation, Handling, Tracking, and Custody Procedures 3.3.1 Sample Collection Documentation 3.3.2 Sample Handling and Tracking System 3.3.3 Sample Custody	• Sample Collection Documentation Handling, Tracking, and Custody SOPs • Sample Container Identification • Sample Handling Flow Diagram • Example Chain-of-Custody (COC) Form and Seal	• WS #26 Sample Handling System • WS #27 Sample Custody Requirements (An example COC form can be found in Attachment B.) More details concerning the field sampling procedures can be found in Attachment B.
3.4 Quality Control (QC) Samples 3.4.1 Sampling Quality Control Samples 3.4.2 Analytical Quality Control Samples	• QC Samples Table • Screening/Confirmatory Analysis Decision Tree	• WS #28 QC Acceptance Criteria Tables A discussion of screening versus confirmatory analysis is presented on WS #17a and 17b.
3.5 Data Management Tasks 3.5.1 Project Documentation and Records 3.5.2 Data Package Deliverables 3.5.3 Data Reporting Formats 3.5.4 Data Handling and Management 3.5.5 Data Tracking and Control	• Project Documents and Records Table • Analytical Services Table • Project SOPs	• WS #29 Project Documents and Records Table • SOPs EIG-RM-001 and EIG-RM-002, Records Generation, Management, and Control provide additional guidance – included in Attachment B. • WS #30 Analytical Services Table • Project SOPs are listed on WS #21 and included in Attachment B.
Assessment/Oversight		
4.1 Assessments and Response Actions 4.1.1 Planned Assessments 4.1.2 Assessment Findings and Corrective Action Responses	• Assessments and Response Actions • Planned Project Assessments Table • Audit Checklists • Assessment Findings and Corrective Action Responses Table	• WS #31 Planned Project Assessments Table and attached Table 31-1 • WS #32 Assessment Findings and Corrective Action Responses CB&I SOPs for quality assessments and reporting are provided in Attachment B. The laboratory audit checklists and assessments can be found in Attachment C.
4.2 Quality Assurance (QA) Management Reports	• QA Management Reports Table	• WS #33 QA Management Reports Table
4.3 Final Project Report	• All QA Management Reports attached • Additional data quality concerns and resolution documentation	• WS #33 QA Management Reports Table CB&I SOPs for quality assessment and reporting are provided in Attachment B.

UFP-QAPP Worksheet #2 – QAPP Identifying Information (continued)
Former George Air Force Base, California

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Crosswalk to Related Worksheet/ Documents
Data Review		
5.1 Overview 5.2 Data Review Steps 5.2.1 Step I: Verification 5.2.2 Step II: Validation 5.2.2.1 Step IIa Validation Activities 5.2.2.2 Step IIb Validation Activities 5.2.3 Step III: Usability Assessment 5.2.3.1 Data Limitations and Actions from Usability Assessment 5.2.3.2 Activities	• Verification (Step I) Process Table • Validation (Steps IIa and IIb) Process Table • Validation (Steps IIa and IIb) Summary Table • Usability Assessment	• WS #34 Verification (Step I) Process Table • WS #35 Validation (Steps IIa and IIb) Process Table • WS #36 Validation (Steps IIa and IIb) Summary Table • WS #37 Usability Assessment SOP FS-020, Data Usability Review, listed on WS #21 is included in Attachment B and provides additional guidance for data usability.

UFP-QAPP Worksheet #3 – Distribution List
Former George Air Force Base, California

QAPP Recipients	Title	Organization	Telephone Number	Fax/Cell Number	E-mail Address	Document Control Number
Joseph Ebert	AFCEC Contracting Officer Representative	AFCEC	210.395.9456	--	joseph.ebert@us.af.mil	1
Donald Gronstal	Former George AFB Installation Restoration Coordinator	AFCEC	916.643.3672 x211	916.208.8542 (c)	donald.gronstal@us.af.mil	2
Linda Stone	Remedial Project Manager (RPM)	RWQCB, Lahontan Region	530.542.5471	--	linda.stone@waterboards.ca.gov	3
Todd Battey, PG	Remedial Project Manager (RPM)	RWQCB, Lahontan Region	760-241-7340	*661-303-7804*	Todd.Battey@waterboards.ca.gov	4
Mary Aycock	RPM	EPA Region 9	415.972.3289	--	aycock.mary@epamail.epa.gov	5
David Daftary	CB&I Project Manager (PM)	CB&I	865.499.3159	805.390.2917 (c)	david.daftary@cbifederalservices.com	6
James Joice	CB&I Health and Safety	CB&I	419.429.5503	419.306.3637 (c)	james.joice@cbifederalservices.com	7
Stephen Massey	CB&I QA/QC Manager	CB&I	619.446.4522	619.987.6557 (c)	stephen.massey@cbifederalservices.com	8
Mark Unruh	CB&I Technical Lead	CB&I	619.533.7301	--	mark.unruh@cbifederalservices.com	9
Tim Roth	CB&I Project Chemist	CB&I	865.560.5272	865.690-3626 (f)	tim.roth@cbifederalservices.com	10
Robert Mall	CB&I Project Site Manager	CB&I	760.246.3867	760.987.2244 (c)	robert.mall@cbifederalservices.com	11
Richard Villafania	Eurofins Calscience PM	Eurofins Calscience, Inc.	714.895.5494	714.894.7501 (f)	RichardVillafania@eurofinsUS.com	12
Larry Lem	Eurofins Calscience QA Officer	Eurofins Calscience, Inc.	714.895.5494	714.894.7501 (f)	LarryLem@eurofinsUS.com	13
Michael Mark Brady	PTS Laboratories, Inc. PM	PTS Laboratories, Inc.	562.347.2502	562.907.3610 (f)	mmbrady@ptslabs.com	14

Note: Copies of the QAPP and any subsequent revisions and addenda will be distributed to the individuals above.

The distribution list above documents key personnel who have read the applicable sections of the QAPP and will perform the tasks as described in the QAPP. WS #4 will be provided to CB&I personnel for their signatures and will be kept in the project files upon completion.

UFP-QAPP Worksheet #3 – Distribution List
Former George Air Force Base, California

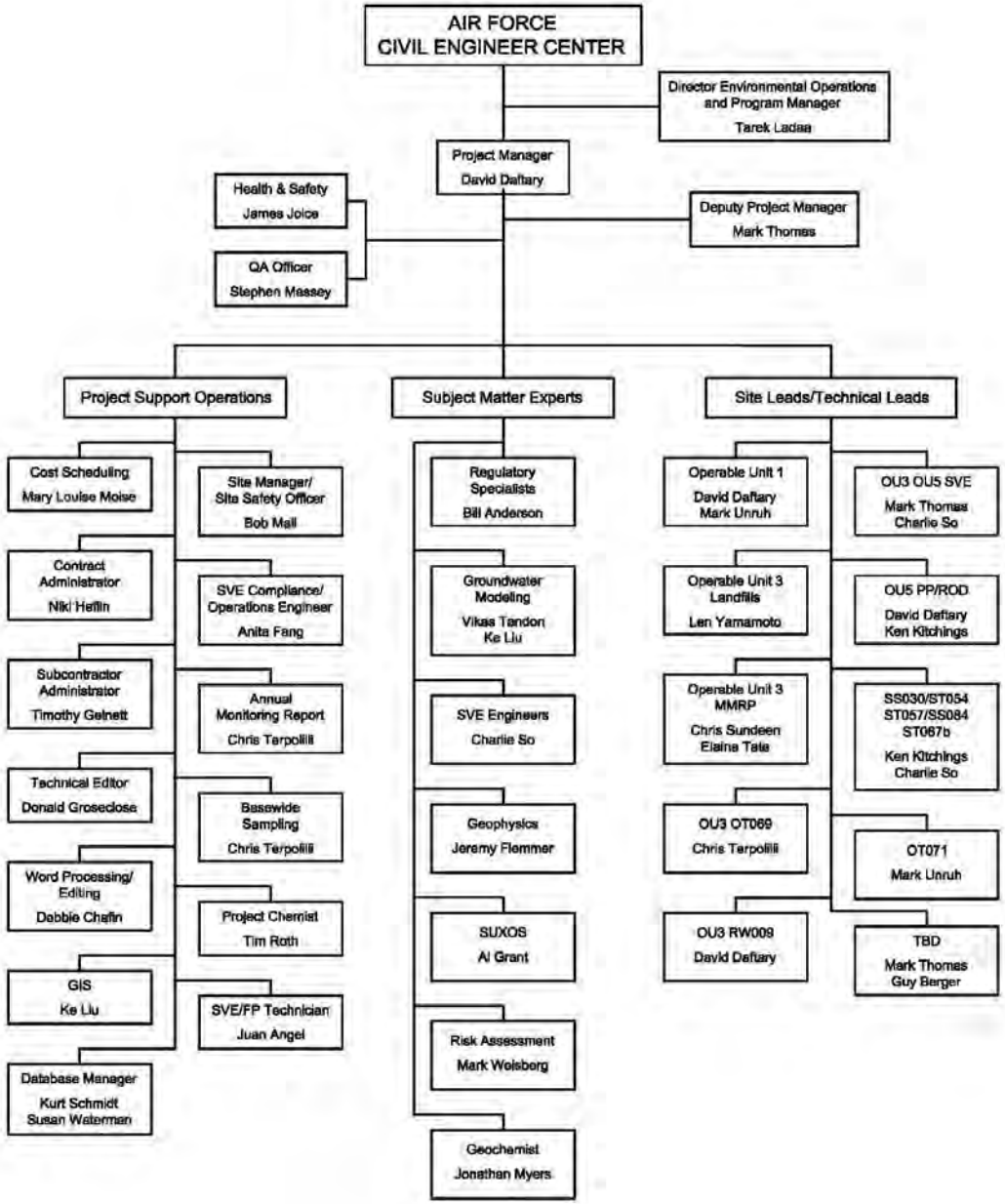
UFP-QAPP Worksheet #4 – Project Personnel Sign-Off Sheet
Former George Air Force Base, California

Organization: CB&I

Project Personnel	Title	Telephone Number	Signature	Date Read – SSI Work Plan MMRP Sites XU400 and SR401 40mm PGRE, Former George AFB
David Daftary	CB&I PM	865.499.3159		
Mark Unruh	CB&I Technical Lead	619.533.7301		
Stephen Massey	CB&I QA/QC Manager	619.446.4522		
Tim Roth	CB&I Project Chemist	865.560.5272		
Don Dill	CB&I Project Lead/Data Validator	865.670.2660		
Robert Mall	CB&I Project Site Manager	760.987.2244		

The individuals who sign above are certifying they have read the former GAFB QAPP. Please forward the original signed form with all columns completed to CB&I Federal Services LLC, c/o Stephen Massey, 1230 Columbia Street, Suite 1200, San Diego, CA 92101, or forward an electronic version via email to stephen.massey@cbifederalservices.com for the project files upon completion.

UFP-QAPP Worksheet #5 – Project Organizational Chart
Former George Air Force Base, California



UFP-QAPP Worksheet #6 – Communication Pathways
Former George Air Force Base, California

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathways, etc.)
Point of Contact (POC) with AFCEC	CB&I PM	David Daftary	805.499.3159	All documents and information will be forwarded to AFCEC by the CB&I PM.
POC with Former George Air Force Base	CB&I PM	David Daftary	805.499.3159	All documents and information will be forwarded to former GAFB by the CB&I PM.
Project Management Actions	CB&I PM	David Daftary	805.499.3159	Maintains communication with all project and task leads.
Changes to Project Documents and Forms	CB&I QA Officer	Stephen Massey	619.446.4522	Maintains revision control for all project documents and forms. All change requests are submitted to the CB&I QA Officer, who issues document revision numbers, reviews documents for consistency, and uploads to the administrative record for the project.
Changes to QAPP	CB&I QA Officer	Stephen Massey	619.446.4522	Any field change requests, variance requests, or deviations are communicated to the QA/QC Manager and the Project Chemist. If a permanent change needs to be implemented, the QA/QC Manager will take appropriate actions to amend or modify the QAPP.
Changes to QAPP	CB&I Project Chemist	Tim Roth	865.560.5272	The QAPP will be revised as needed to update analytical SOPs, reporting levels (Detection Limits [DL], Limit of Detection [LOD], Limit of Quantitation [LOQ]). If the QAPP needs modification, the Project Chemist will coordinate with the QA/QC Manager to take appropriate action.
Field Activities	CB&I Project Site Manager	Robert Mall	760.987.2244	Copies of daily field activities will be uploaded to the portal or emailed to the Project Engineer/Task Manager or designee and Project Chemist at the end of each week.
Stop Work Because of Safety or Quality	All CB&I employees and subcontractors have stop work authority related to safety or quality issues.	All	---	All stop work requests are reported immediately to the CB&I PM or designee. Safety issues are also reported directly to the CB&I Health and Safety lead or designee; quality issues related to sampling or analysis are reported to the CB&I Project Chemist; and other quality issues are reported to the CB&I Quality Assurance Manager. CB&I Procedure CMS-710-05-PR-00400, “Stop Work Authority,” describes the process and responsibilities (a copy is presented in Attachment B of the QAPP).
Temporary Change Requests	CB&I QA Officer	Stephen Massey	619.446.4522	Requests to make temporary changes to field or other procedures are submitted to the CB&I QA/QC Manager, who will forward to the CB&I Technical Lead and appropriate individuals for input and approval.

UFP-QAPP Worksheet #6 – Communication Pathways (continued)
Former George Air Force Base, California

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathways, etc.)
QA/QC Field Change Requests	CB&I Project Site Manager	Robert Mall	760.987.2244	Field changes (i.e., real-time) relating to sampling and analysis are communicated directly to the Project Chemist or the Technical Lead who will approve the change. All other field changes will be communicated to the technical lead and/or the QA/QC lead for approval. Field changes are documented in the field records and copies are forwarded as soon as practicable (e.g., within 48 hours) to the Project/Task Lead, QA/QC Manager, and Project Chemist via fax or email.
Reporting of Data Quality Issues – Field	CB&I Project Site Manager	Robert Mall	760.987.2244	All potential data quality issues will be reported to the Project Engineer/Task Manager, CB&I Quality Assurance Officer, and Project Chemist as soon as practicable (e.g., 48 hours).
Reporting of Data Quality Issues – Laboratory	Laboratory PM	Eurofins Calscience, Inc. Richard Villafania	714.895.5494	The laboratory PM will report any QC deficiencies associated with sample receipt or catastrophic loss of sample during analysis to the Project Chemist as soon as possible after discovery (e.g., 24 hours).
		PTS Laboratories, Inc. Michael Mark Brady	562.347.2502	
Corrective Actions - Laboratory	Laboratory QA Officer	Eurofins Calscience, Inc. Larry Lem	714.895.5494	Any corrective actions requested to be performed by the laboratory shall be documented and communicated to the QA/QC Manager and the Project Chemist in writing within 30 days of any request.
Release of Data for Use	CB&I Project Chemist	Tim Roth	865.560.5272	No analytical data can be released until reviewed by the CB&I Project Chemist.
Data Requests and Reporting	CB&I Project Chemist	Tim Roth	865.560.5272	All requests for data will be directed to CB&I Project Chemist, who will forward to the CB&I Data Manager for processing. The Data Coordinator will also ensure that Environmental Restoration Program Information Management System (ERPIMS) submittals are prepared and submitted to AFCEC on a regular basis.
Database Issues	CB&I Data Manager	Kurt Schmidt	865.560.5283	All issues relating to operation or maintenance of the Environmental Information Management System (EIMS) database will be directed to the CB&I Data Manager, including requests for access, and special reporting formats such as data to support GIS.

UFP-QAPP Worksheet #6 – Communication Pathways (continued)
Former George Air Force Base, California

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathways, etc.)
Data Reports to Users	CB&I Data Manager	Kurt Schmidt	865.560.5283	All data reports will be directed to the CB&I Project Chemist, who will review for completeness and accuracy before distribution and use by the project team.

UFP-QAPP Worksheet #7 – Personnel Roles, Responsibilities, and Qualifications Table
Former George Air Force Base, California

Name	Title	Organizational Affiliation	Roles and Responsibilities	Education and Experience Qualifications
David Warner	Contracting Officer	AFCEC	• Ensure Contractor compliance with the contract	As required
Joseph Ebert	Contracting Officer Representative	AFCEC	AFCEC has designated a contracting officer representative for the former GAFB. The AFCEC Contracting Officer Representative (COR) will: • Represent the government's interest in the technical oversight and the implementation of the contract as designated by the AFCEC Contracting Officer • Ensure Contractor compliance with the contract through surveillance, routine meetings, evaluation of reports, and assurance that performance milestones are met prior to making payment	As required
Donald Gronstal	Base Realignment and Closure Act (BRAC) Environmental Coordinator	AFCEC	• Introduce the Contractor representatives to the appropriate authorities in charge of documentation permits required by the Contractor prior to commencing the work • Provide assistance to the Contractor representatives to obtain necessary documents • Sign all waste manifests • Perform duties as the lead agency and QA Evaluator • Facilitate regulatory interactions to achieve regulatory acceptance/concurrence • Plan, program, budget, and execute funding for this contract and out years • Sign all easement agreements and modifications and/or renewals of new or existing permits and non- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Pesticides Corrective Action Plan (PCAP) and Petroleum Sites Corrective Action Plan (PSCAP) • Ensure Air Force compliance with the Federal Facilities Agreement (FFA)	As required

UFP-QAPP Worksheet #7 – Personnel Roles, Responsibilities, and Qualifications Table (continued)
Former George Air Force Base, California

Name	Title	Organizational Affiliation	Roles and Responsibilities	Education and Experience Qualifications
Linda Geissinger	Public Affairs Officer (PAO)	AFCEC	• Ensure community involvement requirements (e.g., public meetings, notices, comment periods) are met • Coordinate and attend teleconferences with CB&I's PAO about ongoing activities, public outreach status, compliance with regulations, and other project issues • Coordinate with applicable parties in planning and organizing public meetings • Review and approve advertises public notices, TO fact sheets, and presentation materials	As required
Mary Aycock	RPM	EPA Region 9	• Ensure the project is in compliance with CERCLA requirements and other applicable or relevant and appropriate State and Federal regulations • Ensure EPA compliance with the FFA	As required
Todd Battey, PG	RPM	RWQCB, Lahonton Region	• Ensure the project is in compliance with applicable or relevant and appropriate State and Federal regulations • Ensure RWQCB compliance with the FFA	As required
David Daftary *, PE, CHG	PM	CB&I	• Closely communicate/coordinate with AFCEC on a daily basis or per frequency requested by AFCEC • Attend and, if AFCEC requests, lead meetings with stakeholders (i.e., regulators, public, and other agencies) • Approve staff scientists, engineers, other support staff, and selected subcontractors • Review and approve TO procedures, deliverables, schedules, and budgets • Approve procurements for services, equipment, and supplies as needed • Review and approve monthly reports (internal and external) and schedules • Verify that personnel follow approved work plans and specifications • Work with subcontractor's management liaison to resolve issues (if any) that cannot be resolved in the field	5+ years experience in project engineering, environmental investigation, field sampling, and site oversight

UFP-QAPP Worksheet #7 – Personnel Roles, Responsibilities, and Qualifications Table (continued)
Former George Air Force Base, California

Name	Title	Organizational Affiliation	Roles and Responsibilities	Education and Experience Qualifications
Mark Unruh	OT071 Technical Lead	CB&I	• Coordinate staff activities as they prepare and submit (after internal review) zone related reports/deliverables • Track TO progress/financial expenditures and adjust zone activities to ensure schedules and budgets are met • Review site-specific documents, monitor zone issues and update PM • Serve as zone expert/coordinator	5+ years experience in project engineering, environmental investigation, field sampling, and site oversight
James Joice *	Health & Safety Manager	CB&I	• Evaluate the health and safety aspects of the on-site tasks to ensure that activities are performed in a safe manner • Coordinate with task managers to complete health and safety work plan addendum for each major task work plan • Work with on-site personnel to achieve compliance with the applicable health and safety plans • May have additional duties assigned by the PM	5+ years experience in health and safety oversight
Stephen Massey *	QA Officer	CB&I	• Ensure the overall project quality, specifically the outgoing project plans and reports, and ensuring each project deliverable meets the quality standards established in the CB&I corporate quality program and in the contract • Coordinate with the technical members of the project team to evaluate status, procedures, and nonconformances from a quality program standpoint • Gather and coordinate corporate resources and references in the areas of quality improvement, corrective action control, and quality systems auditing for the project • Serve as primary contact for project quality matters and actively identify and respond to QA/QC needs, resolve problems, and answer requests for guidance or assistance • Review, evaluate, and approve the QAPP (and any addendums to it), and approve quality-related changes to the detailed task-specific plans • Actively track the progress of quality tasks in this plan and consult periodically with the program manager and PM on quality related issues • Prepare and submit QC reports to the CB&I PM	5+ years experience in QA/QC

UFP-QAPP Worksheet #7 – Personnel Roles, Responsibilities, and Qualifications Table (continued)
Former George Air Force Base, California

Name	Title	Organizational Affiliation	Roles and Responsibilities	Education and Experience Qualifications
Stephen Massey * (continued)	QA Officer	CB&I	• Approve field corrective actions prior to implementation • Verify that the contractor performs appropriate corrective actions for all contractor nonconformances, and interface with the analytical data coordinator or chemist on all quality issues and concerns associated with the subcontracted laboratory, including subcontractor-performed corrective actions • Provide project-specific training in QA/QC matters to contractor personnel, as needed, identified, or requested by the PM • Ensure that performance and system inspections are performed • Ensure that necessary corrective actions are taken for incidents of nonconformance • Assist in the implementation of corrective actions to prevent recurrence of any problems • If significant conditions exist adverse to quality, implement a Corrective Action Request in accordance with Procedure CMS-720-01-PR-00170 “Corrective and Preventive Action” (Attachment B) (A usable form for implementing a Corrective Action Request is presented in Attachment B [CMS-720-01-FM-00170].)	5+ years experience in QA/QC

UFP-QAPP Worksheet #7 – Personnel Roles, Responsibilities, and Qualifications Table (continued)
Former George Air Force Base, California

Name	Title	Organizational Affiliation	Roles and Responsibilities	Education and Experience Qualifications
Tim Roth *	Project Chemist	CB&I	• Monitor quality of chemistry services to ensure compliance with program/TO-specific requirements • Provide expertise during development of Sampling and Analysis Plan and data quality objectives (DQOs) • Ensure laboratories comply with DoD QSM • Verify data meets DQOs • Verify completeness of data deliverables (hard and electronic); oversee data entry into ERPIMS • Monitor the QA/QC deliverables from the laboratory; ensure conformance with authorized policies, procedures, and sound practices; and assist in identifying and resolving nonconformances and participate in project and laboratory audits • Ensure that all records, logs, standard procedures, and plans are distributed to the CB&I Project Site Manager • Ensure that sampling is conducted in a manner consistent with the QA program through ongoing communication with field personnel • Review all laboratory data before those data are transferred to permanent storage, reported to other project participants, or submitted via ERPIMS • Interface with the data users, task managers, field sampling lead, data coordinator, data manager, and Laboratory PM to determine project DQOs • Prepare quality control summary reports (QCSR) and interface with AFCEC, RWQCB Lahontan Region, and EPA regarding any data quality issues	MS in chemistry plus 5 years, or more experience that includes QA/QC, environmental investigation design, field sampling, field/laboratory analysis, data review, or data management

UFP-QAPP Worksheet #7 – Personnel Roles, Responsibilities, and Qualifications Table (continued)
Former George Air Force Base, California

Name	Title	Organizational Affiliation	Roles and Responsibilities	Education and Experience Qualifications
TBD	Public Affairs Officer (PAO)	CB&I	• Ensure community involvement requirements (e.g., public meetings, notices, comment periods) are met • Coordinate and attend teleconferences with AFCEC's PAO • Brief the PAO about ongoing activities, public outreach status, compliance with regulations, and other project issues • Work with applicable parties to plan and organize public meetings • Prepare and advertise public notices; prepare/distribute TO fact sheets and presentation materials • Perform research and community interviews to gather information (as needed)	5+ years experience in community relations
Don Dill *	Data Validator	CB&I	• Review data against method requirements and project acceptance criteria • Load data into the Automated Data Review module as defined in task project requirements • Perform completeness and accuracy checks on flags data that do not meet performance objectives	BS in chemistry, environmental science or related field or AS plus 5 years experience; plus certification in data validation or 2 years experience using/or reviewing data for each applicable method
Kurt Schmidt *	CB&I Data Manager	CB&I	• Review sampling planning • Load data and information and check for errors • Request data corrections from field and laboratory • Maintain the integrity of the data base • Report data and information as requested from data users	AS or BS in computer science plus 5 years experience in database management

UFP-QAPP Worksheet #7 – Personnel Roles, Responsibilities, and Qualifications Table (continued)
Former George Air Force Base, California

Name	Title	Organizational Affiliation	Roles and Responsibilities	Education and Experience Qualifications
Robert Mall	Site Superintendent	CB&I	• Manage on-site activities including soil vapor extraction operations, sampling, and remediation tasks • Report project progress to PM daily; adjust site activities if completion of a critical path item is slipping • Verify subcontractor performance and progress toward completion; • Approve subcontractor invoices • Ensure TO Work Plans, QC Plans, and Health and Safety Plans are implemented per approved documents • Immediately notify CB&I's PM and on-site client counterpart in the event of an emergency • Track government-furnished property and submit required reports	5+ years experience in field sampling and site oversight
Richard Villafania	Laboratory PM	Eurofins Calscience, Inc.	The laboratory will designate a Laboratory PM as the primary POC for the duration of the former GAFB project. The Laboratory PM will work with the project chemist on designing and implementing each task-specific analysis program. The Laboratory PM will also: • Verify the laboratory achieves and maintains DoD Environmental Laboratory Accreditation Program Certification and State of California approval for applicable analyses according to the subcontractor agreement between the laboratory and CB&I • Verify that the laboratory quantifies the planned parameters and routinely achieves the DLs, LODs, LOQs using the methods specified in WS #15 and in task-specific work plans • Coordinate sample receipt, processing, analysis, and data reporting with members of the laboratory technical staff to ensure accurate and on-time deliverables • Review the deliverables for completeness, accuracy, and compliance with the analytical program.	As required

UFP-QAPP Worksheet #7 – Personnel Roles, Responsibilities, and Qualifications Table (continued)
Former George Air Force Base, California

Name	Title	Organizational Affiliation	Roles and Responsibilities	Education and Experience Qualifications
Larry Lem	Laboratory QA Officer	Eurofins Calscience, Inc.	In addition to the Laboratory PM, the laboratory will identify its Laboratory QA Officer in the contract. This individual will assist the Laboratory PM with the former GAFB projects for their duration and will be responsible for the overall implementation of the laboratory QA program, as well as ensuring adherence to this QAPP and individual task work plans and QAPPs. The Laboratory QA Officer will assist the Laboratory PM during the initial review of analytical data generated to verify that the data meet DQOs established in this QAPP and in task work plans. The Laboratory QA Officer will also assist in defining and resolving analytical nonconformances and participate in any project/laboratory audits.	As required
Michael Mark Brady	Laboratory PM	PTS Laboratories, Inc.	The laboratory will designate a Laboratory PM as the primary POC for the duration of the former GAFB project. The Laboratory PM will work with the project chemist on designing and implementing each task-specific analysis program. The Laboratory PM will also: • Verify that the laboratory quantifies the planned parameters • Coordinate sample receipt, processing, analysis, and data reporting with members of the laboratory technical staff to ensure accurate and on-time deliverables • Review the deliverables for completeness, accuracy, and compliance with the analytical program.	As required

Project team members are identified with an asterisk (*).

Resumes are located online and/or in the project files in CB&I Knoxville, Tennessee office.

UFP-QAPP Worksheet #8 – Special Personnel Training Requirements Table
Former George Air Force Base, California

Project Function	Specialized Training – Title or Description of Course	Training Provider	Training Date	Personnel/Groups Receiving Training	Personnel Titles/ Organizational Affiliation	Location of Training Records/ Certificates
CB&I Project Site Manager	Site Safety and Health Officer (SSHO)	CB&I	July 2012	Field Labor Robert Mall	CB&I	Training records are available on-line at CB&I Talent Connection and will also be maintained onsite
Data Validation	Review project requirements, document experience; or completion of Data Validation Certification based on the National Functional Guidelines for Superfund Organic and Inorganic Methods Data Review	CB&I	Verified 1 March 2010	Project Chemist; Data Validators	CB&I	Training/experience available through Don Dill, CB&I Data Validation Group, Knoxville, Tennessee
Field Operations	Flight-line Training and Badging	Southern California Logistic Airport Operations and Security	To be determined (TBD)	Field Geologist(s)	CB&I	Southern California Logistic Airport Operations and Security

UFP-QAPP Worksheet #9 – Project Scoping Session Participants Sheet
Former George Air Force Base, California

Project Name: AFCEC WERC09; Former George Air Force Base; Task Order 0018 Projected Date(s) of Sampling: FY2016 Project Manager: David Daftary	Site Names: OT071 Site Location: Former George Air Force Base

Date of Session: 22 September 2015

Scoping Session Purpose: Define objectives for Task Order 0018; Site IDs: OT071

Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Donald Gronstal	BRAC Environmental Coordinator	AFCEC/CIBW	916.643.3672 x211	donald.gronstal@us.af.mil	FGAFB POC
Mike Kelly	Counsel	AFCEC/CIBW	916.643.6420 x106	michael.kelly.3@us.af.mil	AFCEC Legal Counsel
Calvin Cox	Technical Support to AFCEC	CNTS	760.246.5360	calvin.cox@cb-bus.com	AFCEC Consultant
Susan Soloyanis	Principal Geoscientist	Sologeo (contractor to Noblis)	719.331.2331	susan@sologeo.com	AFCEC Consultant
Todd Battey	Engineering Geologist	RWQCB	760-241-7340	Todd.Battey@waterboards.ca.gov	RWQCB POC
Linda Stone	Engineering Geologist	RWQCB	530.542.5471	linda.stone@waterboards.ca.gov	RWQCB POC
David Daftary	PM	CB&I	805.499.3159	david.daftary@cbifederalservices.com	PM
Tarek Ladaa	Program Manager	CB&I	865.670.2708	tarek.ladaa@cbifederalservices.com	Program Manager
Mark Unruh	Project Scientist	CB&I	619.533.7301	mark.unruh@cbifederalservices.com	Tech Lead for OT071

UFP-QAPP Worksheet #9 – Project Scoping Session Participants Sheet (continued)
Former George Air Force Base, California

One principal project scoping sessions was held on 22 September 2015.

