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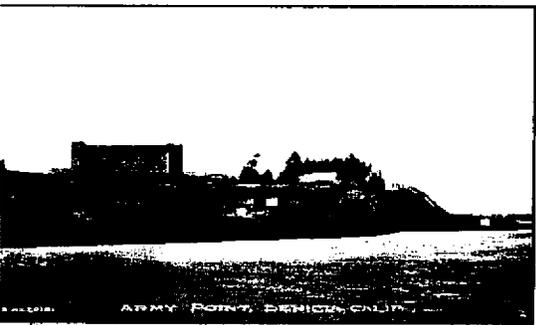
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Arsenal-Wide

Quality Assurance Project Plan

FOR THE BENICIA ARSENAL Revision

November 2001



Prepared for:
US Army Corps
Sacramento District

Prepared by:
**FORSREN AS,
BROWN and C.**
A Joint Ve

**QUALITY ASSURANCE
PROJECT PLAN
Revision 2 -- Final**

For
Environmental Investigation at the Formerly Used Defense Site (FUDS)
At the Benicia Arsenal
Benicia, California

FUDS Site Number: J09CA075600

Prepared for

DEPARTMENT OF DEFENSE
UNITED STATES ARMY ENGINEER DISTRICT, SACRAMENTO DISTRICT
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November 2001

Contract Number:
DACW05-97-D-0038

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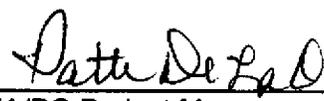
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PREFACE

This Quality Assurance Project Plan (QAPP) has been prepared by Forsgren Associates/Brown and Caldwell (FA/BC) using United States Army Corps of Engineers (USACE) and United States Environmental Protection Agency (USEPA) guidelines. This task order specific QAPP is issued for use in conducting Formerly Used Defense Site (FUDS) program investigative activities at the Benicia Arsenal (Arsenal). This QAPP has been prepared in accordance with the Chemical Data Quality Management Plan (CDQMP) for USACE contract DACW05-97-D-0038. The CDQMP is considered a general guidance document for the contract. This QAPP contains current sampling, analytical, and quality assurance/quality control (QA/QC) procedures and specifications for all contractors performing field, analytical, and data review activities specific to the FUDS investigative program at the Arsenal. These guidance procedures have been established to promote consistency and comparability of all activities, and to assure defensible data collection and production. Implementation of these procedures will promote consistent, technically sound decisions.

Approved:


FA/BC Program Manager


FA/BC Project Manager


FA/BC Quality Reviewer


FA/BC Program Chemist

REVISION HISTORY

The QAPP was originally released in February 1999. Revision 1, produced in September 1999, was not a complete revision. It consisted of a series of amended pages from the text and Appendices A-E plus a revised Standard Operating Procedure (SOP) (#17 – Groundwater Sampling and Purging) from Appendix F. The amended pages were submitted to all recipients of the QAPP as replacement pages to be inserted into the existing document. This current revision (Revision 2) consists of a complete new QAPP. Appendices B (Internal Quality Control Procedures) and D (Calibration Procedures) have been combined as Appendix B for more easy reference to all laboratory quality control requirements. The flagging conventions have been moved forward from Appendix E to Appendix D. The specifications for the current electronic data deliverable (EDD) for the Benicia project have been included as the new Appendix E. One SOP (#7 – Collection of Soil Samples) has been amended and one new SOP (#33 –Passive Diffusion Bag Sampling) was added to Appendix F. All others SOPs remain unchanged from the previous versions.

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LIST OF ACRONYMS

AA	atomic absorption
ARARs	applicable or relevant and appropriate requirements
ARCH	air-rotary casing hammer
Arsenal	Benicia Arsenal
ASTM	American Society for Testing and Materials
BFB	1,4-bromofluorobenzene
bgs	below ground surface
BII	Benicia Industries, Inc.
BOD	biological oxygen demand
CAR	corrective action report
CCC	calibration check compound
CDQMP	Chemical Data Quality Management Plan
CD-ROM	compact disk-read only memory
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIH	Certified Industrial Hygienist
Cl	chloride
CLP	contract laboratory program
CO	contracts officer
COC	chain of custody
COD	chemical oxygen demand
COPC	chemicals of potential concern
COR	contracting officer's representative
CPT	cone penetrometer testing
CQC	chemical quality control
CQL	contract quantitation limit
Cr6	hexavalent chromium
CRQL	contract-required quantitation limit
CVAA	cold vapor atomic absorption
CWM	chemical warfare material
DFTPP	decafluorotriphenylphosphine
DI	deionized
DNAPL	dense nonaqueous phase liquid
DO	delivery order
DoD	Department of Defense
DQCR	data quality control report
DQO	data quality objective
DRO	diesel range organics
DTP	dual-tube percussion
ECD	electron capture detector
EDL	electrodeless discharge lamp
EDS	Environmental Database System
ELCD	electrolytic conductivity detector
ELISA	enzyme-linked immunosorbent assay
EM	electromagnetic
eV	electron volt
EVS	Environmental Visualization System
FA/BC	Forsgren Associates/Brown and Caldwell

LIST OF ACRONYMS (Continued)

FID	flame ionization detector
FLAA	flame atomic absorption
FPD	flame photometric detector
FSIP	field site investigation plan
FTL	field team leader
FUDS	Formerly Used Defense Site
g/l	grams per liter
GC	gas chromatograph
GC/ECD	gas chromatograph/electron capture detector
GC/MS	gas chromatograph/mass spectrometer