The main components of the Site Performance-Remediation activities include:

Site Objectives:

The proposed investigative activities are to fill data gaps identified in the delineation of the dieldrin plume in the Upper and Lower Aquifers, so the appropriate remedial action can be evaluated and selected for pesticides in groundwater at Site OT071. During the working session, the Air Force presented the OU1 well locations and rationales to the RWQCB. The proposed investigation activities will also collect near-surface soil sample to allow calibration of a vadose zone transport model.

Action Items:

- Prepare an OT071 Data Gap Well Installation Work Plan.
- Install five additional monitoring wells.
- Drill and sample five additional geotechnical borings
- Perform soil sampling and analysis at various depths to determine constituent of potential concern (COPC) concentrations at the site.
- Perform geotechnical analyses of vadose zone and aquifer materials for inputs into vadose zone and groundwater models and to update the CSM.

The following discussion of the DQO processes will serve as guidance for developing site-specific task plans to ensure that the goals for investigation or other program activities are met. The process involves one or more planning sessions that are documented on WS #9.

The DQO development process consists of seven steps:

- State the problem.
- Identify the goal of the study.
- Identify information inputs.
- Define the boundaries of the study.
- Develop the analytic approach.
- Specify performance or acceptance criteria.
- Develop the detailed plan for obtaining data.

Several of the steps in the DQO process can occur simultaneously, and in some situations, the process does not have to include all steps. For example, when enforcement or compliance monitoring programs are being developed to comply with existing regulations, many of the steps may have already been completed. Also, when activities in any step reveal that new environmental data are not needed to make decisions, the process can be stopped. Outputs from the DQO process are summarized in WSs #10 and #11.

Step 1 - State the Problem

This step requires that the problem that will require new environmental data be summarized. The resources available to resolve the contamination problem must be specified. Key activities associated with this step include:

- Identifying members of the scoping team
- Developing or refining the conceptual site model (CSM)
- Defining the exposure pathways and exposure scenarios
- Specifying available resources
- Writing a brief summary of the problem.

The main output of this step is a complete description of the contamination problem that includes the regulatory and programmatic context of the problem. This description typically consists of the following:

- A list of the known and suspected contaminants in each environmental medium and estimates of their concentration, variability, distribution, and location.
- The CSM and exposure pathways.
- A summary of the outcome and status of any previous response(s) at the site, such as early actions or previous data collection activities.
- The site's physical and chemical characteristics that influence migration and associated human, environmental, and physical target(s).
- An estimate of the budget, schedule, and available personnel necessary to implement the appropriate response for the site.

The scoping team consists of AFCEC, RWQCB Lahontan Region, and CB&I. Resource specifications are contained in the Data Gaps Well Installation Work Plan. The period of performance for entire former GAFB project is approximately 10 years. This OT071 work is anticipated to start in 2015 and run for approximately 3 months. The start date may differ based on the completion and approval of project plans. The master project schedule is contained in Appendix A of the Project Management Plan (PMP).

The following is a summary of the potential problems that will require new analytical data. Further site background information is contained in Section 2.0 of the OT071 Data Gaps Well Installation Work Plan.

Site OT071 Dieldrin plume

Site OT071 encompasses approximately 900 acres and consists of pesticides in groundwater beneath the former housing areas and the Westwinds Golf Course. No formal administrative agreements or decision documents currently govern the ongoing environmental monitoring and reporting actions at Site OT071. The primary objective of the proposed investigative activities is to fill data gaps identified in the Draft Non-CERCLA OT071 Corrective Action Plan for Pesticides in Groundwater (PCAP) (MWH, 2011) and during discussions between the Air Force (AF) and the Lahontan Region office of the California Regional Water Quality Control Board (RWQCB). The proposed wells are intended to further characterize the lateral and vertical extent of the dieldrin plume at specific locations identified by the Air Force and the RWQCB. In addition, the wells may be useable at a later date as monitoring wells in a long term monitoring program and/or as future sentinel wells (Lower Aquifer). Proposed shallow zone soil sampling is intended to provide Dieldrin concentrations for calibration of vadose zone modeling.

Step 2 - Identify the Goal of the Study

This step requires identification of the decision/objective that requires new environmental data. For example, an early assessment decision is to determine whether a chemical release poses a potential threat to human health or the environment. Key activities associated with this step include:

- Identifying the key objective for the current phase or stage of the project.
- Identifying alternative actions that may be taken based on the findings of the field investigation.
- Identifying relationships between this objective and any other current or subsequent objectives.

The output from this step should include the following:

- A statement of the objectives that will use environmental data.
- A list of the actions that will be taken toward remediation or removal of the potential contamination problem based on the outcome of the field investigation.

The primary proposed field investigative activities include the following:

- Fill data gaps identified in the delineation of the dieldrin plume in the Upper and Lower Aquifers, so the appropriate remedial action can be evaluated and selected for pesticides in groundwater at Site OT071.
- Provide near-surface Dieldrin concentrations in the vadose zone to aid in the calibration of the vadose zone modeling, and
- Provide geotechnical analyses of vadose zone and aquifer materials for inputs into vadose zone and groundwater models and to update the CSM.

Step 3 - Identify Informational Inputs

The purpose of this step is to identify the information needed to support the objective, and specify which inputs require new environmental measurements. Key activities associated with this step include:

- Identifying the informational inputs needed to resolve the objective.
- Identifying sources for each informational input, and listing those inputs that are obtained through environmental measurements.
- Defining the basis for establishing contaminant-specific action levels.
- Identifying potential sampling approaches and appropriate analytical methods.

The outputs that will result from this step include a list of informational inputs needed to make the decision and a list of environmental variables or characteristics that will be measured.

The outputs from this step are actually the inputs that will be used to support the objective, sometimes referred to as the "decision."

The location and rational for installing the additional monitoring wells (five total) are summarized below:

- MW-159 – Located in the Upper Aquifer southeast of NZ-120 to assess the groundwater mound and possible migration to the Lower Aquifer. The well will be screened across the top of the aquifer with between 10 and 15 feet of saturated screened interval to measure dieldrin concentrations near the Upper Aquifer surface.
- MW-160 – Located in the Upper Aquifer south of NZ-125 and paired with MW-161 to assess the southeastern extent of the plume where dieldrin has been detected above the notification level. The well will be screened across the top of the aquifer with between 10 and 15 feet of saturated screened interval to measure dieldrin concentrations near the Upper Aquifer surface.
- MW-161 – Located in the Lower Aquifer south of MW-147 and paired with MW-152 to assess the southern extent of the plume. MW-161 will be doublecased through the Upper Aquifer and screened across the top of the Lower Aquifer with between 10 and 15 feet of saturated screened interval to measure dieldrin concentrations near the Lower Aquifer surface.
- MW-162 – Located in the Lower Aquifer north of MW-147 and paired with MW-152 to assess the southern portion of the plume. The well will be double cased through the Upper Aquifer and screened across the top of the Lower Aquifer with between 10 and 15 feet of saturated screened interval to measure dieldrin concentrations near the Lower Aquifer surface.
- MW-163 – Located in the Lower Aquifer adjacent to MW-149 to assess the groundwater at the top of the water table. The well will be screened across the top of the Lower Aquifer with between 10 and 15 feet of saturated screened interval to measure dieldrin concentrations near the Lower Aquifer surface. MW-149 is screened in a deeper interval more in line with the nearby A4 supply well.

The location and rational for soil borings (five total) are summarized below:

- OT071-SB02 - Located where the highest dieldrin concentration was previously detected (SS-37 at 15,000 ug/kg). Samples will be collected directly beneath the slab and at depths of 2, 4, 7, 10, and 15 feet below grade.
- OT071-SB03 - To be drilled at the location of SS-35 (1710 ug/kg). Samples will be collected at depths of 2, 4, 7, 10, and 15 feet below grade.
- OT071-SB04 - Location to be determined after field survey. To be drilled in an unpaved areas near the locations of former high concentration samples. Samples will be collected at depths of 2, 4, 7, 10, and 15 feet below grade.
- OT071-SB05 - Location to be determined after field survey. To be drilled in an unpaved areas near the locations of former high concentration samples. Samples will be collected at depths of 2, 4, 7, 10, and 15 feet below grade.
- OT071-SB06 - Location to be determined after field survey. To be drilled in a topographic low where runoff may have concentrated Dieldrin Samples will be collected at depths of 2, 4, 7, 10, and 15 feet below grade.

The soil samples collected during this investigation will be analyzed for the following chemical methods:

- Organochlorinated pesticides by SW-846 3550 8081A.

The detection limits associated with method SW-846 3550 8081A are anticipated to be sufficient to confirm presence or absence.

The soil samples collected during this investigation will be analyzed for the following geotechnical methods:

- Full-scale digital core photography ASTM D5079
- Grain-size analysis by laser by ASTM D4464
- TOC by Walkley-Black
- Soil Properties Package (Vadose Zone) – native permeability to air, total porosity, air-filled porosity, grain and bulk density, moisture content, total pore fluid saturation by method API RP40 and ASTM D2216

Step 4 - Define the Boundaries of the Study

This step requires definition of the spatial and temporal aspects of the environmental media that the data must represent to support the objective. Key activities associated with this step include:

- Defining the geographic areas of the field investigation
- Defining each environmental medium of concern
- Dividing each medium into strata having relatively homogeneous characteristics
- Defining the scale of decision making (this is the smallest area, volume, or time frame of the medium) in which the scoping team wishes to control decision errors
- Determining the time frame to which the objective applies
- Determining when to take samples
- Identifying practical constraints that may hinder sample collection (reconsider previous steps as necessary).

Outputs from this step may include:

- A detailed description and physical representation (map) of the geographic limits (boundaries) of each environmental medium (soil, water, air, etc.) within which the decision(s) will be made
- A detailed description of the characteristics that define the population of interest
- Definition of the time period in which samples will be taken and to which objectives will apply
- The most appropriate scale of decision making for each medium of concern
- A description of practical constraints that may impede sampling.

The OT071 Data Gaps Well Installation study is shown on Figure 2-1 and Figure 2-2.

Step 5 - Develop the Analytical Approach

The purpose of this step is to integrate the output from the previous steps of the DQO process into a statement that defines the conditions that would cause the decision-maker to choose among alternative actions. Key activities associated with this step include:

- Specifying the parameter of interest (such as mean, medium, maximum, or proportion)
- Specifying the action level for the decision.

The output from this step is an “if...then...” statement that defines the conditions that would cause the decision maker to choose among alternative courses of action. It should include the decision, the actions, the parameter of interest, the action level, and the scale (magnitude of impact) of decision making.

Samples collected for organochlorinated pesticides are to determine presence or absence.

Step 6 - Specify Performance or Acceptance Criteria

The purpose of this step is to specify the acceptable decision error rates based on a consideration of the consequences of making an incorrect decision. These limits will be used in the last step of the process.

Key activities associated with this step include the following:

- Determining the possible range of the parameter of interest
- Defining both types of decision errors and identifying the potential consequences of each

- Specifying a range of possible parameter values where the consequences of decision errors are relatively minor (gray region), whenever possible
- Assigning probability values to points above and below the action level that reflect the acceptable probability for the occurrence of decision errors, when necessary
- Checking the limits on decision errors to ensure that they accurately reflect the decision-maker's concern about the relative consequences for each type of decision error.

The outputs from this step are the acceptable decision error rates based on a consideration of the consequences of making an incorrect decision. These limits on decision errors can be expressed in a decision error limits table or in a design goal diagram.

Overall precision and accuracy DQOs have been established for this project based on the laboratory's previous experience and on analytical method guidance and are presented in WS #15 tables. From the DQO perspective, quantitative data will be categorized as screening data (data of sufficient quality to support an intermediate or preliminary decision but must eventually be supported by definitive data) or definitive data (analytical data that are suitable for final decision-making). Definitive data will be required to support site characterization and waste characterization. Screening data may be collected to support health and safety operations and to make qualitative assessments in the field.

One hundred percent of the off-site definitive data will be validated based on QC criteria defined in the site-specific QAPP, DoD QSM Version 4.2, and/or SW-846 methodology, with final qualifiers assigned following the logic defined in EPA Contract Laboratory Program NFG for Superfund Inorganic and Organic Data Review (EPA 540-R-013-001 and EPA 540-R-014-002). Data validation is not applicable to the waste characterization testing data collected for waste segregation, transportation, and disposal evaluation.

Completeness is a measure of the amount of valid data obtained during a sampling event as compared to the amount of data planned for collection and determined to be usable for the intended purpose. An overall completeness goal of 90 percent is set for site characterization sampling at former GAFB OT071.

Step 7 - Develop the Plan for Obtaining Data

The purpose of this step is to identify the most resource-effective sampling design that generates data that satisfy the DQOs specified in the preceding steps. To develop the optimal design for the study, it may be necessary to work through this step more than once after revisiting previous steps of the DQO process. Remediation activities and supporting investigations at the former GAFB will require the collection of different kinds of data for each site including both qualitative and quantitative data. From a systematic planning perspective, quantitative data will be categorized as screening data (data of sufficient quality to support an intermediate or preliminary decision but must eventually be supported by definitive data) or definitive data (analytical data that are suitable for final decision-making). The need for chemical or non-chemical analyses will be determined on a site-by-site basis based on the remedial objectives and remedial technologies applicable at each location.

See WS #17 for final sampling and analysis design.

Who will use the data? Data will be used by the CB&I project team and will be reviewed by AFCEC and RWQCB Lahontan Region.
What will the data be used for? The investigative activities proposed in this work plan are intended to provide additional characterization of current site conditions at former GAFB Site OT071. Proposed shallow zone soil sampling is intended to provide Dieldrin concentrations for calibration of vadose zone modeling.
What types of data are needed? (Define parameters/matrices) The DQO process helps define the types of environmental data that will be used and sets guidelines for designing a data collection program that will meet DQOs. The process also provides a logical, objective, and quantitative framework for determining the time and resources that will be used to generate data of the desired level of quality. The DQO process will be applied to each project task and presented in task-specific plans. The purpose of this step is to identify the most resource-effective sampling design that generates data that satisfy the DQOs specified in the preceding steps. To develop the optimal design for this study, it may be necessary to work through this step more than once after revisiting previous steps of the DQO process. WSs #18 summarize the sampling location, sample media, sampling SOPs, and requested analyses to complete the site characterization at OT071. How "good" do the data need to be in order to support the environmental decision? (Screening or Definitive?) As defined in the EPA guidance document entitled "Guidance on Systematic Planning Using the Data Quality Objectives Process" (EPA, 2006), DQOs are qualitative and quantitative statements that specify the quality of data required to support performance-remediation activity decisions. This guidance and the DQO process were developed specifically for CERCLA. DQOs are applicable to all data collection activities, and the level of detail and data quality needed will vary based on the intended uses of the data and will be defined in task-specific work plans. Definitive data will be required for soil characterization sampling and investigation derived waste (IDW) profiling sampling. Screening data may be collected to support health and safety operations and to make qualitative assessments in the field.
How much data are needed? (number of samples for each analytical group, matrix, and concentration) This step requires definition of the spatial and temporal aspects of the environmental media that the data must represent to support the objective. Key activities associated with this step include: • Defining the geographic areas of the field investigation • Defining each environmental medium of concern • Dividing each medium into strata having relatively homogeneous characteristics • Defining the scale of decision making (this is the smallest area, volume, or time frame of the medium) in which the scoping team wishes to control decision errors • Determining the time frame to which the objective applies • Determining when to take samples • Identifying practical constraints that may hinder sample collection (reconsider previous steps as necessary).

Outputs from this step may include:

- A detailed description and physical representation (map) of the geographic limits (boundaries) of each environmental medium (sediment and surface water) within which the decision(s) will be made
- A detailed description of the characteristics that define the population of interest
- Definition of the time period in which samples will be taken and to which objectives will apply
- The most appropriate scale of decision making for each medium of concern
- A description of practical constraints that may impede sampling.

WSs #18 summarize the sampling location, sample media, sampling SOPs, and requested analyses to complete the site characterization at OT071.

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

Project schedule/timeline is updated on monthly basis and is summarized in CB&I Project Manager's Contractors Progress Status and Management Report submitted to AFCEC.

WSs #18 summarize the sampling location, sample media, sampling SOPs, and requested analyses to complete the site characterization at OT071.

Who will collect and generate the data?

CB&I project team personnel will collect all soil samples.

Soil and IDW samples will be sent to Eurofins Calscience Inc. for analysis. Shipping address is as follows:

Eurofins Calscience, Inc.
Attention: Richard Villafania
7440 Lincoln Way
Garden Grove, CA 92841-1427
Phone: 714.895.5494
Fax: 714.894.7501

Geotechnical samples will be sent to PTS Laboratories, Inc. for analysis. Shipping address is as follows:

PTS Laboratories, Inc.
Attention: Michael Mark Brady
8100 Secura Way
Santa Fe Springs, CA 90670
Phone: 562.347.2502
Fax: 562.907.3610

How will the data be reported? Field data will be recorded in field logbooks and copies submitted to data management for uploading into the database. Hard copies of laboratory sample delivery groups (SDG) will be sent to the Project Chemist, including an electronic copy of the SDG and electronic data deliverable (EDD) that can be uploaded into the CB&I EIMS database. Laboratory data will be reviewed on an ongoing basis. All data reported by the laboratory will undergo a three-tiered internal review process by the analyst, a peer or supervisor review, and a project management review before being sent to the task manager and data coordinator for additional project review. In the data review process, the data are compared to information such as the sample history, sample preparation, and QC sample data to evaluate the validity of the results.
How will the data be archived? All chemistry data will be stored in the CB&I project EIMS database. Periodic data transmittals of data will be transferred to AFCEC's ERPIMS database using the most current version of the ERPToolsX software with copies of the transmittal form to AFCEC.

Table 12-1. Measurement Performance Criteria for Organochlorinated Pesticides by EPA Method 8081

Matrix	Soil
Analytical Group	Gas Chromatography-Electron Capture Detector (GC-ECD) – Organochlorinated Pesticides
Concentration Level	Low
Sampling SOP	Soil – EI-FS-101 / EI-FS-107 / EI-GS-021 Water – EI-FS-115
Analytical Method/SOP Reference	SW-846 8081/SOP-M400
Sampler's Name	TBD [1]
Field Sampling Organization	TBD [1]
Analytical Organization	Eurofins-Calscience
No. of Sample Locations	TBD [2]

[1] The sampler's name and organization will be determined in the task/site-specific work plan based on staff availability at the time of sampling.
[2] The number of sample locations will be included in the task/site-specific work plan.

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or Both (S&A)
Soil – EI-FS-101 / EI-FS-107 / EI-GS-021 Water – EI-FS-115	Organochlorinated Pesticides by SW-846 8081 / SOP-M400	Completeness	%Collected >95 %Valid $\geq$90	Data Completeness Check	S&A
		Sensitivity	DL $\leq$ 0.5 x limit of quantitation (LOQ)	Detection Limit (DL) Study	A
		Sampling Precision	Soil: relative percent difference (RPD) $\leq$ 50 %	Field Duplicate	S&A
		Calibration Accuracy	Mean relative standard deviation (RSD)$\leq$ 20%; or r $\geq$0.995; or r^2 $\geq$0.990	Initial Calibration	A
			percent difference (%D) $\pm$ 20%	Continuing Calibration	A
			%D $\pm$ 20%	Second-Source Standard	A

Table 12-2. Measurement Performance Criteria for Chlorinated Herbicides by EPA Method 8151

Matrix	Soil
Analytical Group	Gas Chromatography-Electron Capture Detector (GC-ECD) – Chlorinated Herbicides
Concentration Level	Low
Sampling SOP	Soil – EI-FS-101 / EI-FS-107
Analytical Method/SOP Reference	SW-846 8151/SOP-M402
Sampler's Name	TBD [1]
Field Sampling Organization	TBD [1]
Analytical Organization	Eurofins-Calscience
No. of Sample Locations	TBD [2]

[1] The sampler's name and organization will be determined in the task/site-specific work plan based on staff availability at the time of sampling.
[2] The number of sample locations will be included in the task/site-specific work plan.

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or Both (S&A)
Soil – EI-FS-101 / EI-FS-107	Chlorinated Herbicides by SW-846 8151 / SOP-M402	Completeness	%Collected >95 %Valid $\geq$90	Data Completeness Check	S&A
		Sensitivity	DL $\leq$ 0.5 x limit of quantitation (LOQ)	Detection Limit (DL) Study	A
		Calibration Accuracy	Mean relative standard deviation (RSD)$\leq$ 20%; or r $\geq$0.995; or r^2 $\geq$0.990	Initial Calibration	A
			%D $\pm$ 20%	Continuing Calibration	A
			%D $\pm$ 20%	Second-Source Standard	A

Table 12-3. Measurement Performance Criteria for Volatile Organic Compounds by EPA Method 8260

Matrix	Soil
Analytical Group	Gas Chromatography/Mass Spectroscopy (GC/MS) – VOCs
Concentration Level	Low
Sampling SOP	Soil – EI-FS-101 / EI-FS-107
Analytical Method/SOP Reference	SW-846 8260/SOP-M311
Sampler's Name	TBD [1]
Field Sampling Organization	TBD [1]
Analytical Organization	Eurofins-Calscience
No. of Sample Locations	TBD [2]

[1] The sampler's name and organization will be determined in the task/site-specific work plan based on staff availability at the time of sampling.
[2] The number of sample locations will be included in the task/site-specific work plan.

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or Both (S&A)
Soil – EI-FS-101 / EI-FS-107	VOCs by SW-846 8260 / SOP-M311	Completeness	%Collected >95 %Valid ≥90	Data Completeness Check	S&A
		Sensitivity	DL ≤ 0.5 x LOQ Chlorobenzene and 1,1,2,2-Tetrachloroethane RRF ≥ 0.30; and Chloromethane, Bromoform, and 1,1-Dichloroethane RRF ≥ 0.10	MDL Study	A
		Calibration Accuracy	Mean RSD≤ 15%[CCCs RSD ≤ 30]; or r ≥0.995; or r^2 ≥0.990	Initial Calibration	A
			%D ± 20%	Continuing Calibration	A
			%D ± 20%	Second-Source Standard	A

Table 12-4. Measurement Performance Criteria for Semivolatile Organic Compounds by EPA Method 8270

Matrix	Soil
Analytical Group	GC/MS - SVOC
Concentration Level	Low
Sampling SOP	Soil – EI-FS-101 / EI-FS-107
Analytical Method/SOP Reference	SW8270/SOP-M404
Sampler's Name	TBD[1]
Field Sampling Organization	TBD[1]
Analytical Organization	CELG
No. of Sample Locations	TBD[2]

[1] The sampler's name and organization will be determined in the task/site-specific work plan based on staff availability at the time of sampling.
[2] The number of sample locations will be included in the task/site-specific work plan.

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Soil – EI-FS-101 / EI-FS-107	SVOCs by SW8270/SOP-M404	Completeness	%Collected >95 %Valid $\geq$90	Data Completeness Check	S&A
		Sensitivity	DL $\leq$ 0.5 x LOQ SPCCs RRF $\geq$ 0.05	MDL Study	A
		Calibration Accuracy	Mean RSD$\leq$ 15% [CCCs RSDs $\leq$ 30]; or r $\geq$0.995; or r^2 $\geq$0.990	Initial Calibration	A
			%D $\pm$ 20%	Continuing Calibration	A
			%D $\pm$ 20%	Second-Source Standard	A

Table 12-5. Measurement Performance Criteria for Metals by EPA Method 6010

Matrix	Soil
Analytical Group	Inductively Coupled Plasma (ICP) – Metals
Concentration Level	Low
Sampling SOP	Soil – EI-FS-101 / EI-FS-107
Analytical Method/SOP Reference	SW-846 6010/SOP-M601
Sampler's Name	TBD [1]
Field Sampling Organization	TBD [1]
Analytical Organization	Eurofins-Calscience
No. of Sample Locations	TBD [2]

[1] The sampler's name and organization will be determined in the task/site-specific work plan based on staff availability at the time of sampling.

[2] The number of sample locations will be included in the task/site-specific work plan.

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or Both (S&A)
Soil – EI-FS-101 / EI-FS-107	Metals by SW-846 6010/ SOP-M601	Completeness	%Collected >95 %Valid ≥90	Data Completeness Check	S&A
		Sensitivity	DL ≤ 0.5 x LOQ	MDL Study	A
		Calibration Accuracy	r ≥0.995 [a]	Initial Calibration	A
			%D ± 10%	Continuing Calibration	A
			%D ± 10%	Second-Source Standard	A

Notes:
[a] If more than one standard is used for calibration.

Table 12-6. Measurement Performance Criteria for Mercury by EPA Method 7470

Matrix	Soil
Analytical Group	CVAA - Mercury
Concentration Level	Low
Sampling SOP	Soil – EI-FS-101 / EI-FS-107
Analytical Method/SOP Reference	Soil: 7470/SOP-M620
Sampler's Name	TBD[1]
Field Sampling Organization	TBD[1]
Analytical Organization	CELG
No. of Sample Locations	TBD[2]

[1] The sampler's name and organization will be determined in the task/site-specific work plan based on staff availability at the time of sampling.
[2] The number of sample locations will be included in the task/site-specific work plan.

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Soil – EI-FS-101 / EI-FS-107	Soil: Mercury by SW7470/SOP-M620	Completeness	%Collected >95 %Valid ≥90	Data Completeness Check	S&A
		Sensitivity	DL ≤ 0.5 x LOQ	MDL Study	A
		Calibration Accuracy	r ≥0.995	Initial Calibration	A
			%D ± 10%	Second-Source Standard	A
			%D ± 20%	Continuing Calibration	A

Table 12-7. Measurement Performance Criteria for % Moisture by SM 2540-B

Matrix	Soil
Analytical Group	Gravimetric – Wet Chemistry
Concentration Level	Low
Sampling SOP	Soil – EI-FS-101 / EI-FS-107 / EI-GS-021
Analytical Method/SOP Reference	SM 2540-B/SOP-M700
Sampler's Name	TBD[1]
Field Sampling Organization	TBD[1]
Analytical Organization	Eurofins-Calscience
No. of Sample Locations	TBD[2]

[1] The sampler's name and organization will be determined in the task/site-specific work plan based on staff availability at the time of sampling.
[2] The number of sample locations will be included in the task/site-specific work plan.

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or Both (S&A)
Soil – EI-FS-101 / EI-FS-107 / EI-GS-021	% Moisture by SM 2540-B /SOP M700	Completeness	%Collected >95 %Valid ≥90	Data Completeness Check	S&A
		Sensitivity	DL ≤ LOQ	MDL Study	A
		Sampling Precision	Soil: RPD ≤ 10 %	Laboratory Duplicate	S&A

UFP-QAPP Worksheet #13 – Secondary Data Criteria and Limitations Table
Former George Air Force Base, California

Secondary Data	Data Source (Originating Organization, Report Title, and Date)	Data Generator(s)	How Data Will Be Used	Limitations on Data Use
Existing data	ERPIMS database	AFCEC	Previous data will be used for investigation / remediation activities	No limitations

Field Activities

Field activities at Site OT071 include the following:

- Soil sampling and analysis to provide concentrations of Dieldrin in near surface soil for calibration of the vadose zone model.
- Geotechnical analyses will be to provide soil property data for use in the vadose zone and groundwater modeling.
- Characterization and disposal of IDW during well installation operations
- Surveying of all sample locations
- Upload data from the investigative activities into AFCEC's Environmental Resources Program Information Management System (ERPIMS).

SOPs and specifications for conducting site investigation activities under Former GAFB TO 0018 are provided in the *Former George AFB Basewide QAPP*, Attachment B (CB&I, 2012).

Sampling Tasks:

Sampling tasks are defined in WSs #17 of this site-specific QAPP.

Analysis Tasks:

Analysis tasks are defined in WSs #18 of this site-specific QAPP.

Quality Control Tasks:

QA/QC activities are prescribed by individual methods and the laboratory QA program. A copy of each laboratory's QA Plan and SOPs are provided in Attachment C of this UFP-QAPP, as well as in the *Former George AFB Basewide QAPP,* Attachment C (CB&I, 2012).

Laboratory QC Program:

QC procedures are implemented to provide the quality of data suitable for their intended use and to ensure that the project DQOs are satisfactorily met. Field QC and laboratory QC checks are used to determine if the analysis is in control, as well as if the sample matrix adversely affects the quantitated result. To clarify these requirements, the following definitions are provided.

Field QC Procedures:

In addition to sampling, field QC or matrix-specific QC is performed to check the sampling and analytical accuracy and precision of field data and to determine the origin of contamination originating from the collection, transport, or storage of samples. The purpose of field QC data is to provide important information about field operations. Analytical data are not to be altered or corrected for any results from the field QC samples. The requirements and frequency are determined by the method or specified by the project. The types of matrix-specific QA/QC include matrix spike/matrix spike duplicate (MS/MSD) field duplicates, trip blanks, equipment blanks, and material blanks, and are specified in WS #20 (which will be updated in site-specific work plans).

Matrix Spike/Matrix Spike Duplicates. MS/MSDs are used to determine the accuracy and precision of the method for a sample matrix. The spiked compounds include representative compounds that are quantified during the method and spiked during sample preparation on a specially prepared aliquot of the sample matrix. Results of these spiked aliquots are then compared to the native concentrations of the analytes spiked, and a recovery is calculated. Recovery of the spiked compound is used as an assessment of analytical accuracy on the sample matrix analyzed. These results are essential to identifying sample matrix interferences. Often, MSs are performed in duplicate (as an MSD) on a second aliquot of the sample. In this manner, the precision of the assessment can be quantified as the RPD of the original and duplicate spike. The target acceptance limits for MS recovery and RPD are statistically determined by the analytical laboratory as specified in the method and are presented in WS #12 tables in the *Former George AFB Basewide QAPP* (CB&I, 2012).

Field Duplicates. Field duplicates are used to assess the precision of the sample collection procedures for a specific matrix. No data are qualified based solely on the results of field duplicate analyses. Field duplicate sample analysis will be performed on a task-specific frequency to address the variability of contaminant concentrations in the sample matrix. Because of the additional variability introduced during sampling, the target acceptance criteria are referenced in WS #12 tables in the *Former George AFB Basewide QAPP* (CB&I, 2012).

Equipment Blanks. Equipment blanks are used to check the adequacy of the decontamination of the sampling equipment used for the samples collected. In the event of equipment blank contamination, the associated sample data are evaluated for false positive results.

Performance Evaluation Samples. No performance evaluation samples are planned to be submitted to subcontracted laboratories under this site-specific work plan.

Laboratory QC Procedures:

Laboratory QC implements internal QC checks to monitor the precision and accuracy of an analytical method in the absence of known matrix interferences and can be categorized as batch QC and method QC. These internal QC checks are used together to ensure that the data quality is satisfactory and are required to provide confidence in the consistent quality of the data. WS #28 tables, in the *Former George AFB Basewide QAPP* (CB&I, 2012), summarize the QC acceptance criteria, and the subsequent corrective action for each analytical method.

The sample batch is a group consisting of a maximum of 20 samples that are of the same matrix or of similar composition and that are prepared and/or analyzed together under the same analytical conditions. Samples that are prepared together should be analyzed together, with the exception of failed QC indicators that warrant reanalysis. There is a distinction between a preparation batch and an analytical batch.

The preparation batch is defined as samples that are prepared together using the same equipment, method sequence, and reagents and undergoing the same process. Each preparation batch must contain the required number and type of blanks, laboratory QC samples, and field QC samples defined for the method or the project.

The analytical batch consists of a group of samples that are analyzed together within the same analytical run sequence and within the same time period or in sequential time periods with the required number of calibration standards and QC samples defined by the method or the project.

Batch QC. Samples that are required for every batch are, at a minimum, the method blank and a laboratory control sample (LCS) or blank spike. Further QC requirements are addressed by the method or on a project-specific basis.

Method Blanks. Method blanks are either water or soil matrices that are known to be free of matrix effects, analyzed with each analytical batch and are processed on a per matrix (i.e., soil and water) basis. These blanks are carried stepwise through the same analytical procedure as the field samples, including the addition of solvents, spikes, and reagents required in the analysis process. The purpose of the blank is to identify any possible contaminants that may be introduced to the sample as a result of any part of the analytical process. Contamination identified in the method blank can be compared to the results of the field samples and can be used to assess the origin of the reported concentration and to identify cases where elevated concentrations might be false positive data.

LCSs or Blank Spikes. LCS or blank spike samples consist of known amounts of target analytes in an analyte-free matrix (soil or water). The spiked analytes include all of the single-component analytes that are quantified during the method and are spiked during the sample preparation on a specially prepared aliquot of the sample or blank matrix. A subset of the target analytes containing specific analytes of interest could be substituted and used in place of the full list of target analytes if specified in the project-specific DQOs. A separate LCS spiked with a subset of the multi-component target analytes may be necessary if these analytes are of interest. Results of these spiked aliquots are then compared to the known concentrations of the analytes spiked and a recovery calculated. Recovery of the spiked analyte is used as an assessment of analytical accuracy of the analytical method and to determine control limits for the method. These results are useful in distinguishing sample matrix interferences from analysis interferences through a comparison of MS and blank spike recovery data. Often, the LCS is performed in duplicate (as an LCSD) on duplicately prepared aliquots. In this manner, the precision of the assessment can be quantified as the RPD of the original and duplicate spike. The target acceptance limits for the LCS recovery and RPD are statistically determined by the analytical laboratory as specified in the method and are presented in WS #12 tables.

MS/MSDs. MS/MSDs are used to assess the performance of a method as applied to an environmental sample matrix by quantitative assessment of the recovery of the target analytes from the sample matrix. MS/MSDs, prepared by spiking duplicately prepared sample matrix aliquots, are often requested to be analyzed every 20 samples. They are spiked with the same target analytes and at the same concentration levels as the LCSs. The percent recoveries from each spiked sample and the RPDs between the spiked pairs provide an assessment of the precision and accuracy of the method for the matrix being analyzed. The target acceptance limits for the MS/MSD recoveries and RPDs are statistically determined by the analytical laboratory as specified in the method and are presented in WS #12 tables.

Laboratory Replicates. Laboratory replicates are analyses of replicate aliquots or split aliquots of a field sample. When specified in the task-specific work plan, these samples can provide an indication of the precision of the analytical process.

Method QC. Individual methods often include specific QC measures designed to monitor method or instrument performance during the analysis or over the course of the analytical sequence that is performed.

Surrogates. Surrogates are halogenated or isotopically labeled compounds, similar to the analytes of interest in chemical behavior and not typically occurring in nature, that are used in the analytical program to monitor the efficiency of the sample preparation and analysis procedures on a sample-by-sample basis for organic compound analysis (Methods SW-846 8015B (Modified), 8260B, 8270C). Known spike concentrations of the surrogate compounds are added to laboratory QC and field samples to determine the accuracy of the method for each individual sample matrix. The compounds used as surrogates were those specified in the method and are defined in WS #12 tables along with the QC requirements for acceptance.

Verification Standards. Verification standards are standards that originate from a different source or lot than the calibration standards and are used to verify initial and continuing calibrations for accuracy or linearity after the initial calibration and at a specified frequency of sample analysis. Acceptable continuing calibration verification standards are to bracket all sample analyses for the former GAFB.

Laboratory Data Reduction, Review, and Reporting:

The data provided by the laboratory will have been internally reviewed and judged with respect to compliance to the QA/QC requirements defined in the Uniform Federal Policy (UFP)-QAPP worksheets. Review of the data by the laboratory will be of sufficient quality to assure the validity of the reported data. The laboratory is responsible for complying with internal SOPs during the review process, including data generation, data reduction, data review, and data reporting.

Data reduction involves calculating analyte concentration from instrument outputs. The equations used to calculate analyte concentrations should be addressed in the laboratory SOP for each method. Applicable units and term definitions should also be specified. All software used to generate analytical results should be validated by the manufacturer or by following procedures established in a laboratory SOP.

The data review process consists of at least three levels of review. Each stage of the review process should be documented with an appropriate checklist form that is signed and dated by the reviewer. The following are required elements of the review process:

Review Level 1. One hundred percent of all generated data must be reviewed by the analyst. Each analyst reviews their work based on established guidelines for each method. The review shall at a minimum ensure:

- Sample preparation information is correct and complete.
- Analysis information is correct and complete.
- Appropriate SOPs have been followed.
- Analytical results are correct and complete.
- QC samples are within established control limits.
- Blanks and LCSs are within appropriate QC limits.
- Special sample preparation and analytical requirements have been met.
- Documentation is complete (all anomalies have been documented and forms completed, holding time violations documented, etc.).

Review Level 2. One hundred percent of the generated data are reviewed by a supervisor or data review specialist to provide an independent review of the data package. This review shall also be based on established guidelines and shall ensure the following:

- All appropriate laboratory SOPs have been followed.
- Calibration data are scientifically sound, appropriate to the method, and completely documented.
- QC samples are within established guidelines.
- Qualitative identification of sample components is correct.
- Quantitative results are correct.
- Documentation is complete and accurate and anomalies have been documented.
- Data are ready for incorporation into the final report.
- The data package is complete and ready for data archive.

Review Level 3. Level 3 review is performed by the laboratory's technical director or PM, who is ultimately responsible for the issued report. The review should include the elements of a Level 2 review and provide a total overview of the data package to ensure consistency and compliance with project-specific DQOs.

Errors discovered during the review process are formally transmitted to the appropriate analyst. The cause of the error is then addressed and appropriate corrective action is taken to ensure that similar errors do not occur.

In addition to this review process, the laboratory QC coordinator is responsible for reviewing hard copy analytical data packages periodically, as specified in the corporate SOP, to ensure that the total review process complies with internal guidelines. It is the QC coordinator's responsibility to investigate any failures to follow protocol and to take corrective action.

Secondary Data:

Data from previous RIs, long-term monitoring, waste evaluations, and feasibility studies will be used for decision making. These data have been previously reviewed and considered acceptable for use.

Nondirect measurements are sometimes used to gather data. Examples of these include literature searches and database query and retrieval. In these measurements, it is important to use reliable, documented sources. Once the source of the data is identified and verified as reliable, a reference of this source document should be cited in all data summaries and reports. Whenever possible, verification from multiple, independent sources that yield comparable data should be obtained and documented. This should then be noted in associated data summaries and reports.

Data Management Tasks:

CB&I will provide an electronic deliverable report in the ERPIMS format. ERPIMS is a data management system designed to accommodate all types of data collected for AFCEC projects. Specific codes and data forms have been developed to allow consistent and efficient input of information to the system. The database information will be provided by the Contractor via ASCII files. The information transferred will include all required technical data such as site information; well characteristics; and hydrogeologic, geologic, physical, and chemical analysis results. Electronic data reporting formats and requirements are given in the most current version of the ERPIMS Data Loading Handbook.

Data collected for the former GAFB project will require electronic data submittal in the form of ERPIMS deliverables. Laboratory data will be provided to CB&I within 3 weeks of receipt of samples by the laboratory. According to the Information Management Plan, the time frame for ERPIMS deliverables is "no later than 75 days from the date the sample is collected in the field." Data will be turned around 4 weeks from receipt of validated results.

CB&I will implement data management procedures to meet the deliverable requirements of ERPIMS. CB&I will be responsible for recording field and laboratory data into a computerized format as required by ERPToolsX Version 6.0.0.0 or the most current version of the ERPIMS Data Loading Handbook.

CB&I will assess the accuracy and completeness of all data submitted. All data entered into the ERPIMS data files and submitted by CB&I shall correspond exactly with the data contained in the original laboratory reports and other documents associated with the contracted sampling and laboratory analysis tasks.

In all cases, the hard-copy data packages generated and internally reviewed by the contracted laboratory, and in some cases, validated by third party validation will always be considered the "legal version." Electronic summaries such as the ERPIMS deliverables simply establish the form of transaction of the key elements of the generated database that will provide the end data user with all of the raw sample and QC data necessary to evaluate compliance with the project objectives. All efforts will be made to eliminate known inconsistencies between the electronic and hard copy versions of the data set, realizing that they will always remain different in structure and content.

Documentation and Records:

Field Documentation. Field personnel are responsible for accurately documenting field activities and maintaining the records in a protective manner, safeguarding against damage or loss until submitted to the site supervisor or the project files. All field records are to be accurate, complete and legible. They shall contain sufficient detail to allow future reconstruction of the recorded event by someone other than the originator. Records may be completed electronically or manually, as discussed in Section 6.2 of SOP EI-G-005, *Field Activity Documentation.* EI-G-005 is included in Attachment B of this UFP-QAPP, as well as in the *Former George AFB Basewide QAPP, Attachment B* (CB&I, 2012).

Personnel completing records/forms shall observe the following minimum requirements:

- Keep all record entries concise and legible: make all entries in dark blue or black, indelible ink.
- Complete all forms in such a manner as to accurately and thoroughly document the activity.
- Use the military clock (24-hour) when recording time.
- When using a preprinted form, complete each blank or space. Mark "N/A or equivalent in each space that is not applicable to activity.
- Make any corrections or deletions required by drawing a single line throughout the entry and initialing and dating the correction.
- Do not use correction fluid/tape or erasers.

Field Record Retention. As field logs, forms, and other field documentation are completed by the sampling team and reviewed by the site manager, copies will be maintained on site and the originals forwarded to the CB&I office in Knoxville, Tennessee, for storage. Incoming field data will be reviewed by the task leader, copied, and distributed as needed with the original data forms held for organizing and filing. These files will be labeled, numbered, and delivered to the project central files for long-term storage.

Verification of Technical Work Products. Technical work products such as figures, drawings, tables, and logs shall be verified to ensure that errors are identified and corrected in accordance with CMS-830-03-GL-00002, *Checking of Specifications, Calculations, and Drawings,* presented in the *Former George AFB Basewide QAPP, Attachment B* (CB&I, 2012). The check printing process shall be used for verification of these activities unless an equivalent method is documented in an approved plan or procedure.

Technical work products that include calculations or mathematical equations or codes shall be verified in accordance with CMS-830-03-GL-00002, *Checking of Specifications, Calculations and Drawings,* presented in the *Former George AFB Basewide QAPP, Attachment B* (CB&I, 2012). Work products such as calculations, spreadsheets, and databases shall be verified to ensure that errors are identified and corrected. The extent of verification effort shall depend upon the following:

- The complexity of the task
- The effects of the information being reviewed on the quality of the work product
- The potential for error.

Other factors that may influence this graded approach include client expectations, regulatory concerns, and the level of scrutiny expected for the product.

Verification shall be performed by personnel with sufficient knowledge of the subject matter. Verification shall be performed before results are presented and should be performed as early in the process as practical.

Laboratory Documentation. Laboratory reports will consist of a report summarizing the analytical results and the raw data to support those results. If the raw data are not required for a project, this information will be documented in the project-specific plans and information.

A standard data reporting format will be required for all laboratory reports. Site-specific work plans will address the need for full data package deliverables. EDDs in the EIMS format (Attachment D) will be submitted with each report.

A standard data package report contains the following elements:

1. *Cover Sheet.* The cover sheet shall specify the following information:
   - Title of report (i.e., Test Report, Test Certificate)
   - Name and location of laboratory (to include a POC, phone and facsimile numbers)
   - Name and location of any subcontractor laboratories, and appropriate test method performed
   - Contract number
   - Unique identification of the report (such as serial number)
   - Client name and address
   - Project name and site location
   - Statement of the data authenticity and official signature and title of person authorizing report release
   - Amendments to previously released reports that clearly identify the serial number for the previous report and state the reason(s) for reissuance of the report
   - Total number of pages.
2. *Table of Contents.* Laboratory data packages should be organized in a format that allows for easy identification and retrieval of information. An index or table of contents shall be included for this purpose.
3. *Case Narrative.* A case narrative shall be included in each report. The purpose of the case narrative is to:
   - Describe any abnormalities and deviations that may affect the analytical results.
   - Summarize any issues in the data package that need to be highlighted for the data user to help them assess the usability of the data.

   The case narrative shall provide:
   - A table(s) summarizing samples received, providing a correlation between field sample numbers and laboratory sample numbers, and identifying which analytical test methods were performed; if multiple laboratories performed analyses, the name and location of each laboratory should be associated with each sample
   - A list of samples that were received but not analyzed
   - A description of extractions or analyses that were performed out of holding times
   - A definition of all data qualifiers or flags used
   - Identification of deviations of any calibration standards or QC sample results from appropriate acceptance limits and a discussion of the associated corrective actions taken by the laboratory
   - Identification of samples and analytes for which manual integration was necessary
   - Appropriate notation of any other factors that could affect the sample results (e.g., air bubbles in volatile organic compound [VOC] sample vials, excess headspace in soil VOC containers, the presence of multiple phases, sample temperatures and sample pH excursions, container type or volume, etc.)
   - Identification of numerical results outside of quantitation limits.

4. *Analytical Results.* The results for each sample shall contain the following information at a minimum (information need not be repeated if noted elsewhere in the data package):
   - Project name and site location
   - Field sample identification number as written on custody form
   - Laboratory sample identification number
   - Matrix (soil, water, oil, etc.)
   - Date sample extracted or prepared
   - Date and time sample analyzed
   - Method numbers for all preparation, cleanup, and analysis procedures employed
   - Analyte or parameter
   - Method reporting limits (RLs) and method quantitation limits (at or above the low-level standard concentration) adjusted for sample-specific factors (e.g., aliquot size, dilution/concentration factors, moisture control)
   - All samples and analytes for which manual integration occurred, including the cause and justification
   - DLs, LODs, LOQs
   - Analytical results with correct number of significant figures
   - Any data qualifiers assigned
   - Concentration units
   - Dilution factors
   - Any dilutions or concentrations for all reported data, and if neat or less diluted results are available, recorded and reported data from both runs
   - Percent moisture or percent solids (all soils are to be reported on a dry weight basis).

   The following information is optional, but may be required site-specifically:
   - Laboratory name and location (city and state)
   - Sample description
   - Sample preservation or condition at receipt
   - Date and time sample collected
   - Date sample received
   - Sample aliquot analyzed
   - Final extraction volume
   - Chemical Abstracts Services numbers
   - Statements of the estimated uncertainty of the test results.
5. *Sample Management Records.* These types of records include the documentation accompanying the samples:
   - COC records
   - Shipping documents
   - Records generated by the laboratory which detail the condition of the samples upon receipt at the laboratory (e.g., the sample cooler receipt forms)
   - Telephone conversation records associated with actions taken or quality issues
   - If the laboratory collected the sample, sampling procedures.

6. *QA/QC Information.* The minimum internal QC data package must include:
   - MS percent recovery
   - RPD of required duplicates
   - LCS percent recoveries
   - Surrogate percent recoveries (organics)
   - Method blank results
   - Preparation, analysis, and other batch numbers
   - QC acceptance criteria for MS, LCS, surrogates, etc.
   - Spike concentrations for MS, LCS, surrogates, etc.
7. *Information for Data Validation Review.* The following information is required for data validation or verification to be performed. This information is necessary and should be provided unless the project-specific requirements specify that it is not needed:
   - Calibration data from the initial calibration curve
   - Initial calibration verification
   - Continuing calibration verification
   - Performance standards analyzed in conjunction with the test method (e.g., tuning standards, degradation check standards, etc.)
   - Preparation, analysis, and other batch numbers
   - Raw data (e.g., chromatograms, mass spectrum results)
   - MS, if applicable (includes spike target concentration levels, measured spike concentration, and calculated recoveries)
   - RPD of required duplicates (e.g., MS, LCS, and field duplicates)
   - Method blank results
   - LCS recoveries
   - Surrogate recoveries (organics)
   - Serial dilutions (percent difference [inorganics])
   - Post-digestion spikes recovery (inorganics)
   - Project action levels, DQOs, and associated acceptance criteria
   - Supporting documentation (e.g., run logs, sample preparation logs, standard preparation logs).

Even if not included in a standard report, the laboratory should maintain all raw data necessary to produce a Level IV “Contract Laboratory Program-like” package capable of supporting an independent validation of the data based on specific site or data requirements. If validation is required, the laboratory must provide all documentation necessary for the level of validation requested by CB&I. All original laboratory documents are to be stored by the laboratory in a safe, controlled environment for a period of not less than five years. All original documents should be available for review upon request.

EDDs should be verified by the laboratory to be free of defects and in agreement with the hard copy data. All disks should be scanned for viruses before submittal. Information should comply with specified ERPIMS format and valid values. EDDs found to have significant defects in format or information will be returned to the laboratory for correction and resubmittal. It is the responsibility of the laboratory to perform corrective action to prevent reoccurrence of errors, and to provide the documentation necessary to support the review and correction of the errors.

8. *Data Deliverables:* The data deliverable should include at a minimum:
    - Case narrative
    - Laboratory analyses performed
    - Laboratory identifiers (SDG, work order number, etc.)
    - Number of samples and matrix
    - Dates of leaching, extraction, digestion, and analysis
    - Cross reference of laboratory sample to field sample identification numbers
    - Sample preparation and analysis records
    - Sample results
    - Raw data created during the analysis of samples and quality control samples
    - Results of all initial and continuing calibration checks for all analyses
    - Results of all QC samples including blanks, continuing calibration verification (CCV), calibration checks, duplicates, LCSs, and system performance check compounds
    - Copies of any instrumental printouts, including raw data, quantitation reports, and before and after chromatograms of manual integration
    - Data sufficient to recreate what happened to the sample at all times.

The laboratory will also supply an EDD sufficient to generate an ERPIMS data deliverable. Laboratory data will be supplied to CB&I in hard copy format or on CD. CB&I will be responsible for submitting a copy to AFCEC or their designee if requested.

Assessment/Audit Tasks:

The laboratory QA staff will issue QA reports to the laboratory management, laboratory supervisors, and task leaders. These reports will describe the results of QC measurements, performance audits, and systems audits, and confirmation sample comparisons performed for each sampling and analysis task. Quality problems associated with performance of methods, completeness of data, comparability of data including field and confirmatory data, and data storage will be documented with the corrective actions that have been taken to correct the deficiencies identified.

Performance and Systems Audits:

Scheduled project/laboratory audits will be performed, as project activities allow, to review and evaluate the adequacy of field activities and laboratory performance and to ascertain if the QAPP is being completely and uniformly implemented. The project chemist is responsible for requesting and establishing an audit team. Annual audits may be supplemented by additional audits for one or more of the following reasons:

- When significant changes are made in field or laboratory protocols.
- When it is necessary to verify that corrective action has been taken on a nonconformance reported in a previous audit.
- When requested by the PM.

The objectives of performance and systems audits are to verify that the QAPP developed for this project is being implemented according to the specified requirements, to assess the effectiveness of the plan, to identify nonconformances, and to verify that identified deficiencies are corrected. Upon discovery of any significant deviation from the QAPP, the project chemist and QA officer shall be informed of the nature and extent, and a nonconformance documented and corrective action taken to remedy the deviation.

CB&I Management and QA staff will perform periodic assessments of project activities to ensure that work is consistent with procedures and that data are collected, reviewed, and reported consistent with project requirements.

Data Review Tasks:

All data will be verified for completeness and accuracy. With the exception of IDW data, 100% of the data will be validated to ensure compliance with project and method requirements. A data validation report will present the following information for each laboratory group (SDG, work order, etc.):

- Project name
- Laboratory
- Reviewer, including company
- Analyses
- Matrix
- Date
- Sample cross reference
- COC evaluation
- Holding time evaluation
- Calibration
- Blank sample analyses
- QC Parameters including:
  - Surrogates Spikes,
  - LCSs,
  - MS/MSD Analyses,
  - Analytical Spikes Results,
  - Serial Dilution Analyses,
  - Interference Check Samples, and
  - Duplicate Analyses;
- Compound Identification and Quantitation;
- System Performance; and
- Data Qualifier Definitions.

The data validation reports and/or the QCSR will be included as an appendix to the final report for each task. The reports will use the DQOs outlined in the project-specific plans to assess whether objectives were met. The QCSR will summarize any laboratory contract compliance nonconformances and the anomalies identified in the data validation reports. The QCSR will also discuss any lessons learned and may suggest solutions to problems identified as nonconformances during the project. The QCSR will contain, at a minimum, the following information:

- Sample handling and field analytical procedures
- Laboratory analytical methods used for the project
- Data validation summaries for field and laboratory data
- Precision, accuracy, representativeness, comparability, completeness, and sensitivity parameters analysis
- Laboratory contract compliance nonconformances and corrective actions
- Lessons learned.

The QCSR will be available to data users and will be submitted to AFCEC.

Table 15-1 Reporting Limits and QC Acceptance Criteria for EPA Method 8081, Organochlorinated Pesticides

Analyte	Aqueous DL	Aqueous LOD	Aqueous LOQ	Aqueous Unit	Bias LCS/LCSD %Recovery	LCS/LCSD Precision (RPD)
4,4'-DDD	0.027	0.040	0.10	ug/L	50 - 135	RPD≤25
4,4'-DDE	0.027	0.040	0.10	ug/L	50 - 135	RPD≤25
4,4'-DDT	0.027	0.040	0.10	ug/L	50 - 135	RPD≤25
Aldrin	0.027	0.040	0.10	ug/L	50 - 135	RPD≤25
alpha Chlordane	0.027	0.040	0.10	ug/L	65 - 125	RPD≤25
alpha-BHC	0.028	0.040	0.10	ug/L	60 - 130	RPD≤25
beta-BHC	0.030	0.040	0.10	ug/L	65 - 125	RPD≤25
delta-BHC	0.029	0.040	0.10	ug/L	50 - 135	RPD≤25
Dieldrin	0.029	0.040	0.10	ug/L	60 - 130	RPD≤25
Endosulfan I	0.028	0.040	0.10	ug/L	50 - 110	RPD≤25
Endosulfan II	0.027	0.040	0.10	ug/L	50 - 130	RPD≤25
Endosulfan Sulfate	0.029	0.040	0.10	ug/L	55 - 135	RPD≤25
Endrin	0.031	0.040	0.10	ug/L	55 - 135	RPD≤25
Endrin Aldehyde	0.026	0.040	0.10	ug/L	55 - 135	RPD≤25
Endrin Ketone	0.024	0.040	0.10	ug/L	75 - 125	RPD≤25
gamma Chlordane	0.027	0.040	0.10	ug/L	60 - 125	RPD≤25
gamma-BHC	0.030	0.040	0.10	ug/L	50 - 135	RPD≤25
Heptachlor	0.026	0.040	0.10	ug/L	50 - 130	RPD≤25
Heptachlor Epoxide	0.025	0.040	0.10	ug/L	60 - 130	RPD≤25
Methoxychlor	0.025	0.040	0.10	ug/L	55 - 135	RPD≤25
Toxaphene	0.59	1.0	2.0	ug/L	N/A	N/A
2,4,5,6-Tetrachloro-m-Xylene [Sur]	---	---	---	---	50 - 135	---
Decachlorobiphenyl [Sur]	---	---	---	---	50 - 135	---

Table 15-1. Reporting Limits and QC Acceptance Criteria for EPA Method 8081, Organochlorinated Pesticides

Analyte	Soil DL	Soil LOD	Soil LOQ	Soil Unit	Bias LCS/LCSD %Recovery	LCS/LCSD Precision (RPD)
4,4'-DDD	1.6	2.0	5.0	ug/kg	30 - 135	RPD≤20
4,4'-DDE	1.5	2.0	5.0	ug/kg	70 - 125	RPD≤20
4,4'-DDT	1.7	2.0	5.0	ug/kg	45 - 140	RPD≤20
Aldrin	1.6	2.0	5.0	ug/kg	45 - 140	RPD≤20
alpha Chlordane	1.6	2.0	5.0	ug/kg	65 - 120	RPD≤20
alpha-BHC	1.6	2.0	5.0	ug/kg	60 - 125	RPD≤20
beta-BHC	1.3	2.0	5.0	ug/kg	60 - 125	RPD≤20
delta-BHC	1.3	2.0	5.0	ug/kg	55 - 130	RPD≤20
Dieldrin	1.6	2.0	5.0	ug/kg	65 - 125	RPD≤20
Endosulfan I	1.3	2.0	5.0	ug/kg	15 - 135	RPD≤20
Endosulfan II	1.4	2.0	5.0	ug/kg	35 - 140	RPD≤20
Endosulfan Sulfate	1.7	2.0	5.0	ug/kg	60 - 135	RPD≤20
Endrin	1.8	2.0	5.0	ug/kg	60 - 135	RPD≤20
Endrin Aldehyde	1.2	2.0	5.0	ug/kg	35 - 145	RPD≤20
Endrin Ketone	1.7	2.0	5.0	ug/kg	65 - 135	RPD≤20
gamma Chlordane	1.6	2.0	5.0	ug/kg	65 - 125	RPD≤20
gamma-BHC	1.7	2.0	5.0	ug/kg	60 - 125	RPD≤20
Heptachlor	1.6	2.0	5.0	ug/kg	50 - 140	RPD≤20
Heptachlor Epoxide	1.8	2.0	5.0	ug/kg	65 - 130	RPD≤20
Hexachlorobenzene	1.6	2.0	5.0	ug/kg	60 - 130	RPD≤20
Methoxychlor	1.6	2.0	5.0	ug/kg	55 - 145	RPD≤20
Toxaphene	32	50	100	ug/kg	N/A	N/A
2,4,5,6-Tetrachloro-m-Xylene [Sur]	---	---	---	---	70 - 125	---
Decachlorobiphenyl [Sur]	---	---	---	---	55 - 130	---

UFP-Worksheet #15 – Reference Limits and Evaluation Tables (continued)
Former George Air Force Base, California

Notes:
DL denotes detection limit
LCS/LCSD denotes laboratory control sample / laboratory control sample duplicate
LOD denotes limit of detection
LOQ denotes limit of quantitation
N/A denotes not applicable
RPD denotes relative percent difference
ug/kg denotes micrograms per kilogram
ug/L denotes micrograms per liter
USEPA denotes United States Environmental Protection Agency

Table 15-2. Reporting Limits and QC Acceptance Criteria for RCRA TCLP Parameters, Various Methods

Method	Analyte	TCLP DL	TCLP LOD	TCLP LOQ	Unit	Bias LCS/LCSD %Recovery	LCS/LCSD Precision (RPD)
EPA 6010B (1311)	Arsenic	0.0438	0.0500	0.100	mg/L	80 - 120	RPD≤ 20
EPA 6010B (1311)	Barium	0.0296	0.0500	0.100	mg/L	80 - 120	RPD≤ 20
EPA 6010B (1311)	Cadmium	0.0269	0.0500	0.100	mg/L	80 - 120	RPD≤ 20
EPA 6010B (1311)	Chromium	0.0271	0.0500	0.100	mg/L	80 - 120	RPD≤ 20
EPA 6010B (1311)	Lead	0.0406	0.0500	0.100	mg/L	80 - 120	RPD≤ 20
EPA 6010B (1311)	Selenium	0.0699	0.0750	0.150	mg/L	80 - 120	RPD≤ 20
EPA 6010B (1311)	Silver	0.0139	0.0250	0.0500	mg/L	80 - 120	RPD≤ 20
EPA 7470 (1311)	Mercury	0.000453	0.00100	0.00500	mg/L	80 - 120	RPD≤ 14
EPA 8081 (1311)	Chlordane	3.3	5.0	10	µg/L	N/A	N/A
EPA 8081 (1311)	Endrin	0.31	0.40	1.0	µg/L	50 - 135	RPD≤ 25
EPA 8081 (1311)	Gamma-BHC	0.30	0.40	1.0	µg/L	50 - 135	RPD≤ 25
EPA 8081 (1311)	Heptachlor	0.26	0.40	1.0	µg/L	50 - 135	RPD≤ 25
EPA 8081 (1311)	Heptachlor Epoxide	0.25	0.40	1.0	µg/L	50 - 135	RPD≤ 25
EPA 8081 (1311)	Methoxychlor	0.25	0.40	1.0	µg/L	50 - 135	RPD≤ 25
EPA 8081 (1311)	Toxaphene	5.9	10	20	µg/L	N/A	N/A
EPA 8081 (1311)	2,4,5,6-Tetrachloro-m-Xylene [Sur]	---	---	---	---	50 - 135	---
EPA 8081 (1311)	Decachlorobiphenyl [Sur]	---	---	---	---	50 - 135	---
EPA 8151 (1311)	2,4,5-TP (Silvex)	2.2	2.5	5.0	µg/L	50 - 115	RPD≤ 20
EPA 8151 (1311)	2,4-D	18	25	50	µg/L	35 - 115	RPD≤ 20
EPA 8151 (1311)	2,4-Dichlorophenylacetic acid [Sur]	---	---	---	---	10 - 123	---
EPA 8260 (1311)	1,1-Dichloroethene	43	50	100	µg/L	70 - 130	RPD≤ 20
EPA 8260 (1311)	1,2-Dichloroethane	24	50	100	µg/L	70 - 130	RPD≤ 20
EPA 8260 (1311)	2-Butanone	220	500	1000	µg/L	30 - 150	RPD≤ 20
EPA 8260 (1311)	Benzene	14	50	100	µg/L	80 - 120	RPD≤ 20
EPA 8260 (1311)	Carbon Tetrachloride	23	50	100	µg/L	65 - 140	RPD≤ 20
EPA 8260 (1311)	Chlorobenzene	17	50	100	µg/L	80 - 120	RPD≤ 20
EPA 8260 (1311)	Chloroform	46	50	100	µg/L	65 - 135	RPD≤ 20
EPA 8260 (1311)	Tetrachloroethene	39	50	100	µg/L	45 - 150	RPD≤ 20

Table 15-2. Reporting Limits and QC Acceptance Criteria for RCRA TCLP Parameters, Various Methods

Method	Analyte	TCLP DL	TCLP LOD	TCLP LOQ	Unit	Bias LCS/LCSD %Recovery	LCS/LCSD Precision (RPD)
EPA 8260 (1311)	Trichloroethene	37	50	100	µg/L	70 - 125	RPD≤ 20
EPA 8260 (1311)	Vinyl Chloride	30	50	100	µg/L	50 - 145	RPD≤ 20
EPA 8260 (1311)	1,2-Dichloroethane-d4 [Sur]	---	---	---	---	70 - 120	---
EPA 8260 (1311)	1,4-Bromofluorobenzene [Sur]	---	---	---	---	75 - 120	---
EPA 8260 (1311)	Dibromofluoromethane [Sur]	---	---	---	---	85 - 115	---
EPA 8260 (1311)	Toluene-d8 [Sur]	---	---	---	---	85 - 120	---
EPA 8270 (1311)	1,4-Dichlorobenzene	29	60	100	µg/L	30 - 100	RPD≤ 26
EPA 8270 (1311)	2,4,5-Trichlorophenol	25	60	100	µg/L	50 - 110	RPD≤ 20
EPA 8270 (1311)	2,4,6-Trichlorophenol	25	60	100	µg/L	50 - 115	RPD≤ 20
EPA 8270 (1311)	2,4-Dinitrotoluene	23	60	100	µg/L	50 - 120	RPD≤ 36
EPA 8270 (1311)	2-Methylphenol	21	60	100	µg/L	40 - 110	RPD≤ 20
EPA 8270 (1311)	3/4-Methylphenol	44	120	200	µg/L	30 - 110	RPD≤ 20
EPA 8270 (1311)	Hexachlorobutadiene	29	60	100	µg/L	25 - 105	RPD≤ 20
EPA 8270 (1311)	Hexachlorobenzene	31	60	100	µg/L	50 - 110	RPD≤ 20
EPA 8270 (1311)	Hexachloroethane	30	60	400	µg/L	30 - 95	RPD≤ 20
EPA 8270 (1311)	Nitrobenzene	30	60	100	µg/L	45 - 110	RPD≤ 20
EPA 8270 (1311)	Pentachlorophenol	46	160	400	µg/L	40 - 115	RPD≤ 40
EPA 8270 (1311)	Pyridine	30	60	1000	µg/L	52 - 115	RPD≤ 20
EPA 8270 (1311)	2,4,6-Tribromophenol [Sur]	---	---	---	---	40 - 125	---
EPA 8270 (1311)	2-Fluorobiphenyl [Sur]	---	---	---	---	50 - 110	---
EPA 8270 (1311)	2-Fluorophenol [Sur]	---	---	---	---	20 - 110	---
EPA 8270 (1311)	Nitrobenzene-d5 [Sur]	---	---	---	---	40 - 110	---
EPA 8270 (1311)	Phenol-d6 [Sur]	---	---	---	---	10 - 115	---
EPA 8270 (1311)	p-Terphenyl-d14 [Sur]	---	---	---	---	50 - 135	---

Table 15-2. Reporting Limits and QC Acceptance Criteria for RCRA TCLP Parameters, Various Methods

Notes:
DL denotes detection limit.
LCS/LCSD denotes laboratory control sample/laboratory control sample duplicate.
LOD denotes limit of detection.
LOQ denotes limit of quantitation.
mg/L denotes milligrams per liter.
N/A denotes not applicable.
RPD denotes relative percent difference.
TCLP denotes toxicity characteristic leaching procedure.
µg/L denotes micrograms per liter.
USEPA denotes United States Environmental Protection Agency.

[a] Screening values comprised of the Federal (RCRA-TCLP) Maximum Concentration of Contaminants for Characteristic of TCLP Toxicity.

Table 15-3. Reporting Limits and QC Acceptance Criteria for Wet Chemistry Parameters, Various Methods

Method	Analyte	DL	LOD	LOQ	Unit	Bias LCS/LCSD %Recovery	LCS/LCSD Precision (RPD)
SM 2540 B	Moisture	0.1	0.1	0.1	%	N/A	NA
EPA 1030	Ignitability	70	70	70	^{o}F	NA	NA
SW-846, Chapter 7	Cyanide, Reactive	N/A	N/A	N/A	mg/kg	NA	NA
SW-846, Chapter 7	Sulfide, Reactive	N/A	N/A	N/A	mg/kg	NA	NA
EPA 9045D	pH	0.010	0.010	0.010	pH units	NA	NA

Notes:
DL denotes detection limit.
LCS/LCSD denotes laboratory control sample/laboratory control sample duplicate.
LOD denotes limit of detection.
LOQ denotes limit of quantitation.
mg/kg denotes milligrams per kilogram.
mg/L denotes milligrams per liter.
RPD denotes relative percent difference.
^{o}F denotes degrees Fahrenheit.
USEPA denotes United States Environmental Protection Agency.

UFP-QAPP Worksheet #16 – Project Schedule/Timeline Table
Former George Air Force Base, California

Action Item	Date
Work Plan Review and Approval	December 2015 – January 2016
Field Activities	January – March 2016
Analytical Data Verification and Validation; Data Management; ERPIMS Submittal	March – April 2016
Report of Findings	April – May 2016

UFP-QAPP Worksheet #17 – Site OT071 Sampling Design and Rationale
Former George Air Force Base, California

Location ID	Matrix	Sample Type	Sample Depths (ft bgs) [1,2]	Analytical Fraction(s)	Expected Concentration Level	Number of Samples	CB&I Sampling SOP Reference(s)	Rationale for Sample Location
OT071-SB02	Soil	Discrete	Beneath slab, 2', 4', 7', 10', and 15'	<u>Chemical Analysis:</u> Organochlorinated Pesticides by SW-846 8081A <u>Geotechnical Analysis:</u> Full-scale digital core photography ASTM D5079 Grain-size analysis by laser by ASTM D4464 TOC by Walkley-Black Soil Properties Package (Vadose Zone) – native permeability to air, total porosity, air-filled porosity, grain and bulk density, moisture content, total pore fluid saturation by method API RP40 and ASTM D2216	High	7*	EI-FS-001 – Field Logbook EI-FS-002 – Field Log sheet EI-FS-003 - Chain of Custody Documentation EI-FS-005 – Custody Seals EI-FS-006 – Sample Labeling EI-FS-012 – Shipping and Packaging of Non Hazardous Samples EI-FS-013 – Packaging and Shipping of DOT/IATA Hazardous Samples EI-GS-021 – Standards for Conducting Direct Push Drilling and Soil Sampling EI-GS-025 – Standards for Soils Logging EI-GS-027 – Standards of Generation of Boring Logs	Provide concentration data for use in calibrating the vadose zone model. Location selected based on highest dieldrin concentration previously detected (SS-37 at 15,000 ug/kg)
OT071-SB03	Soil	Discrete	2', 4', 7', 10', and 15'		High	5		Provide concentration data for use in calibrating the vadose zone model. Location to be drilled at previous location SS-35 (1710 ug/kg).
OT071-SB04	Soil	Discrete	2', 4', 7', 10', and 15'		Med	5		Provide concentration data for use in calibrating the vadose zone model. Final location placement will be determined after field survey is conducted.
OT071-SB05	Soil	Discrete	2', 4', 7', 10', and 15'		Med	6*		Provide concentration data for use in calibrating the vadose zone model. Final location placement will be determined after field survey is conducted.
OT071-SB06	Soil	Discrete	2', 4', 7', 10', and 15'		Med	5		Provide concentration data for use in calibrating the vadose zone model. Final location placement will be determined after field survey is conducted.

UFP-QAPP Worksheet #17 – Site OT071 Sampling Design and Rationale
Former George Air Force Base, California

Location ID	Matrix	Sample Type	Sample Depths (ft bgs) [1,2]	Analytical Fraction(s)	Expected Concentration Level	Number of Samples	CB&I Sampling SOP Reference(s)	Rationale for Sample Location
OT071-MW-159	Soil	Discrete	TBD	<u>Geotechnical Analysis:</u> Full-scale digital core photography ASTM D5079 Grain-size analysis by laser by ASTM D4464 TOC by Walkley-Black Soil Properties Package (Vadose Zone) – native permeability to air, total porosity, air-filled porosity, grain and bulk density, moisture content, total pore fluid saturation by method API RP40 and ASTM D2216	Low	1	EI-FS-001 – Field Logbook EI-FS-002 – Field Log sheet EI-FS-003 - Chain of Custody Documentation EI-FS-005 – Custody Seals EI-FS-006 – Sample Labeling EI-FS-012 – Shipping and Packaging of Non Hazardous Samples EI-GS-025 – Standards for Soils Logging EI-GS-027 – Standards of Generation of Boring Logs EI-GS-017 – Standards for Conducting Hollow Stem Auger Drilling (MW-159, MW-160, and MW-163) EI-GS-018 – Standards for Conducting Mud Rotary Drilling (MW-161 and MW-162) EID-GS-019 - Standards for Conducting Air Rotary Drilling (MW-161 and MW-162)	Located in the Upper Aquifer southeast of NZ-120 to assess the groundwater mound and possible migration to the Lower Aquifer
OT071-MW-160	Soil	Discrete	TBD		Low	1		Located in the Upper Aquifer south of NZ-125 and paired with MW-161 to assess the southeastern extent of the plume where dieldrin has been detected above the notification level.
OT071-MW-161	Soil	Discrete	TBD		Low	1		Located in the Lower Aquifer south of MW-147 and paired with MW-152 to assess the southern extent of the plume.
OT071-MW-162	Soil	Discrete	TBD		Low	1		Located in the Lower Aquifer north of MW-147 and paired with MW-152 to assess the southern portion of the plume.
OT071-MW-163	Soil	Discrete	TBD		Low	1		Located in the Lower Aquifer adjacent to MW-149 to assess the groundwater at the top of the water table.

UFP-QAPP Worksheet #17 – Site OT071 Sampling Design and Rationale
Former George Air Force Base, California

Location ID	Matrix	Sample Type	Sample Depths (ft bgs) [1,2]	Analytical Fraction(s)	Expected Concentration Level	Number of Samples	CB&I Sampling SOP Reference(s)	Rationale for Sample Location
OT071-IDW01 through OT071-IDW05	Soil	Composite	---	RCRA TCLP Pesticides by SW-846 1311 8081A RCRA TCLP Herbicides by SW-846 1311 8151A (if necessary) RCRA TCLP VOCs by SW-846 1311 8260B (if necessary) RCRA TCLP SVOCs by SW-846 1311 8270C (if necessary) RCRA TCLP Metals by SW-846 1311 6010/7470A (if necessary)	Low	5	EI-FS-001 – Field Logbook EI-FS-002 – Field Log sheet EI-FS-003 - Chain of Custody Documentation EI-FS-005 – Custody Seals EI-FS-006 – Sample Labeling EI-FS-010 – Sample Homogenization EI-FS-012 – Shipping and Packaging of Non Hazardous Samples EI-FS-101 – Trowel/Spoon Surface Soil Sampling EI-FS-107 – Roll-Off Sampling	IDW soil Characterization
OT071-IDW06	Water	Composite	---	Organochlorinated Pesticides by SW-846 8081A	Low	1	EI-FS-001 – Field Logbook EI-FS-002 – Field Log sheet EI-FS-003 - Chain of Custody Documentation EI-FS-005 – Custody Seals EI-FS-006 – Sample Labeling EI-FS-012 – Shipping and Packaging of Non Hazardous Samples EI-FS-115 – Sampling Tanks and Storage Vessels	IDW wastewater Characterization

Notes:

* Includes field duplicate sample.

[1] Proposed sample depths may be adjusted in the field due to site conditions. Samples from depths below non-detect results will not be analyzed.

[2] One sample, per five feet of core from the shallow vadose zone model calibration borings, will be selected by the geologist based on lithology and the results of the white light core photography. Up to two additional samples may be selected from each of the five well borings at the discretion of the geologist.

ft bgs – feet below ground surface
IDW – investigation derived waste
RCRA – Resource Conservation Recovery Act
SOP – Standard Operating Procedure
TCLP – Toxicity Characteristic Leaching Procedure

Worksheet #18 – Site OT071 Sampling Locations and Methods/SOP Requirements Table
Former George Air Force Base, California

Sampling Location / ID Number	Sample Number	Sample Type	Sample Depth (ft bgs) [1]	Sample Purpose	Sample Method	CB&I SOP Reference No.	Analytical Suite
OT071-SB02	OT071-00001	Discrete	TBD	Reg	Geoprobe or equivalent technique	EI-FS-001 – Field Logbook EI-FS-002 – Field Log sheet EI-FS-003 - Chain of Custody Documentation EI-FS-005 – Custody Seals EI-FS-006 – Sample Labeling EI-FS-012 – Shipping and Packaging of Non Hazardous Samples EI-GS-021 – Standards for Conducting Direct Push Drilling and Soil Sampling EI-GS-025 – Standards for Soils Logging EI-GS-027 – Standards of Generation of Boring Logs	Organochlorinated Pesticides by SW-846 8081A. Full-scale digital core photography ASTM D5079 Grain-size analysis by laser by ASTM D4464 TOC by Walkley-Black Soil Properties Package (Vadose Zone) – native permeability to air, total porosity, air-filled porosity, grain and bulk density, moisture content, total pore fluid saturation by method API RP40 and ASTM D2216 [2]
	OT071-00002	Discrete	2’	Reg			
	OT071-00003	Discrete	2’	FD			
	OT071-00004	Discrete	4’	Reg			
	OT071-00005	Discrete	7’	Reg			
	OT071-00006	Discrete	10’	Reg			
	OT071-00007	Discrete	15’	Reg			
OT071-SB03	OT071-00008	Discrete	2’	Reg	Geoprobe or equivalent technique	EI-FS-001 – Field Logbook EI-FS-002 – Field Log sheet EI-FS-003 - Chain of Custody Documentation EI-FS-005 – Custody Seals EI-FS-006 – Sample Labeling EI-FS-012 – Shipping and Packaging of Non Hazardous Samples EI-GS-021 – Standards for Conducting Direct Push Drilling and Soil Sampling EI-GS-025 – Standards for Soils Logging EI-GS-027 – Standards of Generation of Boring Logs	Organochlorinated Pesticides by SW-846 8081A. Full-scale digital core photography ASTM D5079 Grain-size analysis by laser by ASTM D4464 TOC by Walkley-Black Soil Properties Package (Vadose Zone) – native permeability to air, total porosity, air-filled porosity, grain and bulk density, moisture content, total pore fluid saturation by method API RP40 and ASTM D2216 [2]
	OT071-00008-MS	Discrete	2’	MS			
	OT071-00008-MSD	Discrete	2’	MSD			
	OT071-00009	Discrete	4’	Reg			
	OT071-00010	Discrete	7’	Reg			
	OT071-00011	Discrete	10’	Reg			
	OT071-00012	Discrete	15’	Reg			

Worksheet #18 – Site OT071 Sampling Locations and Methods/SOP Requirements Table (continued)
Former George Air Force Base, California

Sampling Location / ID Number	Sample Number	Sample Type	Sample Depth (ft bgs) [1]	Sample Purpose	Sample Method	CB&I SOP Reference No.	Analytical Suite
OT071-SB04	OT071-00013	Discrete	2’	Reg	Geoprobe or equivalent technique	EI-FS-001 – Field Logbook EI-FS-002 – Field Log sheet EI-FS-003 - Chain of Custody Documentation EI-FS-005 – Custody Seals EI-FS-006 – Sample Labeling EI-FS-012 – Shipping and Packaging of Non Hazardous Samples EI-GS-021 – Standards for Conducting Direct Push Drilling and Soil Sampling EI-GS-025 – Standards for Soils Logging EI-GS-027 – Standards of Generation of Boring Logs	Organochlorinated Pesticides by SW-846 8081A. Full-scale digital core photography ASTM D5079 Grain-size analysis by laser by ASTM D4464 TOC by Walkley-Black Soil Properties Package (Vadose Zone) – native permeability to air, total porosity, air-filled porosity, grain and bulk density, moisture content, total pore fluid saturation by method API RP40 and ASTM D2216 [2]
	OT071-00014	Discrete	4’	Reg			
	OT071-00015	Discrete	7’	Reg			
	OT071-00016	Discrete	10’	Reg			
	OT071-00017	Discrete	15’	Reg			
OT071-SB05	OT071-00018	Discrete	2’	Reg	Geoprobe or equivalent technique	EI-FS-001 – Field Logbook EI-FS-002 – Field Log sheet EI-FS-003 - Chain of Custody Documentation EI-FS-005 – Custody Seals EI-FS-006 – Sample Labeling EI-FS-012 – Shipping and Packaging of Non Hazardous Samples EI-GS-021 – Standards for Conducting Direct Push Drilling and Soil Sampling EI-GS-025 – Standards for Soils Logging EI-GS-027 – Standards of Generation of Boring Logs	Organochlorinated Pesticides by SW-846 8081A. Full-scale digital core photography ASTM D5079 Grain-size analysis by laser by ASTM D4464 TOC by Walkley-Black Soil Properties Package (Vadose Zone) – native permeability to air, total porosity, air-filled porosity, grain and bulk density, moisture content, total pore fluid saturation by method API RP40 and ASTM D2216 [2]
	OT071-00018-MS	Discrete	2’	MS			
	OT071-00018-MSD	Discrete	2’	MSD			
	OT071-00019	Discrete	4’	Reg			
	OT071-00020	Discrete	4’	FD			
	OT071-00021	Discrete	7’	Reg			
	OT071-00022	Discrete	10’	Reg			
	OT071-00023	Discrete	15’	Reg			

Worksheet #18 – Site OT071 Sampling Locations and Methods/SOP Requirements Table (continued)
Former George Air Force Base, California

Sampling Location / ID Number	Sample Number	Sample Type	Sample Depth (ft bgs) [1]	Sample Purpose	Sample Method	CB&I SOP Reference No.	Analytical Suite
OT071-SB06	OT071-00024	Discrete	2'	Reg	Geoprobe or equivalent technique	EI-FS-001 – Field Logbook EI-FS-002 – Field Log sheet EI-FS-003 - Chain of Custody Documentation EI-FS-005 – Custody Seals EI-FS-006 – Sample Labeling EI-FS-012 – Shipping and Packaging of Non Hazardous Samples EI-GS-021 – Standards for Conducting Direct Push Drilling and Soil Sampling EI-GS-025 – Standards for Soils Logging EI-GS-027 – Standards of Generation of Boring Logs	Organochlorinated Pesticides by SW-846 8081A. Full-scale digital core photography ASTM D5079 Grain-size analysis by laser by ASTM D4464 TOC by Walkley-Black Soil Properties Package (Vadose Zone) – native permeability to air, total porosity, air-filled porosity, grain and bulk density, moisture content, total pore fluid saturation by method API RP40 and ASTM D2216 [2]
	OT071-00025	Discrete	4'	Reg			
	OT071-00026	Discrete	7'	Reg			
	OT071-00027	Discrete	10'	Reg			
	OT071-00028	Discrete	15'	Reg			
OW071-MW-159	OT071-MW-159-Depth	Discrete	TBD	Reg	Continuous Sampler or split spoon	EI-FS-001 – Field Logbook EI-FS-002 – Field Log sheet EI-FS-003 - Chain of Custody Documentation EI-FS-005 – Custody Seals EI-FS-006 – Sample Labeling EI-FS-012 – Shipping and Packaging of Non Hazardous Samples EI-GS-017 – Standards for Conducting Hollow Stem Auger Drilling	Full-scale digital core photography ASTM D5079 Grain-size analysis by laser by ASTM D4464 TOC by Walkley-Black Soil Properties Package (Vadose Zone) – native permeability to air, total porosity, air-filled porosity, grain and bulk density, moisture content, total pore fluid saturation by method API RP40 and ASTM D2216 [2]
	OT071-MW-159-Depth [2]	Discrete	TBD	Reg			
	OT071-MW-159-Depth [2]	Discrete	TBD	Reg			

Worksheet #18 – Site OT071 Sampling Locations and Methods/SOP Requirements Table (continued)
Former George Air Force Base, California

Sampling Location / ID Number	Sample Number	Sample Type	Sample Depth (ft bgs) [1]	Sample Purpose	Sample Method	CB&I SOP Reference No.	Analytical Suite
OT071-MW-160	OT071-MW-160-Depth	Discrete	TBD	Reg	Continuous Sampler or split spoon	EI-FS-001 – Field Logbook EI-FS-002 – Field Log sheet EI-FS-003 - Chain of Custody Documentation EI-FS-005 – Custody Seals EI-FS-006 – Sample Labeling EI-FS-012 – Shipping and Packaging of Non Hazardous Samples EI-GS-017 – Standards for Conducting Hollow Stem Auger Drilling	Full-scale digital core photography ASTM D5079 Grain-size analysis by laser by ASTM D4464 TOC by Walkley-Black Soil Properties Package (Vadose Zone) – native permeability to air, total porosity, air-filled porosity, grain and bulk density, moisture content, total pore fluid saturation by method API RP40 and ASTM D2216 [2]
	OT071-MW-160-Depth [2]	Discrete	TBD	Reg			
	OT071-MW-160-Depth [2]	Discrete	TBD	Reg			
OT071-MW-161	OT071-MW-161-Depth	Discrete	TBD	Reg	Continuous Sampler or split spoon	EI-FS-001 – Field Logbook EI-FS-002 – Field Log sheet EI-FS-003 - Chain of Custody Documentation EI-FS-005 – Custody Seals EI-FS-006 – Sample Labeling EI-FS-012 – Shipping and Packaging of Non Hazardous Samples EI-GS-018 – Standards for Conducting Mud Rotary Drilling	Full-scale digital core photography ASTM D5079 Grain-size analysis by laser by ASTM D4464 TOC by Walkley-Black Soil Properties Package (Vadose Zone) – native permeability to air, total porosity, air-filled porosity, grain and bulk density, moisture content, total pore fluid saturation by method API RP40 and ASTM D2216 [2]
	OT071-MW-161-Depth [2]	Discrete	TBD	Reg			
	OT071-MW-161-Depth [2]	Discrete	TBD	Reg			
OT071-MW-162	OT071-MW-162-Depth	Discrete	TBD	Reg	Continuous Sampler or split spoon	EI-FS-001 – Field Logbook EI-FS-002 – Field Log sheet EI-FS-003 - Chain of Custody Documentation EI-FS-005 – Custody Seals EI-FS-006 – Sample Labeling EI-FS-012 – Shipping and Packaging of Non Hazardous Samples EI-GS-018 – Standards for Conducting Mud Rotary Drilling	Full-scale digital core photography ASTM D5079 Grain-size analysis by laser by ASTM D4464 TOC by Walkley-Black Soil Properties Package (Vadose Zone) – native permeability to air, total porosity, air-filled porosity, grain and bulk density, moisture content, total pore fluid saturation by method API RP40 and ASTM D2216 [2]
	OT071-MW-162-Depth [2]	Discrete	TBD	Reg			
	OT071-MW-162-Depth [2]	Discrete	TBD	Reg			

Worksheet #18 – Site OT071 Sampling Locations and Methods/SOP Requirements Table (continued)
Former George Air Force Base, California

Sampling Location / ID Number	Sample Number	Sample Type	Sample Depth (ft bgs) [1]	Sample Purpose	Sample Method	CB&I SOP Reference No.	Analytical Suite
OT071-MW-163	OT071-MW-163-Depth	Discrete	TBD	Reg	Continuous Sampler or split spoon	EI-FS-001 – Field Logbook EI-FS-002 – Field Log sheet EI-FS-003 - Chain of Custody Documentation EI-FS-005 – Custody Seals EI-FS-006 – Sample Labeling EI-FS-012 – Shipping and Packaging of Non Hazardous Samples EI-GS-017 – Standards for Conducting Hollow Stem Auger Drilling	Full-scale digital core photography ASTM D5079 Grain-size analysis by laser by ASTM D4464 TOC by Walkley-Black Soil Properties Package (Vadose Zone) – native permeability to air, total porosity, air-filled porosity, grain and bulk density, moisture content, total pore fluid saturation by method API RP40 and ASTM D2216 [2]
	OT071-MW-163-Depth [2]	Discrete	TBD	Reg			
	OT071-MW-163-Depth [2]	Discrete	TBD	Reg			
Investigative Derived Waste							
OT071-IDW01	OT071-90001	Composite	---	Reg	Trowel	EI-FS-001 – Field Logbook EI-FS-002 – Field Log sheet EI-FS-003 - Chain of Custody Documentation EI-FS-005 – Custody Seals EI-FS-006 – Sample Labeling EI-FS-010 – Sample Homogenization EI-FS-012 – Shipping and Packaging of Non Hazardous Samples EI-FS-101 – Trowel/Spoon Surface Soil Sampling EI-FS-107 – Roll-Off Sampling	RCRA TCLP Pesticides by SW-846 1311 8081A RCRA TCLP Herbicides by SW-846 1311 8151A (if necessary) RCRA TCLP VOCs by SW-846 1311 8260B (if necessary) RCRA TCLP SVOCs by SW-846 1311 8270C (if necessary) RCRA TCLP Metals by SW-846 1311 6010/7470A (if necessary)
OT071-IDW02	OT071-90002	Composite	---	Reg	Trowel		
OT071-IDW03	OT071-90003	Composite	---	Reg	Trowel		
OT071-IDW04	OT071-90004	Composite	---	Reg	Trowel		
OT071-IDW05	OT071-90005	Composite	---	Reg	Trowel		
OT071-IDW06	OT071-90006	Composite	---	Reg	Grab	EI-FS-001 – Field Logbook EI-FS-002 – Field Log sheet EI-FS-003 - Chain of Custody Documentation EI-FS-005 – Custody Seals EI-FS-006 – Sample Labeling EI-FS-012 – Shipping and Packaging of Non Hazardous Samples EI-FS-115 – Sampling Tanks and Storage Vessels	Pesticides by SW-846 8081A

Worksheet #18 – Site OT071 Sampling Locations and Methods/SOP Requirements Table (continued)
Former George Air Force Base, California

Notes:

1 Proposed sample depths may be adjusted in the field due to site conditions. Samples from depths below non-detect results will not be analyzed.

2 One sample, per five feet of core from the shallow vadose zone model calibration borings, will be selected by the geologist based on lithology and the results of the white light core photography. Up to two additional samples may be selected from each of the five well borings at the discretion of the geologist.

FD – field duplicate sample
ft bgs – feet below ground surface
MS – matrix spike sample
MSD – matrix spike duplicate sample
RCRA – Resource Conservation Recovery Act
Reg – regular field sample
SOP – Standard Operating Procedure
TBD – "to be determined"
TCLP – Toxicity Characteristic Leaching Procedure

UFP-QAPP Worksheet #20 – Analytical SOP Requirements
Former George Air Force Base, California

Note: Suffixed SW-846 Methods represent those currently certified by the laboratory and may undergo revision during the periodic QAPP review. QAPP revisions will be submitted for approval.

Analytical Group	Matrix	Concentration Level	Analytical Method [1]/ Preparation Method(s)	Minimum Sample Volumes [2, 3]	Containers (type and size)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/ analysis)
Geotechnical Analyses	Soil	Low	ASTM D2216 ASTM D5079 ASTM D4464 Walkley Black API RP40	12 In	Acetate Sleeve	4±2°C	Analyze Immediately
Organochlorinated Pesticides	Soil	High	Analysis: 8081 Preparation: 3540 or 3550	8 ounces	Wide-mouth glass w/ Teflon-lined cap	4±2°C	14 days until extraction and extracts analyzed within 40 days after extraction
	Water	Low	Analysis: 8081 Preparation: 3520 or 3510	2 x 1L	Amber Glass	4±2°C	7 days until extraction and extracts analyzed within 40 days after extraction
Moisture	Soil	Low	Analysis: SM2540 B	8 ounce	Wide-mouth glass w/ Teflon-lined cap	4±2°C	Analyze Immediately
Reactivity – Reactive cyanide Reactive sulfide	Soil	Low	SW846 Chapter 7	8 ounces	Wide-mouth glass w/ Teflon-lined cap	4±2°C	Reactive Sulfide, 7 days; Reactive Cyanide, 14 days
Corrosivity (pH)	Soil	Low	Analysis: 9045 Preparation: 9045	8 ounces	Wide-mouth glass w/ Teflon-lined cap	4±2°C	Analyze Immediately
Ignitability	Soil	Low	Analysis: 1030 Preparation: 1030	8 ounces	Wide-mouth glass w/ Teflon-lined cap	4±2°C	14 days
TCLP – Extractable Fraction	Soil	Low	Preparation: 1311	8 ounces	Wide-mouth glass w/ Teflon-lined cap	4±2°C	14 days to TCLP extraction, 7 days to prep extraction and extracts analyzed within 40 days after prep extraction.

UFP-QAPP Worksheet #20 – Analytical SOP Requirements (continued)
Former George Air Force Base, California

Analytical Group	Matrix	Concentration Level	Analytical Method [1]/ Preparation Method(s)	Minimum Sample Volumes [2, 3]	Containers (type and size)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/ analysis)
TCLP – Inorganic Fraction (metals except Hg)	Soil	Low	Preparation: 1311	8 ounces	Wide-mouth glass w/ Teflon-lined cap	4±2°C	180 days to TCLP extraction,180 days after TCLP extraction
TCLP – Inorganic Fraction (Hg)	Soil	Low	Preparation: 1311	8 ounces	Wide-mouth glass w/ Teflon-lined cap	4±2°C	28 days to TCLP extraction, 28 days after TCLP extraction

1 The method number is used as the Analytical SOP Reference Number on Worksheet #23.
2 The sample volumes include enough for breakage and/or unforeseen need of additional volume.
3 The sample volumes should be doubled if intended for matrix spike/spike duplicate analyses.

°C denotes degrees Celsius.
mL denotes milliliter.
TCLP denotes toxicity characteristic leaching procedure.

UFP-QAPP Worksheet #20 – Analytical SOP Requirements
Former George Air Force Base, California

Analytical Group	Analytical SOP Reference[1]	Estimated Sample Quantities	Field Quality Control Analyses								Laboratory Quality Control Samples								Estimated Total
			Field Duplicates		Trip Blanks		Equipment Blanks[2]		Performance Evaluation Samples		Laboratory Control Sample [3]		Matrix Spike		Matrix Spike Duplicate		Laboratory Method Blanks [3]		
			Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	
Organochlorinated Pesticides by SW-846 8081	SOP-M400	26	1/20	2	---	---	---	---	---	---	1/Batch	2	1/20	2	1/20	2	1/Batch	2	10
Moisture Content by ASTM D2216	ASTMD2216-MoistureContent SOP	41	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0
Digital Core Photography by ASTM D 5079	Digital Core Photo-SOP	41	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0
Grain Size by ASTM D4464	LPSA-SOP	41	---	---	---	---	---	---	---	---	1/Batch	2	---	---	---	---	---	---	2
TOC by Walkley-Black	TOCWB-SOP	41	---	---	---	---	---	---	---	---	1/Batch	2	---	---	---	---	1/Batch	2	4
Soil Properties Package (Vadose Zone) – native permeability to air, total porosity, air-filled porosity, grain and bulk density, total pore fluid saturation by method API RP40	AIRPERM-SOP and PHI220 POROSIMETER -SOP	41	---	---	---	---	---	---	---	---	1/Batch	2	---	---	---	---	---	---	2

UFP-QAPP Worksheet #20 – Analytical SOP Requirements (continued)
Former George Air Force Base, California

Analytical Group	Analytical SOP Reference[1]	Estimated Sample Quantities	Field Quality Control Analyses								Laboratory Quality Control Samples								Estimated Total
			Field Duplicates		Trip Blanks		Equipment Blanks[2]		Performance Evaluation Samples		Laboratory Control Sample [3]		Matrix Spike		Matrix Spike Duplicate		Laboratory Method Blanks [3]		
			Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	
Investigative Derived Waste Characterization																			
RCRA TCLP Organochlorinated Pesticides by SW-846 1311 8081	SOP-M400	5	---	---	---	---	---	---	---	---	1/Batch	1	---	---	---	---	1/Batch	1	2
RCRA TCLP Chlorinated Herbicides by SW-846 1311 8151 (if necessary)	SOP-M402	5	---	---	---	---	---	---	---	---	1/Batch	1	---	---	---	---	1/Batch	1	2
RCRA TCLP VOCs by SW-846 1311 8260 (if necessary)	SOP-M311	5	---	---	---	---	---	---	---	---	1/Batch	1	---	---	---	---	1/Batch	1	2
RCRA TCLP SVOCs by SW-846 1311 8270 (if necessary)	SOP-M404	5	---	---	---	---	---	---	---		1/Batch	1	---	---	---	---	1/Batch	1	2
RCRA TCLP Metals by SW-846 1311 6010/7470 (if necessary)	SOP-M601 SOP-M620	5	---	---	---	---	---	---	---	---	1/Batch	1	---	---	---	---	1/Batch	1	2
Organochlorinated Pesticides	SOP-M400	1	---	---	---	---	---	---	---	---	1/Batch	1	---	---	---	---	1/Batch	1	2

UFP-QAPP Worksheet #20 – Analytical SOP Requirements (continued)
Former George Air Force Base, California

Note(s):

The numbers provided are estimates. The specific number of samples will be based on site evaluation results, field observations, etc.

Note: Suffixed SW846 Methods represent those currently certified by the lab and may undergo revision in the periodic review of the QAPP.

[1] A cross reference to the Analytical SOPs presented in Attachment C and the Analytical SOP Reference number listed are provided on Worksheet #23. The Standard Operating Procedures in Attachment C provide revision number and date details.

[2] Equipment blanks are not required when dedicated sampling equipment is used.

[3] Minimum number of QC samples (LCS and Method Blanks) required to meet project requirements based on number of field samples collected and a maximum batch size of 20 samples.

1/day denotes one per day.
1/Shipment denotes one per shipment of aqueous VOCs
1/20 denotes one per 20 samples.
1/Batch denotes one per extraction and/or analysis batch.
Freq. denotes frequency.
MS/MSD denotes matrix spike/matrix spike duplicate.
No. denotes number.
SOP denotes standard operating procedure.
SVOC denotes semivolatile organic compounds.
TCLP denotes toxicity characteristic leaching procedure.
VOC denotes volatile organic compound.

UFP-QAPP Worksheet #21 – Project Sampling SOP References Table
Former George Air Force Base, California

SOP Reference Number	Title Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Y/N)	Comments
EID-FS-001 [1]	Field Logbook 08/25/2011 Rev. 2	CB&I	N/A	N	Communicates the requirements for selection, use, and maintenance of all field logbooks. Field logbooks are often used to document observations, sampling information, and other pertinent information on project sites. They are considered legal documents and should be maintained and documented accordingly as part of the project file.
EID-FS-002 [1]	Field Log Sheet 01/23/2013 Rev. 2	CB&I	N/A	N	Communicates the requirements for proper use and completion of Field Log Sheets to document sample collection and data gathering activities. Field Log Sheets are often utilized to document single location/event information. Examples include boring logs and drum/container logs. This procedure also provides several templates that *may* be utilized or modified to a particular need.
EID-FS-003 [1]	COC Documentation – Paper 08/25/2011 Rev. 2	CB&I	N/A	N	Provides the requirements for completion of written COC documentation and to provide a suggested COC Form for project use.
EID-FS-005	Custody Seals 08/25/2011 Rev. 2	CB&I	N/A	N	Provides the requirements for completion and attachment of Custody Seals on environmental samples and shipping containers.
EID-FS-006 [1]	Sample Labeling 08/25/2011 Rev. 2	CB&I	N/A	N	Provides the requirements for completion and attachment of sample labels on environmental sample containers.
EID-FS-010	Sample Homogenization 08/25/2011 Rev. 2	CB&I	N/A	N	Establishes the method for homogenizing samples prior to containerization. Proper homogenization is very important because it helps ensure that sample aliquots are representative of the whole collected sample and helps minimize sampling error so that other errors included in the measurement process, such as laboratory sample preparation and test measurement, can be better assessed.
EID-FS-011	Compositing 08/25/2011 Rev. 2	CB&I	N/A	N	Provides guidance for the compositing of samples collected in the course of environmental program activities.
EID-FS-012 [1]	Shipping and Packaging of Non Hazardous Samples 08/25/2011 Rev. 2	CB&I	N/A	N	Provides general instructions in the packaging and shipping of nonhazardous samples. The primary use of this procedure is for the transportation of samples collected on site to be sent off site for physical, chemical, and/or radiological analysis.

UFP-QAPP Worksheet #21 – Project Sampling SOP References Table (continued)
Former George Air Force Base, California

SOP Reference Number	Title Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Y/N)	Comments
EID-FS-013	Packaging and Shipping of U.S. Department of Transportation (DOT)/International Air Transport Association (IATA)-Hazardous Samples 08/25/2011 Rev. 2	CB&I	N/A	N	Provides general instructions for packaging and shipping of hazardous samples, as defined by DOT and/or IATA, including Class 9 "Environmentally hazardous substances." The primary use of this procedure is for the transportation of samples collected on site to be sent off site for physical, chemical, biological (infectious substance), and/or radiological analysis in accordance with applicable laws and regulations and without destroying sample integrity.
EID-FS-014 [1]	Decontamination of Contact Sampling Equipment 08/25/2011 Rev. 2	CB&I	N/A	N	Provides minimal guidelines for the decontamination of contact sampling equipment. Contact sampling equipment is equipment that comes in direct contact with the sample or the portion of a sample that will undergo chemical analyses or physical testing.
EID-FS-020	Data Usability Review 08/25/2011 Rev. 2	CB&I	N/A	N	Establishes the means by which all subcontracted environmental analytical data will be reviewed for completeness and usability based upon comparison to the project action/decision levels and DQOs before use in the intended decision-making processes.
EID-FS-101	Trowel/Spoon Surface Soil Sampling 08/25/2011 Rev. 2	CB&I	N/A	N	Provides the methods and procedure for sampling of surface soils using trowels or spoons. Trowels or spoons can be used when matrices are composed of relatively soft and non-cemented formations and to depths of up to 12 inches into the ground surface, dependent on site conditions. Samples for VOC analysis should not be collected via trowel or spoon method. However, a trowel or spoon may be utilized to penetrate to and expose the undisturbed material at the desired depth for sampling by more applicable methods.
EID-FS-107 [1]	Roll-Off Sampling 08/25/2011 Rev. 2	CB&I	N/A	N	This procedure provides general information about sampling of roll-off containers.
EID-FS-115	Sampling of Tanks and Storage Vessels 08/25/2011 Rev. 2	CB&I	N/A	N	This procedure is intended to provide general guidance for sampling of tanks and storage vessels for all analyses including waste characterization or compatibility analysis.
EIP-G-005 [1]	Field Activities Documentation 08/25/2011 Rev. 2	CB&I	N/A	N	Establishes a uniform method of documenting field activities so that the resultant documentation is accurate, complete, and sufficient to withstand scientific and legal scrutiny.

UFP-QAPP Worksheet #21 – Project Sampling SOP References Table (continued)
Former George Air Force Base, California

SOP Reference Number	Title Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Y/N)	Comments
EID-GS-017 [1]	Standards for Conducting Hollow Stem Auger Drilling 01/02/2013 Rev. 2	CB&I	N/A	N	This procedure provides the standard practice for hollow stem auger drilling.
EID-GS-018 [1]	Standards for Conducting Mud Rotary Drilling 01/02/2013 Rev. 2	CB&I	N/A	N	This procedure provides the standard practice for mud rotary drilling.
EID-GS-019 [1]	Standards for Conducting Air Rotary Drilling 01/02/2013 Rev. 2	CB&I	N/A	N	This procedure provides the standard practice for air rotary drilling.
EID-GS-021 [1]	Standards for Conducting Direct Push Drilling and Soil Sampling 01/02/2013 Rev. 2	CB&I	N/A	N	This procedure provides the standard practice for direct push drilling and soil sampling.
EIP-GS-025 [1]	Standards for Soils Logging 01/30/2007 Rev. 1	CB&I	N/A	N	Provides the standard practice for soils logging (the description of soils).
EIP-GS-027 [1]	Standards for Generation of Boring Logs 01/30/2007 Rev. 1	CB&I	N/A	N	Provides the standard for the generation of boring logs.
EIP-GS-031 [1]	Standards for Design and Installation of Groundwater Monitoring Wells 01/02/2013 Rev. 2	CB&I	N/A	N	Provides the standard practice for groundwater monitoring well design and installation.
EIP-GS-037 [1]	Standards for Conducting Well Development 01/02/2013 Rev. 2	CB&I	N/A	N	Provides the standard practice for development of monitoring, extraction, and injection wells completed primarily in granular formations.

UFP-QAPP Worksheet #21 – Project Sampling SOP References Table (continued)
Former George Air Force Base, California

SOP Reference Number	Title Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Y/N)	Comments
EIG-RM-001	Records Management Procedures 11/10/2011 Rev. 0	CB&I	N/A	N	Establishes the requirements and guidelines to manage records throughout their lifecycle.
EIP-RM-002	Using ShawRecords to Manage Project Records 11/10/2011 Rev. 0	CB&I	N/A	N	Describes the process for using ShawRecords to manage project records.
CMS-710-05-PR-00400	Stop Work Authority 12/11/2013 Rev. 0	CB&I	N/A	N	Describes the process and responsibilities for issuing, resolving, and verifying acceptable responses/actions for Stop Work Orders (SWO) associated with quality related items.
CMS-720-01-PR-00150	Identification, Control, and Disposition of Nonconforming Products 09/2/2014 Rev. 4	CB&I	N/A	N	Establishes the system for initiating, processing, and controlling nonconforming items, services, or activities to include disposition and corrective actions.
CMS-720-01-PR-00170	Corrective and Preventive Action 9/22/2009 Rev. 2	CB&I	N/A	N	Defines the requirements for identifying and processing a Corrective and Preventive Action Request.
CMS-720-01-FM-00170	Corrective/Preventative Action Request Form 09/22/2009, Rev. 2	CB&I	N/A	N	Corrective and Preventive Action Form
CMS-720-01-GL-00230	Guidelines for Quality Surveillance Activities 9/2/2014 Rev. 2	CB&I	N/A	N	Describes the methods and responsibilities for performing and documenting inspections on project work activities and materials to ensure compliance with established requirements. Also, provides instructions for performing and documenting the surveillance of project activities and functional areas.
CMS-720-01-PR-00220 [1]	Management System Audits 12/19/2014 Rev. 9	CB&I	N/A	N	Establishes the requirements for a comprehensive system of planned and documented quality audits to verify the effectiveness of the Quality Management System, mitigate performance risk, and promote continual improvement.
CMS-830-03-GL-00002 [1]	Checking of Specifications, Calculations and Drawings 10/19/2009 Rev. 0	CB&I	N/A	N	Provides acceptable methods for the verification of technical work products to include figures, drawings, tables, and logs to ensure that information is correct and accurately presented.

UFP-QAPP Worksheet #21 – Project Sampling SOP References Table (continued)
Former George Air Force Base, California

SOP Reference Number	Title Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Y/N)	Comments
EIP-Q-013 [1]	Analytical Laboratory Oversight and Performance Monitoring 02/15/2007 Rev. 0	CB&I	N/A	N	Provides procedures to establish the oversight requirements for monitoring the performance of laboratories providing analytical services.

Notes:
[1] Presented in Attachment A of the Workplan.

UFP-QAPP Worksheet #22 – Field Equipment Calibration, Maintenance, Testing, and Inspection Table
Former George Air Force Base, California

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Photoionization Detector Meter	Daily calibration with standard within range of measurement	As needed	As needed	Check condition before use	At beginning of work activity	Meets specification	Repeat, or tag as "out of calibration – do not use"	Field Lead or designee	FS-203

UFP-QAPP Worksheet #23 – Analytical SOP References Table – Lab
Former George Air Force Base, California

Note: Suffixed SW-846 Methods represent those currently certified by the laboratory and may undergo revision during periodic QAPP review. QAPP revisions will be submitted for approval.

Method Reference Number	Laboratory/Field SOP Cross Reference Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
SW846 8081	SOP-M400, Rev. 4.4	EPA Method 8081A, Organochlorine Pesticides by GC; March, 1, 2011	Definitive	Organochlorine Pesticides	GC	Calscience Environmental Laboratories, Inc. – Garden Grove, CA	N
SW846 8151	SOP-M402, Rev. 3.3	EPA Method 8151A, Chlorinated Herbicides by GC via Methylation Derivatization; March 1, 2011	Definitive	Organochlorinate d Herbicides	GC	Calscience Environmental Laboratories, Inc. – Garden Grove, CA	N
SW846 8260	SOP-M311, Rev. 0.0	EPA Method 8260B, Volatile Organic Compounds by Gas Chromatography / Mass Spectroscopy (GC/MS); November 12, 2010	Definitive	VOCs	GC/MS	Calscience Environmental Laboratories, Inc. – Garden Grove, CA	N
SW846 8270	SOP-M404, Rev. 4.7	EPA Method 8270C, Semivolatile Organic Compounds by Gas Chromatography / Mass Spectroscopy (GC/MS); March 1, 2011	Definitive	SVOCs PAHs	GC/MS	Calscience Environmental Laboratories, Inc. – Garden Grove, CA	N
SW846 6010	SOP-M601, Rev. 5.2	EPA Method 6010B, Inductively Coupled Plasma – Atomic Emisson Spectrometry (ICP-AES); May 16, 2011	Definitive	Metals	Inductively-coupled plasma spectroscopy (ICP)	Calscience Environmental Laboratories, Inc. – Garden Grove, CA	N
SW846 7470	SOP-M619, Rev. 2.8	EPA Method 7470A, Mercury in Liquid Waste (Cold Vapor Technique); November 15, 2010	Definitive	Mercury	Atomic absorption (AA)	Calscience Environmental Laboratories, Inc. – Garden Grove, CA	N
ASTM SM 2540 B	SOP-M700, Rev. 2.3	SM 2540 B, Determination of Moisture or Solids Content; November 11, 2011	Definitive	Moisture content	Balance	Calscience Environmental Laboratories, Inc. – Garden Grove, CA	N
EPA 9045	SOP-M736, Rev. 1.0	EPA Method 9045D, Soil and Waste pH / Corrosivity; April 20, 2007	Definitive	pH (Soil)	Wet Chemistry	Calscience Environmental Laboratories, Inc. – Garden Grove, CA	N

UFP-QAPP Worksheet #23 – Analytical SOP References Table – Lab
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Method Reference Number	Laboratory/Field SOP Cross Reference Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
EPA 1030	SOP-M708, Rev. 0.0	EPA Method 1030, Ignitability of Solids; June 11, 2010	Definitive	Ignitability (Soil)	Wet Chemistry	Calscience Environmental Laboratories, Inc. – Garden Grove, CA	N
SW846 Chapter 7	SOP-M734, Rev. 1.1	SW-846, Chapter 7, Reactive Cyanide; July 20, 2006	Definitive	Reactive Cyanide	Wet Chemistry	Calscience Environmental Laboratories, Inc. – Garden Grove, CA	N
SW846 Chapter 7	SOP-M733, Rev. 2.3	SW-846, Chapter 7, Reactive Sulfide; July 30, 2006	Definitive	Reactive Sulfide	Wet Chemistry	Calscience Environmental Laboratories, Inc. – Garden Grove, CA	N
EPA 1311	SOP-M226, Rev. 2.5	EPA Method 1311, Toxicity Characteristic Leaching Procedure (TCLP) March 30, 2012	Definitive	Extraction	Not applicable	Calscience Environmental Laboratories, Inc. – Garden Grove, CA	N
ASTM D2216	ASTMD2216-MoistureContent SOP, Rev. 1.2	Determination of Water (Moisture) Content July 13, 2012	Definitive	Moisture content	Balance	PTS Laboratories, Inc. - 8100 Secura Way Santa Fe Springs, CA	N
ASTM D 5079	Digital Core Photo-SOP, Rev. 1.2	Digital Core Photography of Cryogenically Preserved Core July 29, 2012	Definitive	Geotechnical	Digital Photography – Visible and Ultra Violet	PTS Laboratories, Inc. - 8100 Secura Way Santa Fe Springs, CA	N
ASTM D4464	LPSA-SOP, Rev. 1.2	LS 200 Laser Particle Size Analyzer (LPSA) May 10, 2012	Definitive	Geotechnical	Laser Light Defraction	PTS Laboratories, Inc. - 8100 Secura Way Santa Fe Springs, CA	N
Walkley-Black Method	TOCWB-SOP, Rev. 1.2	Determination of Total Organic Carbon (TOC) by Walkley-Black Method March 6, 2013	Definitive	Geotechnical	Wet Chemistry	PTS Laboratories, Inc. - 8100 Secura Way Santa Fe Springs, CA	N

UFP-QAPP Worksheet #23 – Analytical SOP References Table – Lab
Former George Air Force Base, California

Method Reference Number	Laboratory/Field SOP Cross Reference Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
API RP40	AIRPERM-SOP, Rev. 1.2	Permeability to Air June 23, 2014	Definitive	Geotechnical	Permeameter Balance	PTS Laboratories, Inc. - 8100 Secura Way Santa Fe Springs, CA	N
	PHI220POROSIMETER -SOP, Rev. 1.0	Determination of Grain Volume and Pore Volume by Helium Porosimetry (Coretest Systems PHI-220) May 18, 2012	Definitive	Geotechnical	Helium Porosimeter	PTS Laboratories, Inc. - 8100 Secura Way Santa Fe Springs, CA	N

Notes:
Laboratory SOPs are presented in Attachment C.

UFP-QAPP Worksheet #24 – Analytical Instrument Calibration Table – Lab
Former George Air Force Base, California

Note: Suffixed SW-846 Methods represent those currently certified by the laboratory and may undergo revision during periodic QAPP review. QAPP revisions will be submitted for approval.

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	Method Reference No./ Laboratory SOP Reference [1]
GC – Organochlorinated Pesticides Chlorinated Herbicides	Five-point initial calibration for all analytes. For pesticides; single point may be run for toxaphene and chlordane. If either is detected, a 5-point calibration will be run and the samples reanalyzed	When instrument performance criteria are not met	WS 28-1	Correct problem and recalibrate	Lab section manager	8081 / SOP-M400 8151 / SOP-M402
	Continuing calibration	Daily, after initial calibration, after every 10 samples, and at the end of each analytical sequence	WS 28-1	Correct problem and recalibrate	Lab section manager	
GC/MS – VOCs, SVOCs	Five-point initial calibration for all analytes.	When instrument performance criteria are not met	WS 28-2 WS 28-4	Correct problem and Recalibrate	Lab section manager	SW846 8260 / SOP-M311 SW846 8270 / SOP-M404
	Continuing calibration	Daily before sample analysis and every 12 hours of analysis time	WS 28-2 WS 28-2	Correct problem and Recalibrate	Lab section manager	
ICP-Metals	Initial calibration (minimum 1 high standard and a calibration blank)	When instrument performance criteria are not met	WS 28-3	Correct problem and recalibrate	Lab section manager	SW-846 6010 / SOP-M601
	Continuing calibration verification	Daily, after initial calibration, after every 10 samples, and at the end of each analytical sequence	WS 28-3	Correct problem and recalibrate	Lab section manager	

UFP-QAPP Worksheet #24 – Analytical Instrument Calibration Table – Lab (continued)
Former George Air Force Base, California

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	Method Reference No./ Laboratory SOP Reference [1]
AA Mercury	Initial multipoint calibration (minimum 5 standards and a blank)	When instrument performance criteria are not met	WS 28-3	Correct problem and recalibrate	Lab section manager	SW-846 7470 / SOP-M619 SW-846 7471 / SOP-M620
	Continuing calibration verification	Daily, following initial calibration verification (ICV) and initial calibration blank verification (ICBV) Every 10 samples and at the end of each analytical sequence	WS 28-3	Correct problem and recalibrate	Lab section manager	
Moisture	Analytical Balance: Three Class 2 weights Top Loading Balance: Two Class 2 weights.	When instrument performance criteria are not met	WS-28-4	Correct problem and recalibrate balance	Lab section manager	SM 2540-B / SOP-M700
Ignitability	CCV	Daily, prior to sample analysis	o-Xylene Flashpoint at 90±2°F	Correct problem, and reanalyze CCV. No samples may be analyzed until the CCV meets criteria.	Analyst, Supervisor	EPA 1030 / SOP-M708
pH	Initial calibration (minimum 3 standards consisting of pH=4.00, 7.00, and 10.00)	When instrument performance criteria are not met	WS 28-4	Correct problem and recalibrate	Lab section manager	SW-846 9045D / SOP-M736
	Continuing calibration verification	Daily, after initial calibration, after every 20 samples, and at the end of each analytical sequence	WS 28-4	Correct problem and recalibrate	Lab section manager	
Titration – Reactive Sulfide	Titrant check	Monthly	Perform twice, amount of titrant used should agree within 0.1 ml	Correct problem then repeat titrant check	Analyst, Supervisor	SW-846 Chapter 7 / SOP-M733

UFP-QAPP Worksheet #24 – Analytical Instrument Calibration Table – Lab (continued)
Former George Air Force Base, California

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	Method Reference No./ Laboratory SOP Reference [1]
UV-Visible Spectrometer Reactive Cyanide	ICAL Minimum 5 standards and a blank	Initial calibration prior to sample analysis	Correlation coefficient ≥ 0.995 for linear regression	Recalibrate and/or perform necessary equipment maintenance.	Analyst, Supervisor	SW-846 Chapter 7 / SOP-M734
	CCV	CCV after every 10 samples and at the end of the analytical sequence	All analytes within ± 10% of expected value	Repeat initial calibration and reanalyze all samples analyzed since the last successful calibration verification	Analyst, Supervisor	
	ICV (Second source)	Once after ICAL	All analytes within ± 10% of expected value	Repeat initial calibration and reanalyze all samples analyzed since the last successful calibration verification	Analyst, Supervisor	

Notes:

[1] The SOP Reference Number corresponds to WS #23 with the actual SOPs presented in Attachment C.

UFP-QAPP Worksheet #25 – Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table
Former George Air Force Base, California

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference [1]
GC-ECD	Routine GC performance check	Pesticides Herbicides	Review instrument performance whenever LCS or acceptance criteria are outside limits	Daily	Applicable method criteria	Perform routine maintenance, repeat instrument calibration	Lab section lead	Per manufacturer's instructions (refer to Attachment C SOPs)
GC/MS	Routine GC/MS performance check	VOCs SVOCs	Review instrument performance whenever LCS or acceptance criteria are outside limits	Daily	Applicable method criteria	Perform routine maintenance, repeat instrument calibration	Lab section lead	Per manufacturer's instructions (refer to Attachment C SOPs)
ICP	Routine performance check	Metals	Review instrument performance whenever LCS or acceptance criteria are outside limits	Daily	Applicable method criteria	Perform routine maintenance, repeat instrument calibration	Lab section lead	Per manufacturer's instructions (refer to Attachment C SOPs)
AA	Routine performance check	Metals	Review instrument performance whenever LCS or acceptance criteria are outside limits	Daily	Applicable method criteria	Perform routine maintenance, repeat instrument calibration	Lab section lead	Per manufacturer's instructions (refer to Attachment C SOPs)
pH Meter	Routine performance check	pH	Review instrument performance whenever LCS or acceptance criteria are outside limits	Daily	Applicable method criteria	Perform routine maintenance, repeat instrument calibration	Lab section lead	Per manufacturer's instructions (refer to Attachment C SOPs)
UV-Visible Spectrometer	Routine performance check	Reactive Cyanide	Review instrument performance whenever LCS or acceptance criteria are outside limits	Daily	Applicable method criteria	Perform routine maintenance, repeat instrument calibration	Lab section lead	Per manufacturer's instructions (refer to Attachment C SOPs)
Balance	Routine performance check	Moisture	Review instrument performance whenever LCS or acceptance criteria are outside limits	Daily	Applicable method criteria	Perform routine maintenance, repeat instrument calibration	Lab section lead	Per manufacturer's instructions (refer to Attachment C SOPs)

Notes:
The Analytical SOPs are provided in Attachment C of this QAPP.

UFP-QAPP Worksheet #26 – Sample Handling System
Former George Air Force Base, California

Calscience Environmental Laboratories, Inc.

Sample Collection, Packaging, and Shipment
Sample Collection (Personnel/Organization): CB&I Site Manager or designee
Sample Packaging (Personnel/Organization): CB&I Site Manager or designee
Coordination of Shipment (Personnel/Organization): CB&I Site Manager or designee
Type of Shipment/Carrier: Laboratory Courier or Commercial Courier
Sample Receipt and Analysis
Chemistry Sample Receipt (Personnel/Organization): Primary – Eurofins Calscience, Inc. Geotechnical Sample Receipt (Personnel/Organization): Primary – PTS Laboratories, Inc.
Chemistry Sample Custody and Storage (Personnel/Organization): Primary – Eurofins Calscience, Inc. Geotechnical Sample Custody and Storage (Personnel/Organization): Primary – PTS Laboratories, Inc.
Chemistry Sample Preparation (Personnel/Organization): Primary – Eurofins Calscience, Inc. Geotechnical Sample Preparation (Personnel/Organization): Primary – PTS Laboratories, Inc.
Chemistry Sample Determinative Analysis (Personnel/Organization): Primary – Eurofins Calscience, Inc. Geotechnical Sample Determination Analysis (Personnel/Organization): Primary – PTS Laboratories, Inc.
Sample Archiving
Chemistry Field Sample Storage (No. of days from sample collection): Primary – Eurofins Calscience, Inc. - 28 days Geotechnical Field Sample Storage (No. of days from sample collection): Primary – Primary – PTS Laboratories, Inc.- 6 months
Chemistry Sample Extract/Digestate Storage (No. of days from extraction/digestion): Primary – Eurofins Calscience, Inc. – 40 days
Sample Disposal
Chemistry Personnel/Organization: Primary – Eurofins Calscience, Inc. Geotechnical Personnel/Organization: Primary – PTS Laboratories, Inc.
Chemistry Number of Days from Reporting: Primary – Eurofins Calscience, Inc. – 21 days Geotechnical Number of Days from Reporting: Primary – PTS Laboratories, Inc.- 28 days

Examples of field forms that will be used are found in Attachment B of the QAPP.

Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory):

Procedures to ensure the custody and integrity of the samples begin at the time of sampling and continue through transport, sample receipt, preparation, analysis and storage, data generation and reporting, and sample disposal. Records concerning the custody and condition of the samples are maintained in field and laboratory records.

CB&I shall maintain COC records for all field and field QC samples. A sample is defined as being under a person's custody if any of the following conditions exist: (1) it is in their possession, (2) it is in their view, after being in their possession, (3) it was in their possession and they locked it up, or (4) it is in a designated secure area.

Samples collected in the field shall be transported to the laboratory or field testing site as expeditiously as possible. When a 4 °C requirement for preserving the sample is indicated, the samples shall be packed in ice or chemical refrigerant to keep them cool during collection and transportation. During transit, it is not always possible to rigorously control the temperature of the samples. As a general rule, storage at low temperature is the best way to preserve most samples. A temperature blank (a VOC sampling vial filled with tap water) shall be included in every cooler and used to determine the internal temperature of the cooler upon receipt of the cooler at the laboratory. If the temperature of the samples upon receipt exceeds the temperature requirements, the exceedance shall be documented in laboratory records and discussed with CB&I. The decision regarding the potentially affected samples shall also be documented.

Additional details regarding custody procedures are provided in CB&I SOP EID-FS-003.

Laboratory Sample Custody Procedures (receipt of samples, archiving, disposal):

Once the samples reach the laboratory, they shall be checked against information on the COC/request for analysis (RFA) form for anomalies. The condition, temperature, and appropriate preservation of samples shall be checked and documented on the COC form. Checking an aliquot of the sample using pH paper is an acceptable procedure except for VOCs where an additional sample is required to check preservation. The occurrence of any anomalies in the received samples and their resolution shall be documented in laboratory records. All sample information shall then be entered into a tracking system, and unique analytical sample identifiers shall be assigned. A copy of this information shall be reviewed by the laboratory for accuracy. Sample holding time tracking begins with the collection of samples and continues until the analysis is complete. Holding times for methods required routinely for this work are specified in QAPP WS #19. Samples not preserved or analyzed in accordance with these requirements shall be resampled and analyzed at no additional cost. Subcontracted analyses shall be documented with the CB&I COC form. Procedures ensuring internal laboratory COC shall also be implemented and documented by the laboratory. Specific instructions concerning the analysis specified for each sample shall be communicated to the analysts. Analytical batches shall be created, and laboratory QC samples shall be introduced into each batch.

While in the laboratory, samples shall be stored in limited-access, temperature-controlled areas. Refrigerators, coolers and freezers shall be monitored for temperature 7 days a week. Acceptance criterion for the temperatures of the refrigerators and coolers is 4°C ± 2°C. Acceptance criterion for the temperatures of the freezers shall be less than 0°C. All of the cold storage areas shall be monitored by thermometers that have been calibrated with a National Institute of Standards and Technology (NIST)-traceable thermometer. As indicated by the findings of the calibration, correction factors shall be applied to each thermometer. Records that include acceptance criteria shall be maintained. Samples for volatile organics determination shall be stored separately from other samples, standards, and sample extracts. Samples shall be stored after analysis until disposed of in accordance with applicable local, state, and federal regulations. Disposal records shall be maintained by the laboratory.

SOPs describing sample control and custody shall be maintained by the laboratory.

Sample Identification Procedures:

All samples shall be uniquely identified, labeled, and documented in the field at the time of collection in accordance with CB&I SOPs EID-FS-001 and EID-FS-006.

UFP-QAPP Worksheet #27 – Sample Custody Requirements (continued)
Former George Air Force Base, California

Chain-of-Custody Procedures:

The following information concerning the sample shall be documented on the CB&I COC form:

- Unique sample identification
- Date and time of sample collection
- Source of sample (including name, location, and sample type)
- Designation of MS/MSD
- Preservative used
- Analyses required
- Name of collector(s)
- Pertinent field data (pH, temperature, etc.)
- Serial numbers of custody seals and transportation cases (if used)
- Custody transfer signatures and dates and times of sample transfer from the field to transporters and to the laboratory or laboratories
- Bill of lading or transporter tracking number (if applicable).

Table 28-1. Summary of Calibration and QC Procedures for Organic Analysis by Gas Chromatography (SW-846 8081 and 8151)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Equipment Blanks	TBD	No analytes detected ≥ reporting limit (LOQ)	Qualify samples, identify source(s).	TBD	Representativeness	DV: Apply "5x/10x" rule. Qualify as non-detect U if analyte is < "5x/10x" the level of contamination.
Field Duplicate	1 every 20 samples	RPD ≤ 50% Soil	Identify source of error and correct as needed.	Field samplers	Field precision	DV: Apply J to the specific analyte(s) in the parent sample and its associated field duplicate sample.
Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Prior to using any test method and at any time there is significant change in instrument type, personnel, test method, or sample matrix.	QC acceptance criteria, WS #15	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria.	Lab	Accuracy and Precision	N/A
LOD determination	See DoD QSM Version V4.2; Box D-13					
LOQ determination	See DoD QSM Version V4.2; Box D-14					
Retention time (RT) window width calculated for each analyte	After method setup and after major maintenance.	RT width ± 3 times standard deviation for each analyte RT over 24 hour period	N/A	Lab	Representativeness	N/A

Table 28-1 (continued). Summary of Calibration and QC Procedures for Organic Analysis by Gas Chromatography (SW-846 8081 and 8151)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Five-point initial calibration	Initial calibration prior to sample analysis.	Linear - mean RSD for all analytes ≤ 20% Linear – least squares regression r ≥ 0.995 for each analyte Nonlinear – correlation coefficient ≥ 0.990 (6 points will be used for second order, 7 points will be used for third order)	Correct problem then repeat initial calibration.	Lab	Accuracy	Lab: Apply Q qualifier to all results for all samples associated with the calibration. DV: Apply R/J to all results for all samples associated with the calibration.
Second-source calibration verification for all analytes	Immediately following initial calibration.	All project analytes within the established RT windows. GC Methods: All analytes within ± 20% of expected value.	Prepare fresh ICV and re-analyze to rule out standard degradation or inaccurate injection. If problem persists perform instrument maintenance/correct problem and repeat ICAL.	Lab	Accuracy	Lab: Apply Q qualifier. DV: if % Difference is > upper control limit (UCL); apply J to all results greater than the DL. If % Difference is < lower control limit (LCL); apply J to all results greater than the DL and UJ to all results not detected above the DL for specific analyte(s) for all samples associated with the ICV.
RT window calculated for each analyte and surrogate	Each initial calibration and calibration verifications.	Position shall be set using the midpoint standard of the ICAL curve when the ICAL is performed. On days when the ICAL is not performed, the initial CCV is used.	Correct problem then reanalyze all samples analyzed since the last RT check.	Lab	Accuracy	Lab: Apply Q qualifier. DV: Apply R/J to all results for the specific analyte(s) in the sample unless matrix effect is documented.

Table 28-1 (continued). Summary of Calibration and QC Procedures for Organic Analysis by Gas Chromatography (SW-846 8081 and 8151)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Continuing calibration verification (CCV)	Initially, prior to sample or QC analysis, every 10 samples and at the end of the sequence.	All project analytes within the established RT windows. GC Methods: All analytes within ± 20% of expected value.	Prepare fresh ICV and re-analyze to rule out standard degradation or inaccurate injection. If problem persists perform instrument maintenance/correct problem and repeat ICAL.	Lab	Accuracy	Lab: Apply Q qualifier. DV: if % Difference is > UCL; apply J to all results greater than the DL. If % Difference is <LCL; apply J to all results greater than the DL and UJ to all results not detected above the DL for specific analyte(s) for all samples associated with the CCV.
Method Blank	One per analytical batch.	No analytes detected ≥ 0.5XLOQ.	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank unless sample results are nondetect.	Lab	Representativeness	Lab: Apply B to all results for the specific analyte(s) in all samples in the associated analytical batch. DV: Apply "5x/10x" rule. Qualify as non-detect U if analyte is < "5x/10x" the level of contamination.
LCS containing all analytes of interest including surrogates	One LCS per analytical batch.	QC acceptance criteria, WS #15	Correct problem then reanalyze; if still out, and sufficient sample volume and holding time remain, re-extract and reanalyze the batch. Otherwise, narrate. No action needed if LCS/LCSD recoveries high and sample results are nondetect.	Lab	Accuracy and Precision	Lab: Apply Q qualifier. DV: For specific analyte(s) in all samples in the associated analytical batch: if the LCS %R > UCL, apply J to all positive results; if the LCS %R < LCL, apply J to all positive results, apply UJ to all non-detects; if the LCS %R < 30% and < LCL, apply J to all positive results, apply R to all non-detects.

Table 28-1 (continued). Summary of Calibration and QC Procedures for Organic Analysis by Gas Chromatography (SW-846 8081 and 8151)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
MS/MSD	One MS/MSD per every 20 project samples per matrix.	QC acceptance criteria, WS #15	None	Lab	Accuracy and Precision	Lab: Apply Q qualifier. DV: For the specific analyte(s) result in the parent sample that are < "4x" MS spike concentration, apply J if: (1) %R for MS or MSD > UCL or (2) J/UJ if %R for MS or MSD < LCL or (3) MS/MSD RPD > CL.
Surrogate spike	Every sample, spiked sample, standard, and method blank.	QC acceptance criteria, WS #15	Reanalyze extract, if confirmed and sufficient sample volume and holding time remain, re-extract and reanalyze sample in another batch. Otherwise, narrate.	Lab	Accuracy	Lab: Apply Q qualifier. DV: For the samples: if the %R > UCL for the surrogate apply J to all positive results; if the %R < LCL for the surrogate, apply J to all positive results, apply UJ to all non-detects; if the surrogate recovery is < 10%, apply J to all positive results, apply R to all non-detects.
Confirmation of positive results (second column or second detector)	All positive results must be confirmed	Calibration and QC criteria same as for initial or primary column analysis. Results between the primary and second column RPD≤40%.	Apply J qualifier if RPD>40%. Discuss in the SDG case narrative. Report highest concentration unless matrix interference is suspected.	Lab	Accuracy	Lab: Apply J qualifier. DV: Apply J to result if the calculated RPD>40%.
Manual integration	N/A	N/A	Both before and after chromatograms will be submitted as a portion of the raw data package.	Lab	Accuracy	Lab: The data will be qualified with an "M" on the raw data report. Manual integration will be discussed in the case narrative.

Table 28-1 (continued). Summary of Calibration and QC Procedures for Organic Analysis by Gas Chromatography (SW-846 8081 and 8151)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Results reported between DL and LOQ	None	None	None	Lab	Representativeness, Accuracy	Lab: Apply J to all results between DL and LOQ. DV: Apply J to all results between DL and LOQ.

Table 28-2. Summary of Calibration and QC Procedures for Organic Analysis by Gas Chromatography/Mass Spectrometry (SW-846 8260 and 8270)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Equipment Blanks	TBD	No analytes detected ≥ LOQ	Qualify samples, identify source(s)	TBD	Representativeness	DV: Apply "5x/10x" rule. Qualify as non-detect U if analyte is < "5x/10x" the level of contamination.
Field Duplicate	1 every 20 samples	RPD ≤ 50%Soil	Identify source of error and correct as needed	Field samplers	Field precision	DV: Apply J to the specific analyte(s) in the parent sample and its associated field duplicate sample.
Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria, Worksheet #15	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria	Lab	Accuracy and Precision	N/A
LOD determination	See DoD QSM Version V4.2; Box D-13					
LOQ determination	See DoD QSM Version V4.2; Box D-14					

Table 28-2 (continued). Summary of Calibration and QC Procedures for Organic Analysis by Gas Chromatography/Mass Spectrometry (SW-846 8260 and 8270)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Method 8260: Check of mass spectral ion intensities using bromofluorobenzene (BFB)	Every 12 hours, prior to initial calibration and continuing calibration verification	mass 50 15 – 40 percent of mass 95 mass 75 30 – 60 percent of mass 95 mass 95 base peak, 100 percent relative abundance mass 96 5 – 9 percent of mass 95 mass 173 less than 2 percent of mass 174 mass 174 greater than 50 percent of mass 95 mass 175 5 – 9 percent of mass 174 mass 176 greater than 95 percent, but less than 101 percent of mass 174 mass 177 5 –9 percent of mass 176	Retune instrument and verify	Lab	Representativeness, Comparability Accuracy and Precision	Lab: No samples shall be run until tune passes QC criteria DV: Use professional judgment to review data and reject all affected sample results associated with the failing tune. Quality as unusable, R.

Table 28-2 (continued). Summary of Calibration and QC Procedures for Organic Analysis by Gas Chromatography/Mass Spectrometry (SW-846 8260 and 8270)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Method 8270 Check of mass spectral ion intensities using DFTPP	Every 12 hours, prior to initial calibration and continuing calibration verification	mass 51 30 – 60 percent of mass 198 mass 68 less than 2 percent of mass 69 mass 70 less than 2 percent of mass 69 mass 127 40 – 60 percent of mass 198 mass 197 less than 1 percent of mass 198 mass 198 base peak, 100 percent relative abundance mass 199 5 – 9 percent of mass 198 mass 275 10 – 30 percent of mass 198 mass 365 greater than 1 percent of mass 198 mass 441 present, but less than mass 443 mass 442 greater than 40 percent of mass 198 mass 443 17 – 23 percent of mass 442	Retune instrument and verify	Lab	Representativeness, Comparability Accuracy and Precision	Lab: No samples shall be run until tune passes QC criteria DV: Use professional judgment to review data and reject all affected sample results associated with the failing tune. Quality as unusable, R.

Table 28-2 (continued). Summary of Calibration and QC Procedures for Organic Analysis by Gas Chromatography/Mass Spectrometry (SW-846 8260 and 8270)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Method 8270 DDT Breakdown Check	At the beginning of each 12-hour period, prior to analysis of samples	Degradation ≤20% for DDT. Benzidine and pentachlorophenol should be present at their normal responses, and should not exceed a tailing factor of 2.	Correct problem then repeat breakdown check.	Lab	Accuracy and Precision	Lab: No samples shall be run until degradation ≤20%. DV: Quality R all sample results associated with the failing DDT breakdown check.
Method 8260 Five-point initial calibration for all analytes	Initial calibration prior to sample analysis	Average response factor (RRF) for chlorobenzene and 1,1,2,2-tetrachloroethane ≥ 0.30 and RRF for chloromethane, bromoform, and 1,1-dichloroethane ≥ 0.10. % Relative standard deviation (RSD) for CCCs ≤ 30% and one option below	Correct problem then repeat initial calibration	Lab	Accuracy	Lab: Apply Q qualifier DV: Qualify non-detects that do not meet minimum RRF as unusable, R. Estimate positive results that do not meet minimum RRF as J/UJ
		Option 1 linear – RSD for all analytes ≤ 15% with no CCC analyte RSD > 30%	Correct problem then repeat initial calibration	Lab	Accuracy	Lab: Apply Q qualifier DV: Estimate all results with RSD >30 as J/UJ.
		Option 2 linear – linear least squares regression r ≥ 0.995 for each analyte	Correct problem then repeat initial calibration	Lab	Accuracy	Lab: Apply Q qualifier DV: Estimate all results with RSD r ≥ 0.995as J/UJ.
		Option 3 nonlinear – correlation coefficient ≥ 0.990 (6 points will be used for second order, 7 points will be used for third order)	Correct problem then repeat initial calibration	Lab	Accuracy	Lab: Apply Q qualifier DV: Estimate all results with RSD r ≥ 0.990as J/UJ.

Table 28-2 (continued). Summary of Calibration and QC Procedures for Organic Analysis by Gas Chromatography/Mass Spectrometry (SW-846 8260 and 8270)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
<u>Method 8270</u> Five-point initial calibration for all analytes	Initial calibration prior to sample analysis	Average response factor (RRF) for all SPCCs ≥ 0.050.	Correct problem then repeat initial calibration	Lab	Accuracy	Lab: Apply Q qualifier DV: Qualify non-detects that do not meet minimum RRF as unusable, R. Estimate positive results that do not meet minimum RRF as J/UJ
		Option 1 linear – RSD for all analytes ≤ 15% with no CCC analyte RSD > 30%	Correct problem then repeat initial calibration	Lab	Accuracy	Lab: Apply Q qualifier DV: Estimate all results with RSD >30 as J/UJ.
		Option 2 linear – linear least squares regression r ≥ 0.995 for each analyte	Correct problem then repeat initial calibration	Lab	Accuracy	Lab: Apply Q qualifier DV: Estimate all results with RSD r ≥ 0.995 as J/UJ.
		Option 3 nonlinear – correlation coefficient ≥ 0.990 (6 points will be used for second order, 7 points will be used for third order)	Correct problem then repeat initial calibration	Lab	Accuracy	Lab: Apply Q qualifier DV: Estimate all results with RSD r ≥ 0.990 as J/UJ.
Second-source calibration verification	Immediately following ICAL	All calibration analytes within ± 20% of expected value (when using RFs) or drift (when using least squares regression or nonlinear calibration)	Prepare fresh ICV standard and re-analyze to rule out standard degradation or inaccurate injection. If problem persists, perform instrument maintenance to correct the problem and repeat ICAL.	Lab	Accuracy	Lab: Apply Q qualifier DV: Estimate results (J/UJ) if second source std ± 20% of expected value.

Table 28-2 (continued). Summary of Calibration and QC Procedures for Organic Analysis by Gas Chromatography/Mass Spectrometry (SW-846 8260 and 8270)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Retention time window calculated for each analyte and surrogate and Evaluation	Each sample	Position shall be set using the midpoint standard of the ICAL curve when the ICAL is performed. On days when the ICAL is not performed, the initial CCV is used. Relative retention time (RRT) of the analyte within ± 0.06 RRT units of the RRT	Correct problem then reanalyze all samples analyzed since the last retention time check	Lab	Representativeness	Lab: Apply Q qualifier DV: Review spectral fit and use professional judgment to qualify any results that do not fall within expected retention time windows, or where a matrix effect is documented.
<u>Method 8260</u> Continuing Calibration verification (CCV)	Every 12 hours of analysis time	RRF for chlorobenzene and 1,1,2,2-tetrachloroethane ≥ 0.30; RRF for chloromethane, bromoform, and 1,1-dichloroethane ≥ 0.10; All other target compounds RRF ≥ 0.30	Prepare fresh standard and re-analyze to rule out standard degradation or inaccurate injection. If problem persists, perform instrument maintenance to correct the problem and repeat ICAL.	Lab	Accuracy	Lab: Apply Q qualifier DV: Qualify non-detects that do not meet minimum RRF as unusable, R. Estimate positive results that do not meet minimum RRF as J/UJ. Estimate results (J/UJ) if CCV exceeds ± 20% of expected value.
		All calibration analytes within ± 20% of expected value (when using RFs) or drift (when using least squares regression or nonlinear calibration)		Lab	Accuracy	

Table 28-2 (continued). Summary of Calibration and QC Procedures for Organic Analysis by Gas Chromatography/Mass Spectrometry (SW-846 8260 and 8270)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Method 8270 Continuing Calibration verification (CCV)	Every 12 hours of analysis time	RRF for all SVOC compounds RRF ≥ 0.050. All calibration analytes within ± 20% of expected value (when using RFs) or drift (when using least squares regression or nonlinear calibration)	Prepare fresh standard and re-analyze to rule out standard degradation or inaccurate injection. If problem persists, perform instrument maintenance to correct the problem and repeat ICAL.	Lab	Accuracy	Lab: Apply Q qualifier DV: Qualify non-detects that do not meet minimum RRF as unusable, R. Estimate positive results that do not meet minimum RRF as J/UJ. Estimate results (J/UJ) if CCV exceeds ± 20% of expected value..
Internal Standards (ISs)	Every sample, spiked sample, standard, and method blank	Retention time ±30 seconds from retention time of the IS in the CCV. IS area counts within -50% to +100% of area from IS in CCV.	Inspect mass spectrometer and GC for malfunctions. If sufficient volume and hold time is available, reanalyze affected samples. If not qualify data as needed.	Lab	Accuracy	Lab: Apply Q qualifier DV: Estimate J/UJ, all results for analytes associated with a failed IS unless a matrix effect can be verified,.
Method Blank	One per analytical batch	No analytes detected ≥ 0.5xLOQ	Correct problem then reanalyze; if still out, and sufficient sample volume and holding time remain, re-extract and reanalyze the batch. Otherwise, narrate No action needed if sample results are nondetect	Lab	Representativeness	Lab: Apply B to all results for the specific analyte(s) in all samples in the associated analytical batch. DV: Apply “5x/10x” rule. Qualify as non-detect U if analyte is < “5x/10x” the level of contamination.

Table 28-2 (continued). Summary of Calibration and QC Procedures for Organic Analysis by Gas Chromatography/Mass Spectrometry (SW-846 8260 and 8270)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
LCS for all analytes	One LCS per analytical batch	QC acceptance criteria, Worksheet #15	Correct problem then reanalyze; if still out, and sufficient sample volume and holding time remain, re-extract/reextract and reanalyze the batch. Otherwise, narrate. No action needed if LCS/LCSD recoveries high and sample results are nondetect	Lab	Accuracy and Precision	Lab: Apply Q qualifier DV: For specific analyte(s) in all samples in the associated analytical batch: if the LCS %R > UCL, apply J to all positive results; if the LCS %R < LCL, apply J to all positive results, apply UJ to all non-detects; if the LCS %R < 30% and < LCL, apply J to all positive results, apply R to all non-detects.
Matrix spike/Matrix spike duplicate (MS/MSD)	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria, Worksheet #15	Re-prep and re-analyze if sufficient sample volume is available	Lab	Accuracy and Precision	Lab: Apply Q qualifier DV: For the specific analyte(s) result in the parent sample that are < "4x" MS spike concentration, apply J if: (1) %R for MS or MSD > UCL or (2) J/UJ if %R for MS or MSD < LCL or (3) MS/MSD RPD > CL.
Surrogate spike	Every sample, spiked sample, standard, and method blank	QC acceptance criteria, Worksheet #15	Reanalyze extract or sample. If still out, reanalyze, reprepare/ reanalyze if sufficient volume and hold time remain. Otherwise qualify data as needed.	Lab	Accuracy	Lab: Apply Q qualifier DV: For the samples: if the %R > upper control limit (UCL) for the surrogate apply J to all positive results; if the %R < lower control limit (LCL) for the surrogate, apply J to all positive results, apply UJ to all non-detects; if the surrogate recovery is < 10%, apply J to all positive results, apply R to all non-detects

Table 28-2 (continued). Summary of Calibration and QC Procedures for Organic Analysis by Gas Chromatography/Mass Spectrometry (SW-846 8260 and 8270)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Manual integration	N/A	N/A	Both before and after chromatograms will be submitted as a portion of the raw data package	Lab	Accuracy	Lab: The data will be qualified with an "M" on the raw data report. Manual integration will be discussed in the case narrative
Results reported between DL and LOQ	None	None	None	Lab	Representativeness, Accuracy	Lab: Apply J to all results between DL and LOQ DV: Apply J to all results between DL and LOQ

Table 28-3. Summary of Calibration and QC Procedures for Metals Analysis by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectrophotometry (SW-846 6010 and 7000 Series)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Equipment Blanks	TBD	No analytes detected ≥ LOQ	Qualify samples, identify source(s)	TBD	Representativeness	DV: Apply "5x/10x" rule. Qualify as non-detect U if analyte is < "5x/10x" the level of contamination.
Field Duplicate	1 every 20 samples	RPD ≤ 50% Soil	Identify source of error and correct as needed	Field samplers	Field precision	DV: Apply J to the specific analyte(s) in the parent sample and its associated field duplicate sample.
Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample	Once per analyst	QC acceptance criteria, WS #15	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria	Lab	Accuracy and Precision	N/A
LOD determination	See DoD QSM Version V4.2; Box D-13					
LOQ determination	See DoD QSM Version V4.2; Box D-14					
Method 6010: Instrument Detection Limit Study (IDL)	Every 6 months	Within ±10% of true value	N/A	N/A	Accuracy	N/A

Table 28-3 (continued). Summary of Calibration and QC Procedures for Metals Analysis by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectrophotometry (SW-846 6010 and 7000 Series)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Initial calibration for all analytes ICP: (minimum one high standard and a calibration blank GFAA: Minimum three standards and a calibration blank CVAA: Minimum five standards and a calibration blank	Daily initial calibration prior to sample analysis	If more than one standard is used, correlation coefficient must be ≥ 0.995.	If applicable, correct problem and repeat initial calibration.	Lab	Accuracy	Lab: No samples shall be analyzed until the ICAL meets QC criteria. DV: Apply R to all results for specific analyte(s) for all samples associated with the failing initial calibration.
Initial calibration verification (second source)	Daily after initial calibration	All analytes within ± 10% of expected value.	Correct problem then repeat initial calibration.	Lab	Accuracy	Lab: Apply Q qualifier. DV: if % Difference is > UCL; apply J to all results greater than the DL. If % Difference is <LCL; apply J to all results greater than the DL and UJ to all results not detected above the DL for specific analyte(s) for all samples associated with the ICV.

Table 28-3 (continued). Summary of Calibration and QC Procedures for Metals Analysis by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectrophotometry (SW-846 6010 and 7000 Series)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Continuing calibration verification	After every 10 field samples and at the end of the analysis sequence.	ICP: within ± 10% of true value GFAA and CVAA: within ± 20% of true value	Prepare fresh CCV and re-analyze to rule out standard degradation or inaccurate injection. If problem persists perform instrument maintenance/correct problem and repeat ICAL.	Lab	Accuracy	Lab: Apply Q qualifier. DV: if % Difference is > UCL; apply J to all results greater than the DL. If % Difference is <LCL; apply J to all results greater than the DL and UJ to all results not detected above the DL for specific analyte(s) for all samples associated with the CCV.
ICP only: Low level calibration check standard (at or below RL)	Once per analytical batch prior to sample analysis unless multi-point (3+) calibration with low standard at or below RL is performed	All analyte(s) with ± 20% of expected value	Correct problem then reanalyze.	Lab	Accuracy	DV: If check is > UCL, no action is necessary. If check is < LCL, Qualify non-detects as R, qualify positive results as J for all samples associated with the calibration.
Method Blank	One per analytical batch	No analytes detected ≥ 0.5xLOQ	Correct problem then reanalyze; if still out, and sufficient sample volume and holding time remain, re-extract and reanalyze the batch. Otherwise, narrate No action needed if sample results are nondetect.	Lab	Representativeness	Lab: Apply B to all results for the specific analyte(s) in all samples in the associated analytical batch. DV: Apply "5x/10x" rule. Qualify as non-detect U if analyte is < "5x/10x" the level of contamination.

Table 28-3 (continued). Summary of Calibration and QC Procedures for Metals Analysis by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectrophotometry (SW-846 6010 and 7000 Series)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Calibration blank	Following the ICV or CCVs, prior to QC or sample analysis	No analytes detected ≥ LOD	Correct problem then analyze ICB or CB and associated samples unless sample results are nondetect.	Lab	Representativeness	Lab: Apply B to all results for the specific analyte(s) in all samples in the associated analytical batch. DV: Apply "5x/10x" rule. Qualify as non-detect U if analyte is < "5x/10x" the level of contamination.
ICP only: Interference check solutions (ICS)	At the beginning of an analytical run	ICS-A: All non-spiked analytes < LOD unless they are a verified trace impurity from one of the spiked analytes ICS-AB: Within ± 20% of true value	Terminate analysis; correct problem; reanalyze ICS; reanalyze all affected samples.	Lab	Accuracy	Lab: Apply Q qualifier. DV: Apply J/UJ to all results for specific analyte(s) in all samples associated with the ICS
LCS	One LCS per analytical batch	QC acceptance criteria, WS #15	Correct problem then reanalyze; if still out, and sufficient sample volume and holding time remain, re-extract and reanalyze the batch. Otherwise, narrate. No action needed if LCS/LCSD recoveries high and sample results are nondetect.	Lab	Accuracy and Precision	Lab: Apply Q qualifier. DV: For specific analyte(s) in all samples in the associated analytical batch: if the LCS %R > UCL, apply J to all positive results; if the LCS %R < LCL, apply J to all positive results, apply UJ to all non-detects; if the LCS %R < 30% and < LCL, apply J to all positive results, apply R to all non-detects.

Table 28-3 (continued). Summary of Calibration and QC Procedures for Metals Analysis by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectrophotometry (SW-846 6010 and 7000 Series)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
MS/MSD	One MS/MSD per every 20 project samples per matrix	QC acceptance criteria, WS #15	Perform a post digestion spike (PDS) whenever an MS does not meet acceptance limits.	Lab	Accuracy and Precision	Lab: Apply Q qualifier. DV: For the specific analyte(s) result in the parent sample that are < "4x" MS spike concentration, apply J if: (1) %R for MS or MSD > UCL or (2) J/UJ if %R for MS or MSD < LCL or (3) MS/MSD RPD > CL.
ICP and GFAA only: Serial Dilution test	Each new sample matrix, at least once per analytical batch (only applicable for analytes with concentrations ≤ 50X LOD)	Fivefold (1+4) dilution must agree within ± 10% of the original determination.	ICP: Perform post digestion spike addition. GFAA: Perform recovery test.	Lab	Accuracy	Lab: Apply Q qualifier. DV: Apply J to sample result for specific analyte(s) from the parent sample if either of the following exist: (1) dilution test not run and batch had analyte concentrations ≥50X MDL; (2) %Difference (%D) ≥ 10 and post digestion spike not performed
ICP only: Post digestion spike addition	When dilution test fails or if an analyte's concentration for all samples in a batch is less than 50X LOD	Recovery within 75-125% of expected results.	Check for instrumental problem then reanalyze post digestion spike addition if appropriate.	Lab	Accuracy	Lab: Apply Q qualifier. DV: Apply J to sample result for specific analyte(s) from the parent sample associated with the post digestion spike addition if recovery is >125% or < 75% but >10%. If post digestion spike addition recovery is < 10%, apply R to sample result for specific analyte(s) from the parent sample associated with the post digestion spike addition.

Table 28-3 (continued). Summary of Calibration and QC Procedures for Metals Analysis by Inductively Coupled Plasma Atomic Emission Spectroscopy and Atomic Absorption Spectrophotometry (SW-846 6010 and 7000 Series)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
GFAA only: Recovery Test	When dilution test fails or if an analyte's concentration for all samples in a batch is less than 25X LOD	Recovery within 85-115% of expected results.	Check for instrumental problem then reanalyze post digestion spike addition if appropriate.	Lab	Accuracy	Lab: Apply Q qualifier. DV: Apply J to sample result for specific analyte(s) from the parent sample associated with the post digestion spike addition if recovery is >115% or < 85% but >10%. If post digestion spike addition recovery is < 10%, apply R to sample result for specific analyte(s) from the parent sample associated with the post digestion spike addition.
Method of Standard Additions (MSA)	When matrix interference is confirmed.	N/A	N/A	Lab	Accuracy	N/A
Results reported between DL and LOQ	None	None	None	Lab	Representativeness, Accuracy	Lab: Apply J to all results between DL and LOQ. DV: Apply J to all results between DL and LOQ.

Table 28.4. Summary of Calibration and QC Procedures for Analysis of Reactivity, Corrosivity and Ignitability (Chapter 7, SW-846 9045, and 1030)

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Reactive Sulfide by Chapter 7						
Method Blank	One per analytical batch	No analytes detected ≥ LOQ	Correct problem if sufficient sample volume and holding time remain, re-extract and reanalyze the batch. Otherwise, narrate No action needed if sample results are nondetect	Lab	Representativeness	Lab: Apply B to all results for the specific analyte(s) in all samples in the associated analytical batch.
Laboratory Duplicate	Once per every 20 samples	%RPD ≤25%	NA	NA	Representativeness	Lab: Apply Q qualifier
Reactive Cyanide by Chapter 7						
Six-point initial calibration	Initial calibration prior to sample analysis.	Linear - RSD ≤ 20% Linear – least squares regression r ≥ 0.995 Nonlinear – correlation coefficient ≥ 0.990 (6 points will be used for second order, 7 points will be used for third order)	Correct problem then repeat initial calibration.	Lab	Accuracy	Lab: Apply Q qualifier to all results for all samples associated with the calibration.
Continuing calibration verification (CCV)	Initially, prior to sample or QC analysis, every 10 samples and at the end of the sequence.	%D ± 15% of expected value.	Prepare fresh ICV and re-analyze to rule out standard degradation or inaccurate injection. If problem persists perform instrument maintenance/correct problem and repeat ICAL.	Lab	Accuracy	Lab: Apply Q qualifier.
Method Blank	One per analytical batch	No analytes detected ≥ LOQ	Correct problem if sufficient sample volume and holding time remain, re-extract and reanalyze the batch. Otherwise, narrate No action needed if sample results are nondetect	Lab	Representativeness	Lab: Apply B to all results for the specific analyte(s) in all samples in the associated analytical batch.
Laboratory Duplicate	Once per every 20 samples	%RPD ≤25%	NA	NA	Representativeness	Lab: Apply Q qualifier

Table 28.4 (Continued). Summary of Calibration and QC Procedures for Analysis of Corrosivity and Ignitability (Chapter 7, SW9045, and 1020)

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Corrosivity (pH) by Method SW9045 (soil)						
Calibration 3-point calibration with pH buffers: 4, 7, 10	Daily, prior to sample analysis	Slope – 90-105%	If calibration is not achieved, check meter, buffer solutions, and probe; replace if necessary; repeat calibration	Lab	Accuracy	Lab: No analysis shall be performed without a valid ICAL.
Initial calibration verification (ICV) Buffer pH 7	Immediately following ICAL	± 0.05 pH units	If calibration is not verified, check meter, probe, buffer solutions; replace if necessary; repeat ICAL	Lab	Accuracy	Lab: No analysis shall be performed without a valid ICV.
Laboratory Duplicate	Once per 20 samples	%RPD ≤ 25%	NA	NA	Representativeness	Lab: Apply Q qualifier
Ignitability by Method 1030 (soil)						
ICAL	Defer to test kit manufacturers specifications		Correct problem, and reanalyze ICAL.	Lab	Accuracy and Precision	Lab: No analysis shall be performed without a valid ICAL.
CCV	Daily, prior to sample analysis	EPA 1010: p-Xylene Flashpoint at 27±2°C EPA 1030: Not Applicable	Correct problem, and reanalyze CCV. No samples may be analyzed until the CCV meets criteria	Lab	Accuracy	Lab: Apply Q qualifier
Laboratory Duplicate	Once per every 20 samples	%RPD ≤10%	NA	NA	Representativeness	Lab: Apply Q qualifier

Table 28-5. Summary of Calibration and QC Procedures for Analysis of Moisture (Method SM 2540-B)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Field Duplicate	1 every 20 samples	Relative percent difference RPD≤50% for soil	Identify source of error and correct as needed	Field samplers	Field precision	DV: Apply J to the result in the parent sample and its associated field duplicate sample.
Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of an LCS.	Prior to using any test method and at any time there is significant change in instrument type, personnel, test method, or sample matrix	QC acceptance criteria, Worksheet #15	Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria	Lab	Accuracy and Precision	N/A
Calibration Verification Analytical Balance	Daily prior to use	The quality of the weights used for this calibration verification, class "S" or "2" shall be documented. Balance calibration verifications shall be documented in appropriate logbooks.	Correct Problem	Lab	Accuracy	Lab: Apply Q qualifier DV: Apply R to all results for specific analyte for all samples associated with the calibration
Method Blank	One per analytical batch	No analytes detected ≥ 0.5XLOQ	Correct problem if sufficient sample volume and holding time remain, re-extract and reanalyze the batch. Otherwise, narrate No action needed if sample results are nondetect	Lab	Representativeness	Lab: Apply B to all results for the specific analyte(s) in all samples in the associated analytical batch. DV: Apply "5x/10x" rule. Qualify as non-detect U if analyte is < "5x/10x" the level of contamination.

Table 28-5 (continued). Summary of Calibration and QC Procedures for Analysis of Moisture (Method SM 2540-B)

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria for Data Validation (DV)
Laboratory control sample (LCS) for the analyte	One LCS per analytical batch	QC acceptance criteria, Worksheet #15	Correct problem, if sufficient sample volume and holding time remain, re-extract and reanalyze the batch. Otherwise, narrate. No action needed if LCS/LCSD recoveries high and sample results are nondetect	Lab	Accuracy and Precision	Lab: Apply Q qualifier DV: If the LCS %R > UCL, apply J to all positive results; if the LCS %R < LCL, apply J to all positive results, apply UJ to all non-detects; if the LCS %R < 30% and < LCL, apply J to all positive results, apply R to all non-detects.
Laboratory Duplicate	Once per 20 samples	Moisture %RPD≤ 10%	NA	NA	Precision Representativeness	Lab: Apply Q qualifier DV: Apply J to the pH result in the parent sample.
Results reported between DL and LOQ	None	None	None	Lab	Representativeness and Accuracy	Lab: Apply J to all results between DL and LOQ DV: Apply J to all results between DL and LOQ

UFP-QAPP Worksheet #29 – Project Documents and Records Table
Former George Air Force Base, California

Sample Collection Documents and Records	On-site Analysis Documents and Records	Off-site Analysis Documents and Records	Data Assessment Documents and Records	Other	Health and Safety
Field Activity Log	Field Activity Log	CB&I COC / RFA	Organic Data Review Checklist – Organochlorinated Pesticide, Chlorinated Herbicides, VOCs, SVOCs	ERPIMS Submittal	Project Environmental, Safety &Health Plan and Sign-off Sheet
Sample Collection Log	Sample Collection Log	Laboratory SDG Report	Inorganic Data Review Checklist – Metals		Daily Tailgate Safety Meeting
CB&I COC /Request for Analyses COC/RFA	Equipment Calibration Receipt	EIMS Electronic Data Deliverable	QCSR		Daily Activity Hazard Analysis
	Equipment Calibration Logs	Data Validation Reports			Equipment Calibration Receipt
	Visual Classification – Rock	Final Data Packages and Final Analytical Report			Equipment Calibration Logs
	Visual Classification – Soil				Health and Safety Activity Reports and Documentation
	Photo – Documentation and Tracking Log				Training Records
	Well Construction Log				Accident Reports
	Well Development Log				Lessons Learned

Notes:
Refer to CB&I SOPs EIG-RM-001, *Records Management Procedure;* and EIP-RM-002, *Using ShawRecords to Manage Project Records*, in Attachment B for guidance regarding adequate generation and proper handling of project records to ensure their completeness, protection, and ability to be retrieved.

UFP-QAPP Worksheet #30 – Analytical Services Table
Former George Air Force Base, California

Information regarding analytical services will be defined in each task-specific work plan. Analytical services information will be provided in tabular format as referenced below:

Matrix	Analytical Group	Concentration Level	Sample Locations / ID Numbers	Laboratory Analytical SOP	Data Package Turnaround Time	Laboratory/Organization (Name and Address, Contact Person and Telephone Number)	Backup Laboratory/Organization (Name and Address, Contact Person and Telephone Number)
Soil	• Organochlorinated Pestides • Chlorinated Herbicides • VOCs • SVOCs • Metals • RCI Parameters	High Levels Expected	See WS #18	See WS #23	21 Days	Eurofins Calscience, Inc. 7440 Lincoln Way Garden Grove, CA 92841 Phone: 714.895.5494 Fax: 714.894.7501 POC: Richard Villafania	Not Applicable
Soil	• Full-scale digital core photography ASTM D5079 • Grain-size analysis by laser by ASTM D4464 • TOC by Walkley-Black • Soil Properties Package (Vadose Zone) – native permeability to air, total porosity, air-filled porosity, grain and bulk density, moisture content, total pore fluid saturation by method API RP40 and ASTM D2216	Low Levels Expected	See WS #18	See WS #23	28 Days	PTS Laboratories 8100 Secura Way Santa Fe Springs, CA 90670 Phone: 562.347.2500 Fax: 562.907.3610 POC:	Not Applicable

UFP-QAPP Worksheet #31 – Planned Project Assessments Table
Former George Air Force Base, California

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment (Title and Organizational Affiliation)	Person(s) Responsible for Responding to Assessment Findings (Title and Organizational Affiliation)	Person(s) Responsible for Identifying and Implementing Corrective Actions (CA) (Title and Organizational Affiliation)	Person(s) Responsible for Monitoring Effectiveness of CA (Title and Organizational Affiliation)
Management Assessments	Quarterly	Internal	CB&I	PM, David Daftary	TBD – based on assessment findings	TBD – based on assessment findings	TBD – based on assessment findings
Laboratory Audits and Inspections	Periodic (in accordance with Laboratory QA Plan	External	Eurofins Calscience, Inc.	Laboratory QA Manager or appointee	Laboratory PM; Richard Villafania, Laboratory QA Manager or appointee	TBD – based on audit/assessment findings	TBD – based on audit/assessment findings
QCSR	Each definable feature of work	Internal	CB&I	Project Chemist; Tim Roth	N/A	N/A	N/A
Field Inspections	As required	Internal	CB&I	Technical Lead; On-Site QA, Task Lead, or appointee	CB&I QA/QC Manager; Stephen Massey	TBD – based on assessment findings	TBD – based on assessment findings
Preparatory Inspections	Task kick-off	Internal	CB&I	Technical Lead; Stephen Massey, On-Site QA, Task Lead, or appointee	TBD – based on assessment findings	TBD – based on assessment findings	TBD – based on assessment findings
Follow-up Inspections	Task as required	Internal	CB&I	Technical Lead; Stephen Massey, On-Site QA, Task Lead, or appointee	TBD – based on assessment findings	TBD – based on assessment findings	TBD – based on assessment findings
Final Inspections	Task as required	Internal	CB&I	Technical Lead; Stephen Massey, On-Site QA, Task Lead, or appointee	TBD – based on assessment findings	TBD – based on assessment findings	TBD – based on assessment findings

Notes:
Table 31-1 provides guidance on assessments and inspections.

Table 31-1. Assessment and Audit Frequency

Assessment and Audit Frequency
Technical inspections and assessments should be conducted during initial stages of fieldwork to identify and correct problems as quickly as possible. Independent assessments will be performed at least annually. If required by the CB&I project chemist, an on-site laboratory audit will be performed for each laboratory selected for use to support project objectives and will be scheduled prior to start-up of field activities. The laboratory audit will include all sample analysis procedures that will be performed by the laboratory being audited. The CB&I QA Manager or CB&I PM may conduct audits at a greater frequency than indicated in WS #31.
Management Assessments Management assessments may be used to review sample collection, handling, analysis, and documentation procedures. Assessment results are used to evaluate a system's ability to produce data that fulfill program objectives and to identify any areas requiring corrective action. Inspections are routine qualitative reviews of the overall sampling or measurement system, or may have a narrow focus such as a follow-up inspection while assessments provide an overall examination of the measurement system. Assessment and inspection records are reviewed by the CB&I QA Manager or designated staff to determine whether data will fulfill the program objectives. Additional inspections or reviews for designated methods may be conducted, or additional information requested if data quality problems are indicated. Management assessments may be conducted on a routine basis by the CB&I Site Operations Manager, CB&I PM, or their designees. Management assessments are informal reviews of work progress, functionality, adherence to policies and procedures, compliance with requirements, or effectiveness of implementation and provide the basis for follow-up inspections or independent assessments whenever deficiencies are indicated. All observations are documented and any recommendations or corrective actions are submitted to the CB&I QA/QC manager for tracking, implementation, additional review if required, and completion.
Final Inspections The field inspections are on-site, qualitative reviews of a sampling or analysis system. Inspections are conducted, preferably at the beginning of the sampling task, by the CB&I QA/QC Manager, field lead, or a designated qualified technical staff member who has the authority to act independently of the project staff. Critical items for a field inspections include: • Calibration procedures and documentation for field instruments • Documentation in field logbooks and on sampling data sheets • Document control • Equipment decontamination procedures • Sample collection, storage, and transportation procedures • COC procedures for sample documentation and for transfer to a laboratory • Work instructions. The checklist for each inspection will contain detailed questions regarding the critical items requiring yes/no answers and comments. A debriefing session will be held for all participants to discuss any inspection results and to discuss any required corrective action. The reviewer then completes the inspection and submits a report, including observations of strengths and deficiencies and any recommendations for improvements.

Table 31-1 (continued). Assessment and Audit Frequency

Inspections for Field Activities Inspections shall be performed upon materials or services to determine compliance with contractual, planning, and other requirements. Inspection criteria shall be established prior to the inspection and shall be based upon project specifications, requirements, code specifications and product acceptability and shall be conducted in accordance with Procedure EI-Q-005, *Inspection*. Acceptance criteria shall be adequate for the activity and shall be verified during inspection activities Inspection may be performed and verified through visual observation, measurement of materials or equipment, examination of documentation/certification, evaluation of performance, or testing. EI-Q-005, *Inspection,* and a usable form are presented in Attachment B to the QAPP. Inspections may be performed using the three-phase inspection method. The preparatory inspections will be performed prior to startup and will examine training, procedures, equipment and materials, work plans and documents, and overall readiness to perform work. Initial inspections are performed when work begins on a particular feature of work and include an examination of the quality of workmanship and a review of control testing for compliance with contract and work plan requirements. Follow-up inspections will be performed to verify compliance with procedures. Follow-up inspections will ensure a continuation of quality and safety standards established during preparatory and initial inspections until completion of the definable work feature. Final follow-up inspections will be conducted at the completion of each task. Participants in this inspection may include QA (AFCEC) and QC (CB&I). The final follow-up inspection will be performed to ensure that the completed feature of work meets contract requirements. Any deficiencies noted during this inspection will be documented and a determination will be made as to the corrective actions necessary to mitigate the deficiency. All significant deficiencies must be corrected prior to turnover. Records of inspections will be maintained in the project files. At a minimum, inspection files will include inspection reports/checklists, inspection responses, any supporting documents as well as applicable client comments.
Performance and System Audits Scheduled project/laboratory audits will be performed, as project activities allow, to review and evaluate the adequacy of field activities and laboratory performance, and to ascertain if the QAPP is being completely and uniformly implemented. The CB&I project chemist is responsible for requesting and establishing an audit team. Annual audits may be supplemented by additional audits for one or more of the following reasons: • When significant changes are made in field or laboratory protocols • When it is necessary to verify that corrective action has been taken on a nonconformance reported in a previous audit • When requested by the CB&I PM. The objectives of performance and systems audits are to verify that the QAPP developed for this project is being implemented according to the specified requirements, to assess the effectiveness of the plan, to identify nonconformances, and to verify that identified deficiencies are corrected. Upon discovery of any significant deviation from the QAPP, the CB&I project chemist and CB&I QA/QC officer shall be informed of the nature and extent, and a nonconformance documented and corrective action taken to remedy the deviation.
Assessment Findings and Corrective Action All observations and assessment findings are documented, and the checklist is submitted with a written assessment and recommendations including any required or recommended corrective action to the CB&I QA/QC Manager, CB&I PM, AFCEC COR, representatives of the audited organization, and others as appropriate. The information and any corrective action documentation also will be summarized and included in program reports.

UFP-QAPP Worksheet #32 – Assessment Findings and Corrective Action Responses
Former George Air Force Base, California

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (Name, Title, Organization)	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response (Name, Title, Org.)	Timeframe for Response
Management Assessments	Nonconformance Report (NCR) [1, 2]	Executive Sponsor, Patrick McGinnis; CB&I QA/QC Manager, Stephen Massey	30 Days	As required by NCR	TBD – based on nature of corrective action or severity of deviation	As required
QCSR	QCSR	AFCEC; CB&I Chemist, Tim Roth; Data Users	N/A	N/A	N/A	N/A
Preparatory Inspections	NCR	CB&I PM, David Daftary; CB&I QA/QC Manager, Stephen Massey; Technical Lead, Mark Unruh	As required	As required by NCR	TBD – based on nature of corrective action or severity of deviation	As required
Follow-up Inspections	NCR	CB&I PM, David Daftary; CB&I QA/QC Manager, Stephen Massey; Technical Lead, Mark Unruh	As required	As required by NCR	TBD – based on nature of corrective action or severity of deviation	As required
Final Inspections	NCR	CB&I PM, David Daftary; CB&I QA/QC Manager, Stephen Massey; Technical Lead, Mark Unruh	As required	As required by NCR	TBD – based on nature of corrective action or severity of deviation	As required

Table 32-1 provides guidance on nonconformance and variance documentation.

Notes:

1 Copies of all NCRs need to be directed to the PM.

2 Procedure CMS-720-01-PR-00150, "Identification, Control, and Disposition of Nonconforming Products," establishes the system for initiating, processing, and controlling nonconforming items, services, or activities to include disposition and corrective actions. A copy of the procedure is included in Attachment B of the QAPP with a usable form (CMS-720-01-FM-00170).

Table 32-1. Nonconformance and Variance Documentation Guidance

Nonconformance Documentation

Complex field investigation, remediation, sampling, and analysis tasks, such as those performed routinely as part of the former GAFB project, are sometimes subject to nonconformances. A nonconformance is defined as an unplanned deviation that occurs during the implementation of a task that cannot usually be corrected until after it has occurred. Nonconformance activities may include using unapproved methods, not following procedures specified in the QAPP or task work plan, or substituting unapproved materials or equipment to perform an activity. Nonconforming supplies may also include suspect and counterfeit items. All nonconformance activities and/or material must go through a cycle of being identified, documented, assessed, corrected, and reported in accordance with CB&I Procedure (CMS-720-01-PR-00150), *Identification, Control, and Disposition of Nonconforming Products*. Each of these steps described in Procedure CMS-720-01-PR-00150 are critical in handling nonconformances as they are encountered. CMS-720-01-PR-00150, *Identification, Control, and Disposition of Nonconforming Products,* is presented with a usable form (CMS-720-01-FM-00170) in Attachment B of the QAPP.

The identification of a nonconformance is the responsibility of every person assigned to support the former GAFB project. This responsibility is incorporated into each person's understanding of the tasks assigned to them by their supervisor or task leader and their function on the project. As individuals perform their duties on the project, they must constantly be aware of the scope of the activity and recognize when a deviation from the planned activity has occurred or is occurring. After recognizing the deviation, they must take action by informing their PM and documenting in writing the specifics of what occurred using the CB&I NCR form. The site QC Officer shall maintain a status log of open and closed nonconformances. The log will also serve as the basis for numbering each discrepancy and tracking it through closure. If the nonconforming activity, service, or material is severe, it may require all activities cease and Procedure CMS-710-05-PR-00400, *Stop Work Authority,* be implemented. CMS-710-05-PR-00400 can be found in Attachment B.

Satisfactory resolution of nonconformances must be verified by the site CB&I QA/QC Officer. Nonconformances are not to be closed until the required corrective and preventative actions have been completed to the satisfaction of the site QC Officer, or long-term corrective actions have been established and implemented. Nonconformances will be monitored until the action is verified as complete and closed as documented on the NCR.

Nonconformances and associated documentation will be documented in the project file and will be referenced and discussed in the final task report.

Variance Documentation

Variances are similar to nonconformances with respect to how they are defined, resolved, and documented. The primary difference is the timing of when the deviation occurs. A variance can be identified prior to implementation of a task, whereas a nonconformance is generally not identified until the task is in progress or complete. Therefore, with a variance, alternative techniques, modified methods, or a change in task and DQOs can be considered. Substitute data, alternate success criteria, or even the deletion of data points may be contemplated after gathering information about why the deviation is necessary and examining what was the intended use of the data as planned. Project variances will be subject to the same step-wise process of identification, documentation, assessment, correction, and reporting as nonconformances.

An example project variance form is included in Attachment B of the QAPP. This form has been designed to ensure key information is recorded by the personnel who identify variances, review the documentation, assess the impact on task objectives, and consider alternative strategies for corrective action.

Variances will be documented in the project file and will be referenced and discussed in the final task report.

UFP-QAPP Worksheet #33 – QA Management Reports Table
Former George Air Force Base, California

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (Title and Organizational Affiliation)	Report Recipient(s) (Title and Organizational Affiliation)
Daily Field Log	Daily	Monthly	CB&I Project Site Manager	CB&I QA Officer, CB&I Task Lead, CB&I PM
Monthly Status Report	Monthly	Monthly	CB&I PM	AFCEC COR
Inspection Checklist	As needed	As needed	CB&I Project Site Manager	CB&I QA Officer, CB&I Task Lead, CB&I PM
NCR	As needed	As needed	CB&I Project Site Manager	CB&I Executive Sponsor; CB&I QA Officer; CB&I PM; CB&I Task Lead; AFCEC COR

UFP-QAPP Worksheet #34 – Verification (Step I) Process Table
Former George Air Force Base, California

Verification Input	Description	Internal/ External	Responsible for Verification (Name, Organization)
COC and Shipping Forms	COC forms and shipping documentation will be reviewed by the laboratory upon receipt of samples for verification against the sample coolers they represent. The COC form will be signed by all parties that had custody of samples, with the exception of commercial carriers.	External	Eurofins Calscience, Inc. PM or Designee
Field Records	All field records, including COC/RFA, field activity logs, and sample collection logs, will be verified for completeness.	Internal	Mark Unruh, CB&I Technical Lead or Designee
Laboratory Data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal.	External	Eurofins Calscience, Inc. PM or Designee
Laboratory Data	All laboratory data packages will be verified for content upon receipt.	Internal	Tim Roth, CB&I Project Chemist
Data Input/Verification	Verified information will be inserted into the EIMS database. A hard copy record will be printed from database records and verified against original information.	Internal	Tim Roth, CB&I Project Chemist
Data Input/Verification	EDDs will be loaded into EIMS database and are self-verifying based on input information.	Internal	Kurt Schmidt, CB&I Data Manager
Data Qualifiers and Use Codes	Following entry of data validation qualifiers and Use Codes, a hard copy validation QC table is printed and verified against the original data validation checklists.	External	Don Dill, CB&I Data Validator
Data Completeness Summary	Reviews data validation information and determines number of valid data.	External	Tim Roth, CB&I Project Chemist

UFP-QAPP Worksheet #34 – Verification (Step I) Process Table (continued)
Former George Air Force Base, California

Table 34-1. Data Reduction and Review of Field Activities

Data Reduction and Review of Field Activities:

Data collected during the field activities will be reviewed by checking the procedures used and comparing the data to previous measurements. The CB&I field coordinator or sampling coordinator will be responsible for checking all field samples to verify that sample collection and field measurement protocols have been observed. These checks will include:

- Use of SOPs
- Calibration method and frequency
- QC bottle lot number
- Date/time sampled
- Preservation
- Samplers
- Laboratory
- COC number
- Date shipped
- Airbill number.

UFP-QAPP Worksheet #35 – Validation (Steps IIa and IIb) Process Table
Former George Air Force Base, California

Step IIa/IIb	Validation Input	Description	Responsible for Validation (Name, Organization)
IIa	Compliance Review	Review all laboratory information against Request for Analysis and determine if all samples were preserved, received, and analyzed within project specifications. Determine if SDG is complete.	Tim Roth, CB&I Project Chemist or designee
IIb	Organics Level 1 Data Validation (DV)	Perform first-level DV review. Complete DV checklist based on EPA NFG for Superfund Organic Methods Data Review (EPA 540-R-014-002), and project requirements.	Level 1, CB&I Data Validator
IIb	Inorganics Level 1 DV	Perform first-level DV review. Complete checklist based on EPA NFG for Inorganic Superfund Data Review (EPA 540-R-013-001), and project requirements.	Level 1, CB&I Data Validator
IIb	Organics Level 2 Data Review	Perform second-level DV review.	Level 2, CB&I Data Validator
IIb	Inorganics Level 2 Data Review	Perform second-level DV review.	Level 2, CB&I Data Validator
IIb	QCSR	Review data validation results and provide concurrence, determine data usability, and summarize data quality issues.	Tim Roth, CB&I Project Chemist

Note:
The DV Group in CB&I acts as a separate unit. The validators are not responsible for fieldwork or associated with the technical team working on the former GAFB project.

UFP-QAPP Worksheet #36 –Validation (Steps IIa and IIb) Summary Table
Former George Air Force Base, California

Step IIa/IIb	Matrix	Analytical Group	Concentration Level	Validation Criteria	Data Validator (title and organizational affiliation)
IIa	TCLP Soil	•TCLP Organochlorinated Pesticides by SW1311 8081 •TCLP Chlorinated Hercides by SW1311 8151 •TCLP VOCs by SW1311 8260 •TCLP SVOCs by SW1311 8270 •TCLP Metals by SW1311 6010/7470 •RCI Parameters by EPA Chapter 7, SW846 9045, and EPA 1010	Low	• Review all laboratory information against Request for Analysis and determine if all samples were preserved, received, and analyzed within project specifications. Determine if SDG is complete. • IDW Data will not be validated.	Tim Roth, CB&I Project Chemist or designee
IIa	Waste Water	•Organochlorinated Pesticides by SW-846 8081	Low	• Review all laboratory information against Request for Analysis and determine if all samples were preserved, received, and analyzed within project specifications. Determine if SDG is complete. • IDW Data will not be validated.	Tim Roth, CB&I Project Chemist or designee
IIa & IIb	Soil	•Organochlorinated Pesticides by SW-846 8081	High	• EPA NFG for Superfund Organic Methods Data Review (August 2014) • DoD QSM 4.2 (October 2010) • SW-846 Method 8081 • Laboratory SOP	DV Group, CB&I
IIa	Soil	•Full-scale digital core photography ASTM D5079 •Grain-size analysis by laser by ASTM D4464 • TOC by Walkley-Black • Soil Properties Package (Vadose Zone) – native permeability to air, total porosity, air-filled porosity, grain and bulk density, moisture content, total pore fluid saturation by method API RP40 and ASTM D2216	Low	• Review all laboratory information against Request for Analysis and determine if all samples were preserved, received, and analyzed within project specifications. Determine if SDG is complete. • Geotechnical Data will not be validated.	Tim Roth, CB&I Project Chemist or designee

UFP-QAPP Worksheet #36 –Validation (Steps IIa and IIb) Summary Table
Former George Air Force Base, California

Note:
The DV Group in CB&I acts as a separate unit. The validators are not responsible for fieldwork or associated with the technical team working on the former GAFB project.

The following data qualifiers and data validation reason codes will be applied during data validation. Potential impacts on project-specific data quality objectives will be discussed in the data usability assessment.

Table 36-1. Data Validation Qualifier Descriptions

Data Validation Qualifier [1]	Data Validation Qualifier Description
U	The analyte was not detected at or above the indicated detection limit.
UJ	The analyte was not detected or was classified as a non-detection. The reporting limit is estimated due to failure of one or more quality control criteria.
J	The result was less than the quantitation limit and is an estimate and / or the result has been classified as an estimated concentration due to one or more quality issues.
R	The result has been classified as unusable due to one or more quality issues.

[1] When multiple qualifiers are assigned to a sample result, the 'R' qualifier if assigned takes precedence over the 'J' qualifier, "UJ" qualifier and/or the 'U' qualifier during validation.

UFP-QAPP Worksheet #36 –Validation (Steps IIa and IIb) Summary Table
Former George Air Force Base, California

Table 36-2. Data Validation Reason Code Definitions

Data Validation Reason Code	Data Validation Reason Code Definition
01	Sample received outside of 4+/-2 degrees Celsius
01A	Improper sample preservation
02	Holding Time Exceeded
02A	Extraction
02B	Analysis
03	Instrument Performance - Outside Criteria
03A	BFB
03B	DFTPP
03C	DDT and/or Endrin % breakdown exceeds criteria
03D	retention time windows
03E	Resolution
04	Initial Calibration results outside specified criteria
04A	Compound mean RRF<0.05
04B	Compound %RSD>20
04C	Correlation Coefficient<0.995
05	Continuing Calibration results outside specified criteria
05A	Compound mean RRF<0.05
05B	Compound %D>20
06	Result qualified as a result of the 5x/10x blank correction
06A	Method or Preparation Blank
06B	ICB or CCB
06C	ER
06D	TB
06E	FB
07	Surrogate Recoveries outside control limits
07A	Sample
07B	Associated method blank or LCS
08	MS/MSD/Duplicate results outside criteria
08A	MS and/or MSD recovery not within control limits (accuracy)
08B	%RPD outside acceptance criteria (precision)
09	Post Digestion Spike outside criteria (GFAA)
10	Internal Standards outside specified control limits
10A	Recovery
10B	Retention Time
11	Laboratory Control Sample recoveries outside specified control limits
11A	Recovery
11B	%RPD (if run in duplicate)
12	Interference Check Standard
13	Serial Dilution
14	Tentatively Identified Compounds
15	Quantitation
16	Multiple results available; alternate analysis preferred
17	Field duplicate RPD criteria exceeded
18	Percent difference between original and second column > 25%
19	Professional judgment was used to qualify the data
20	Pesticide clean-up checks
21	Target compound identification
24	Reported result and/or lab qualifier revised to reflect validation findings
999	See hard copy for details.

Identify the personnel responsible for performing the usability assessment:

Field data generated by the field personnel will be initially reviewed, processed, and evaluated on site by the CB&I technical lead, task manager, and/or their designee. Copies of the original forms will be maintained on site for reference and the originals will then be forwarded to the CB&I Project Chemist for further review, inclusion into the ERPIMS database, and final storage in the project Central Files.

The CB&I Project Chemist will perform the usability assessment on analytical data. Guidance for usability is also provided in SOP FS-020.

Describe the documentation that will be generated during usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies:

A combination of checklists and/or Data Validation Summaries will be used to document data validation activities. A QCSR or similar documentation will be used to summarize DQOs for each task, qualifications placed on data, implications or constraints on data use, and an overall assessment of data completeness and usability.

Hard copy and electronic analytical data will be delivered to the data coordinator for initial review, copying, and distribution, with the original hard copy going to project Central Files. If required, data validators will receive a working hard copy to review. Electronic files will be forwarded to the database manager for checking and uploading into the EIMS database. CB&I will then issue summary reports and updates as required as final data reviews are completed. The final project deliverables will include electronic file copies of the ERPIMS batch files database for stakeholder use. The Data Usability Assessment will be performed by CB&I for data associated performance based remediation activities. The CB&I Project Chemist will (1) determine if the DQOs have been met, and (2) calculate the data completeness for the project. These results will be included in the data package deliverables for each task.

For a given investigation task, a specific list of target constituents will be formulated, and if they cannot be quantified by the methods summarized in this QAPP, they will be addressed in a task-specific plan. All applicable analyses will meet the recommended method guidance found in Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Third Edition (EPA, 1997) and its subsequent updates. All other requested analyses must conform to their specified method. These may include the Annual Book of ASTM Standards, American Society for Testing and Materials ([ASTM], 2002), Methods for Chemical Analysis of Water and Waste (EPA, 1993), and similar sources.

Part of the review to determine whether DQOs were met will be to evaluate a series of data quality indicators that include measurements of the precision, accuracy, representativeness, comparability, completeness, and sensitivity (PARCCS) parameters. How each of these measurements is to be performed and assessed is discussed in this worksheet. The target acceptance criteria for the results have been developed for a wide variety of anticipated analyses on soil/sediment, surface water, and groundwater matrix samples and are presented in the internal laboratory QC validation criteria found in Table 37-1 that follows this worksheet. Other data quality indicators may be developed as needed for other sampling media and other analysis programs and presented in their task-specific plans.

Precision

Precision refers to the reproducibility of measurements and is defined as the measurement of mutual agreement among individual measurements of the same property, usually under "prescribed similar conditions." Precision is expressed in terms of the RPD between duplicate determinations; or in terms of the relative standard deviation (RSD) when three or more determinations are made. Various measures of precision exist depending on the prescribed similar conditions.

Overall sampling and analysis precision will be assessed using RPD for duplicate environmental samples. The RPD for MS/MSD sample results will be used to assess laboratory spike recovery precision. RPD is defined as the difference between two measurements divided by their mean and expressed as a percent as shown in Equation (1).

$$\mathrm{RPD} = \left[\frac{|D_1 - D_2|}{\left(\frac{D_1 + D_2}{2} \right)} \right] \times 100 \qquad (1)$$

where:

D_1 = The result from the original determination.
D_2 = The result from a duplicate measurement.

RSD is the standard deviation of a set of values divided by the average value expressed as a percent as shown in Equation (2):

$$\text{RSD} = \left(\frac{\sigma_{n-1}}{\overline{X}(x_1 \ldots x_n)} \right) \times 100 \qquad (2)$$

where:

σ_{n-1} = The sample standard deviation of the sample data.
n = The number of determinations.
$\overline{X}(x_1 \ldots x_n)$ = The arithmetic mean of the sample data.

Accuracy

Accuracy is a measure of the bias in a system or the degree of agreement of a measurement X (or an average of measurements of the same parameter) against an accepted reference or true value, T. Accuracy is typically expressed as a percent recovery calculated by the ratio of the measurement and accepted true value as shown in Equation (3):

$$\text{Percent Recovery} = \left(\frac{(X - S)}{T} \right) \times 100 \qquad (3)$$

where:

X = The experimentally determined concentration.
S = The sample concentration before spiking.
T = The "true" concentration.

Analytical accuracy is assessed through the analysis of spikes such as surrogates, MS/MSDs and LCS, audit samples and/or standard reference materials, and calibration check samples. With the surrogates and MS/MSDs that are spiked onto the actual sample matrix and analyzed, these accuracy indicators must take into account the nature of the matrix in question and the native concentration of the analyte spiked. Matrix variability or interferences from high concentrations of native compounds may adversely affect spike recovery and yield less than conclusive data. Accuracy checks that focus on analytical method and consist of compounds spiked in a "blank" or noninterfering matrix (e.g., LCSs, standard reference materials, or calibration check samples) address the accuracy of the method and/or instrumentation at detecting the target analyte(s) at a certain quantification level and are not considered to be subject to matrix effects.

Measuring the bias of the overall sampling program is also difficult, especially with respect to collection of samples for analysis for VOC. These organic compounds can be volatilized and lost from collected samples and result in a negative bias, or the sample can become contaminated with foreign compounds during sample collection, handling, and preparation, and result in a positive bias. Using proven sample collection methods that incorporate steps to minimize sample disturbance during collection, providing for the isolation of samples from known sources of contamination, and incorporating the immediate preservation of samples on ice should reduce the potential for bias. Accuracy of the sampling system, emphasizing cross-contamination with volatile compounds, will be assessed by evaluating analytical results for field QA samples, including field-prepared field blanks, laboratory-prepared trip blanks, equipment rinsate blanks, laboratory storage blanks, and analytical method blanks.

Representativeness

Representativeness is a qualitative parameter that expresses the degree to which sample data actually represent the matrix conditions. For example, in conducting groundwater

monitoring, representativeness requires proper location of wells and the collection of samples under consistent, documented procedures. Wells are located based upon the results of the hydrogeologic study in progress and are designed to provide maximum coverage of the flow conditions. Requirements and procedures for sample collection and handling are designed to maximize sample representativeness. Representativeness can also be monitored by reviewing field documentation and by performing field QA audits.

Other sampling approaches where representativeness is a concern is in building composite samples and using an unbiased grid sampling system. In compositing, individual subsamples are collected and combined to represent a greater physical area or cover a particular time period. Often to characterize a large unknown surface area, a grid sampling pattern is established and then samples are collected at randomized node locations where horizontal and vertical traverse lines intersect. Considerations such as number of samples required and their spatial relationship will affect how representative the unbiased grid sample results are. In such cases, the sampling objective must be well defined and the intended purpose for the sample data generated must be reviewed to establish the DQOs for representativeness through statistical analysis. Parameters such as the number of subsamples composited, the number of samples submitted for analysis, and the sampling interval can then be specified to increase confidence interval and improve representativeness when warranted by the performance objective.

Completeness

Data completeness represents the percentage of valid data collected from a sampling/analytical program or measurement system compared to the amount expected to be obtained under optimal conditions. The completeness goal for critical samples (i.e., field samples requiring chemical or geotechnical analysis) is 95 percent. Task-specific completeness goals may also be defined in task-specific work plans.

Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Comparability for sampling and analysis tasks is achieved by:

- Specifying well-recognized techniques and accepted standard methods for sampling and analysis using well-trained sampling and analysis technicians to execute the prescribed methods consistently
- Requiring that all involved sampling and analysis personnel produce adequate documentation to record how the prescribed methods were actually executed, noting nonconformances and corrective measures taken.

The specification of standardized laboratory methods helps to ensure that the data generated for an event are comparable to past and future activities. Periodic field and laboratory audits to assess consistency of method implementation for these prescribed procedures are also critical in determining comparability.

Sensitivity

Sensitivity is a qualitative parameter that addresses the ability of the analytical method or instrumentation to differentiate between responses that represent concentrations of analytes. Sensitivity is important as it is the ability to detect the target analytes at the levels of interest so that project-specific goals are met. The requirements of sensitivity include the establishment of various limits such as those for calibration which include instrument detection limits (DL), limit of detection (LOD), and limit of quantitation (LOQ). DLs, LODs, and LOQs are based on interference-free matrices which do not take into account the matrix effects of environmental samples. Therefore, project-specific RLs are established to meet project objectives for analytes of interest (these values are provided in WS #15 tables).

The CB&I Project Chemist will review all preliminary data for obvious data quality issues such as sensitivity and QC errors and will perform a final review of the raw data to ensure that data has been transcribed correctly, review chromatograms and mass spectra to ensure that compounds have been identified correctly, and review quality control data to ensure that all data has been qualified correctly. The CB&I Project Chemist will not recalculate data from raw data. When required, any recalculations will be performed by the CB&I Data Validator. The CB&I data validator will review a minimum of 10 percent of the raw data against the QC requirements presented in the QAPP.

The following guidelines will be considered during evaluation for usability:

- Review the case narratives pertaining to the data packages and establish that corrective actions were performed.
- Review all qualifier flags based on acceptance criteria.

- Ascertain if the representativeness objective for the project was achieved.
- Awareness of previous investigations for the specific projects and pre-existing data gaps.
- Calculate completeness of sample and analytical data collection to check against the objectives of the project.
- Identify data gaps based on completeness and non-conformance events.
- Identify data that do not meet project-specific sensitivity requirements
- Evaluate if the data gaps prevent the former GAFB from making decisions intended in DQOs.
- Document instances where professional judgment should be used and discuss them with the AFCEC chemist.
- Document all evaluations, calculation, rejections, recommendations, and provide rationale for all specific validation actions.
- Submit a QCSR.

The following items should be considered when evaluating data usability when acceptance criteria have been exceeded:

- Holding times – Consider the stability of the different analytes when holding times have not been met. Volatile organics are more susceptible to loss over time than semivolatile organic compounds such as pesticides and dioxins or metals. Samples that are reanalyzed a few days past holding time because the QC results are outside acceptance criteria, but have passing criteria in the reanalysis and have comparable results to the original analyses should not be rejected with the exception of volatile organics. If the holding time for volatile organics is exceeded, the data will be rejected and there will be no further use of the data.
- Blanks – If the concentration of the analyte in the sample is greater than 5 times the concentration in the blank, then do not qualify the sample concentration as "B." Special attention will be paid when the result is near the governing criterion.
- Sample preservation – All analytes in the sample. If a sample is received at no greater than 10°C and within 48 hours of collection, and if there is documentation that the sample was properly preserved with ice at the time of shipment, then the samples should be qualified as UJ for nondetects and JL for positive results. Sample preservation criteria must be adhered to whenever possible. Volatiles samples that are improperly preserved will be rejected.
- Surrogates – Matrix effects may impact surrogate recovery. If surrogates are within acceptance criteria in the LCS and the method blank, and the internal standard area counts are acceptable in the sample, evaluate the raw data to see if the results in the sample are acceptable. In multiple surrogate methods, one surrogate may be slightly outside acceptance criteria and the data for that sample are still usable. The validator should investigate whether the root cause of the poor recoveries was examined by the laboratory and, when necessary, the corrective action was performed before accepting the data. Evaluate the raw data for usability based on DQOs.
- Surrogates and Matrix Spikes – Surrogates and MSs whose concentrations are diluted out cannot be evaluated.
- Sensitivity – Where generic action limits such as EPA Region 9 preliminary remediation goals (PRG) are used as action levels, the lowest achievable laboratory reporting limit will be used to evaluate sensitivity. Where project or task-specific action levels have been developed, sample results that do not meet the expected sensitivity requirements will be identified during a preliminary review of the data and a determination made as to why the exceedance occurred. If the exceedance is determined to be minor, (i.e., < 20 percent) evaluate the sample result against the laboratory's limits of detection and review similar data that were collected to determine the extent of the condition. If a systematic error has occurred, the overall impact to the data is determined and the condition is reported to the project/task manager and regulators as needed to determine if additional sampling should be performed. If the results are clearly unusable (i.e., exceedance > 20 percent) determine the cause for the exceedance, initiate corrective action if required, and request re-analysis and/or re-sampling as may be appropriate.

In the event that the data validator needs to modify the data qualifiers due to a scenario that is not presented in the QAPP, the CB&I Project Chemist will contact the AFCEC chemist for discussion on effects on data and corrective action.

Describe the evaluative procedures used to assess overall measurement error associated with the project:

Data verification is defined as "confirmation by examination and provision of objective evidence that specified requirements have been fulfilled." Data validation is defined as "confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use have been fulfilled" (EPA QA/G-5).

The Project chemist or designee will review the entire definitive data report package with the field records, and apply the final data qualifiers for the definitive data. The Contractor will evaluate laboratory data, QC results, and laboratory data qualifiers and apply data validation qualifiers. These qualifiers may be different than those applied by the laboratory. The reviewer will use various checklists during the verification process to document all the verification activities. Completed checklists will be available for review upon request. However, these checklists will not be included as part of the data packages. All qualifications will be explained in the Data Validation Report. All qualified data near the governing criteria will be evaluated against project DQOs for fitness for use.

WSs #12, #15, and #28 summarize the target acceptance criteria for the analyses requested. Note that all criteria that are included in the QAPP are to be considered as target goals. Generally, the data are flagged by the laboratory and a more detailed evaluation of the data is performed. Evaluation of the exceedances by the analytical data coordinator, the laboratory PM, and the laboratory QA officer will be completed and a recommendation made concerning the usefulness of the data. Corrective action procedures may then be formulated and implemented in the field or laboratory to avoid reoccurrence of the condition. In all cases, the results of the data usefulness evaluation will be documented and discussed in the project reports.

To determine the precision of an analytical method and/or laboratory analyst, a routine program of replicate analyses is performed. The results of the replicate analyses are used to calculate the RPD, which is the governing QC parameter for precision. CB&I will determine the precision of the analyses conducted during this investigation by reviewing the results of field replicate samples and laboratory duplicate samples (where applicable), then, if sufficient data are obtained, the arithmetic mean and standard deviation of a group of results may be calculated.

Statistical comparison of both field and laboratory duplicate samples as a measure of precision evaluating both sample collection procedures and laboratory instrument performance may be accomplished by first comparing the obtained duplicate results with the published DoD QSM criteria for method precision. If DoD QSM criteria are not available, the RPD may be calculated and compared to the precision criteria established by the laboratory for the analysis of laboratory duplicates. Should the RPD exceed the QC acceptance range, the associated data should be considered as estimated.

The accuracy of a method is an estimate of the difference between the true value and the determined mean value. Certain QA parameters such as LCSs, reagent water spike samples, QC check samples, MS samples, and surrogate spike samples all have known concentrations prior to analysis. By comparing the percent recovery of the analysis of these samples to the true value, it is possible to measure the accuracy of the analysis.

Percent recovery values and control limits or DQOs are reported by the laboratory as a measure of method accuracy and will be compared with the established laboratory limits or the published DoD QSM criteria for the accuracy of an individual method. QC data not meeting the established laboratory criteria or DoD QSM target criteria for accuracy may be flagged and their usability assessed; associated field sample data should be considered as estimated.

Data completeness will be expressed both as the percentage of total tests conducted that are deemed valid and as the percentage of the total tests required in the scope of work that are deemed valid. Percent completeness is calculated with respect to the purpose of analysis (i.e., chemical, geotechnical, soil classification), as well as type of sample (i.e., field sample or QA/QC sample). The purpose and total number of each type of sample planned in the scope of work will be calculated and tabularized in the task work plan for each specific task. As part of the evaluation of the task completeness performed in the task final report, the actual number of samples collected will be compared to the planned number, and completeness will be discussed in the task-specific report. The completeness goal for all the different types of samples on this project is 90 percent, except for QA/QC samples. Completeness of QA/QC samples will have to be judged on a case-by-case basis in the report documents. Enough QA/QC data must be available to allow a thorough assessment of data quality to be performed.

Preliminary Data Use

To meet the goals of the former GAFB project, it may be necessary to make use of preliminary data but not for site closure or action level compliance. The data must be released by the project chemist or QA officer to the project staff for use. Ideally, the data will have been reviewed against the former GAFB QC criteria before the data is released to the project team. The team will be made aware that the data has not been completely validated and that they are using the data at risk. Acceptable uses for preliminary data include step-out discussions, additional sampling requirements, etc. Unacceptable uses of preliminary data include public meetings, risk assessment decisions, no further action decisions, and final, decision-making purposes.

The project chemist or designee will review the entire definitive data report package with the field records and apply the final data qualifiers for the definitive data. CB&I will evaluate laboratory data, QC results, and laboratory data qualifiers and apply data validation qualifiers. These qualifiers may be different than those applied by the laboratory. CB&I will use various checklists during the verification process to document all the verification activities. Completed checklists will be available for review upon request. However, these checklists should not be included as part of the data packages. All qualifications must be explained in the Data Validation Report. All qualified data near the governing criteria will be evaluated against project DQOs for fitness for use.

CB&I will review the QC (laboratory and field) samples and field logs, and will then appropriately flag any of the associated samples identified with the QC samples, as explained in Table 37-1, *Validator General Flagging Guidelines*, Table 37-2, *Guidelines for Reporting Results*, and Table 37-3, *Validator Flagging Guidelines Specific to Organic Methods*. At minimum, case narratives, calibrations, blanks, spikes, and duplicates will be reviewed. Additionally, raw data such as chromatograms, mass spectra, and instrument output will be reviewed for transcription errors. Each MS sample will only be qualified by the laboratory, while CB&I will apply the final qualifying flag for a matrix effect to all samples collected from the same site as the parent sample or all samples showing the same lithologic characteristics as the MS/MSD.

Definitions for Validation Data Qualifiers:

U - Not detected. The compound/analyte was analyzed for, but not detected above the associated DL.

R - The reported sample results are rejected due to the following: 1) Severe deficiencies in the supporting quality control data, 2) Anomalies noted in the sampling and/or analysis process which could affect the validity of the reported data, 3) The presence or absence of the constituent cannot be verified based on the data provided, 4) To indicate not to use a particular result in the event of a reanalysis.

J - The compound/analyte was positively identified; the reported value is the estimated concentration of the constituent detected in the sample analyzed.

UJ - The compound/analyte was analyzed for, but not detected above the established reporting limit. The review and evaluation of supporting QC data and/or sampling and analysis process have indicated that the reporting limit may be inaccurate or imprecise. The nondetect result should be estimated.

Table 37-1. Validator General Flagging Guidelines

QC Requirement	Criteria	Flag	Flag Applied To [a]
Holding Time	Time exceeded for completion of extraction or analysis	"R" for the nondetects > 2X hold time, or "J" for the positive results.	All analytes in the sample. In the event that holding time is only marginally exceeded, qualify positive results as J. Volatile hold times may not be exceeded.
LCS	Percent recovery (%R) > UCL %R < LCL %R < 10%	"J" for the positive results. "J" for the positive results, "UJ" for the nondetects. "J" for the positive results, "R" for the nondetects.	The specific analyte(s) in all samples in the associated analytical batch. If the recovery is slightly outside acceptance criteria, see the text.
Method Blank	Analyte(s) detected	"U" for the results within 5x/10x the blank concentration. Special attention will be paid to analytes where the result is near the governing criteria.	The specific analyte(s) in all samples in the associated analytical batch.
Equipment Blank	Analyte(s) detected	"U" for the results within 5x/10x the blank concentration. Special attention will be paid to analytes where the result is near the governing criteria.	The specific analyte(s) in all samples with the same sampling date and sampling equipment as the equipment blank.
Field duplicates	Parent sample and Field duplicate results > LOQ and RPD outside control limits 35 Water; 50 Soil	"J" for the positive results greater than the LOQ. No qualification required if parent sample result and field duplicate result is < LOQ.	The specific analyte(s) in all samples collected on the same sampling date by the same sampling crew at the same site.

Table 37-1 (continued). Validator General Flagging Guidelines

QC Requirement	Criteria	Flag	Flag Applied To [a]
MS/MSD	MS or MSD %R > UCL or MS or MSD %R < LCL or MS/MSD RPD > CL	"J" for all positive results. "J/UJ" for all results. "J/UJ" for all results.	Where the concentration in the parent sample is <4x the spike concentration. Qualify MS/MSD sample only. Use professional judgment to qualify other samples in batch.
Sample Preservation/ Collection	Preservation/ collection requirements not met	"R" for all nondetect results. However if a sample is received at no greater than 10°C and within 48 hours of collection, and if there is documentation that the sample was properly preserved with ice at the time of shipment, then the samples should be qualified as UJ for non detects and J for positive results. Volatile samples must be preserved at a temperature of 4 ± 2°C without exception. Volatile water samples must be at a pH of < 2.	All analytes in the sample.
Laboratory Sample Storage	4 ± 2ºC	"J" for the positive results. "R" for the nondetects.	All analytes in the sample.

Notes:
[a] Qualify the data as presented in this table. Keep in mind the instructions to the data validators.

Table 37-2. Guidelines for Reporting Results

Result	Flag *
≤ detection limit (DL)	U
> DL < Limit of Quantitation (LOQ)	J
≥ LOQ	As needed
≥ high standard / linear range	J

Notes:

* Example 1: If the DL is 0.04, the LOQ is 0.9 and the result is 0.03, the concentration reported on the tabulated data form would be ND (0.04) (the sample specific DL) and in the ERPIMS submittal would be 0.04 U (0.9).

Example 2: If the DL is 0.04, the LOQ is 0.9 and the result is 0.07, the concentration reported on the result form would be 0.07 and the qualifier flag would be J. The ERPIMS submittal would be 0.07 J (0.9).

Example 3: If the DL is 0.04, the LOQ is 0.9 and the result is 1.2, the concentration reported on the result form would be 1.2 and the qualifier would be any flag needed because of a data quality problem (e.g., R, J, B, etc.). The ERPIMS submittal would be 1.2 qualifier (0.9).

Table 37-3. Validator Flagging Guidelines Specific to Organic Methods

QC Requirement	Criteria	Flag	Flag Applied To [1]
Temperature Blank (as applicable)	Temperature on sample receipt at lab	J/UJ for results outside the range of 4C+ 2.	All compound(s) in the affected sample shipment.
Initial Five Point Calibration (gas chromatography (GC) and high performance liquid chromatography (HPLC methods)	Linearity criterion not met	R	The specific analyte(s) in all samples associated with the initial calibration.
Second Source Calibration Verification	Calibration limit (CL) exceeded	J for the positive results UJ for the nondetects	The specific analyte(s) in all samples associated with the second source calibration verification.
Initial Daily Calibration Verification (GC & HPLC methods)	CL exceeded	J for the positive results UJ for the nondetects	The specific analyte(s) in all samples associated with the initial calibration verification.
Calibration Verification (GC & HPLC methods)	CL exceeded	J for the positive results UJ for the nondetects	The specific analyte(s) in the sample associated with the continuing calibration verification.
Retention time	RT of analyte outside of established RT window	R	The specific analyte(s) in the sample.
Surrogates	Surrogate %R > UCL; or	J for the positive results	All analytes in the sample associated with the surrogates.
	Surrogate %R < LCL; or	J for the positive results UJ for the nondetects	
	Surrogate %R < LCL and %R < 10%	J for the positive results R for the nondetects	
Second Column/ Second Detector Confirmation (GC & HPLC methods)	Not performed	R	All analytes ≥ RL.
	Agreement between results not within ±40%	J	All affected analytes.
Lowest Calibration Standard	At or below RL in Initial Calibration	J	All results below the lowest calibration standard used.

Notes:

[1] Qualify the data as presented in this table.

Table 37-4 – Validator Flagging Guidelines Specific to Inorganic Methods

QC Requirement	Criteria	Flag	Flag Applied To[1]
Temperature Blank (as applicable)	Temperature on sample receipt at lab	J/UJ for results outside the range of 4C+ 2.	All compound(s) in the affected sample shipment.
Initial Multi-Point Calibration	Linearity criterion not met	R	The specific analyte(s) in all samples associated with the initial calibration
Second Source Calibration Verification	CL exceeded	J for the positive results UJ for the nondetects	The specific analyte(s) in all samples associated with the second source calibration verification
Initial Daily Calibration Verification	CL exceeded	J for the positive results UJ for the nondetects	The specific analyte(s) in all samples associated with the initial calibration verification
Calibration Verification	CL exceeded	J for the positive results UJ for the nondetects	The specific analyte(s) in the sample associated with the continuing calibration verification
ICS	Analyzed at the beginning of each analytical batch. ICS-A: Absolute value of concentration for all non-spiked analytes < LOD (unless they are verified as a trace impurity from one of the spiked analytes. ICS-AB: Within ±20% of true value.	J for the positive results UJ for the nondetects	The specific analyte(s) in the samples associated with the failing ICS.
Dilution Test	Analyze one per preparatory batch. Five-fold dilution must agree within ±10% of the original measurement	J for positive results with concentrations greater than "50x" LOQ.	The specific analyte(s) in sample
PDS	Analyze when MS/MSD %Recoveries < 30% or when dilution test fails or analyte concentration for all samples are less than "50x" the LOQ. Recovery within 75-125%	J for the positive results UJ for the nondetects	The specific analyte(s) in sample

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Notes:

1 Qualify the data as presented in this table.

CL denotes control limit.
ICS denotes interference check standard.
LOD denotes limit of detection.
LOQ denotes limit of quantitation.
MS/MSD denotes matrix spike / matrix spike duplicate.
PDS denotes post digestion spike,

Appendix C
Response to Comments

AIR FORCE RESPONSE TO TECHNICAL REVIEW COMMENTS

Lahontan Regional Quality Control Board Comments on
Draft Data Gap Investigation Work Plan, Non-CERCLA Site OT071, Former George Air Force Base, Victorville, San Bernardino County

April 2016

The Lahontan Regional Water Quality Control Board (RWQCB) comments, in a letter to the US Air Force (Air Force) dated March 28, 2016:

Introduction

The California Regional Water Quality Control Board, Lahontan Region (Water Board) staff received the *Draft Final Data Gap Wei/Installation Work Plan, Non-CERCLA Site OT071, Former George Air Force Base* (GAFB; Work Plan) on February 25, 2016 and comments were requested by March 25, 2016. This letter conveys Water Board comments on the Draft Final Work Plan. The Draft Final Work Plan generally addresses Water Board comments on the Draft version.

The Draft Final Work Plan also provides additional information regarding the vadose zone model that will be used to estimate future impacts to groundwater from dieldrin in the soil in addition to vadose zone modeling procedures - details that were not available when the Air Force issued the Draft Work Plan. Water Board and Department of Toxic Substances (DTSC) staff are still discussing with CB&I staff the applicability of the proposed HYDRUS vadose zone model for colloidal transport of dieldrin through the vadose zone. We recommend that the remaining issues be documented in a technical memorandum than can be inserted into an additional appendix (e.g., Appendix D) to document the Water Board approved details for the HYDRUS modeling and the evaluation of colloidal particle sizes after these issues are resolved. The Final Work Plan can be issued with a tab for the additional appendix so that the field work can proceed to install the wells and conduct the soil boreholes.

Response to Letter Text:

Once the Water Board, Department of Toxic Substances (DTSC), and CB&I staff have resolved the outstanding issues regarding HYDRUS modeling a technical memorandum will be inserted as Appendix D. Responses to the individual comments are addressed below.

Item - Section, Page	Comment	Response
Comment 1, Document Title	The Draft version of the Report was titled "Data Gap Investigation Work Plan...." whereas the Draft Final was titled "Data Gap Well Installation Work Plan..." Considering that the Work Plan addresses more than well installation and for the sake of consistency, we request the document title not be changed from draft through final and the Air Force use the "Data Gap Investigation Work Plan" title for the final version of the document.	The Air Force will use the "Data Gap Investigation Work Plan" title for the final version of the document.
Comment 2, Page 3-2, 2nd Paragraph, 1st Bullet, 5th line	There appears to be a typo: replace "bgun" with "begun."	The text has been corrected.
Comment 3, Page 3-5, 6th Paragraph (Section 3.3.2.3), 2nd Sentence	There appears to be another typo: replace "tho" with "the."	The text has been corrected.
Comment 4, Page 3-6, Section 3.3.2.7 (Bentonite Seal)	Based on the March 21, 2016 discussion between the Water Board, DTSC, and CB&I, we recommend that the bentonite seal be installed with a 6:1 to 7:1 ratio of hydrated bentonite powder to fine sand (#40 sand or finer) to be tremied into place. The sand is to prevent the propagation of cracks and loss of seal integrity as the seal dries out.	The following has been added to Section 3.3.2.7: *"Seal material must be a 6:1 to 7:1 ratio of hydrated bentonite powder to fine sand (#40 sand or finer) to be tremied into place. The bentonite absorbs water (hydration) and swells to form a seal in the annular space above the filter pack. For this reason, once the bentonite is placed in the borehole and wetted, a period of time must be allowed for the bentonite to absorb the water and swell. The sand is to prevent the propagation of cracks and loss of seal integrity as the seal dries out."*
Comment 5, Page 3-7, Section 3.3.2.8 (Annular Seal)	The Draft Final Work Plan indicated 3 to 5 percent by weight bentonite for the cement-bentonite mix for the annular seal. Based on the March 21, 2016 discussion between the Water Board, DTSC, and CB&I, we recommend that the target bentonite content be limited to 3 to 4 percent by weight.	The text has been revised to state: *"Cement grouts must be mixed using 6.5 to 7 gallons of water per 94-pound bag of portland cement (Type I) and 3 to 4 percent by weight bentonite."*

Item - Section, Page	Comment	Response
Comment 6, Appendix A (Standard Operating Procedures), EI-GS018.pdf, Section 6.4	Dilatancy testing should be conducted to distinguish between silts and clays, and plasticity observations should be noted following the standard Unified Soil Classification System (USGS) field methods. For gravels, the general rock type (e.g., granite, quartzite, limestone, etc.) and color should be mentioned on boring logs. The boring logs should be reviewed by a Professional Geologist.	Dilatancy testing will be conducted and plasticity observations will be noted following the standard Unified Soil Classification System (USGS) field methods.

Appendix D
Technical Memoradum – HYDRUS Model

FINAL PAGE

ADMINISTRATIVE RECORD

FINAL PAGE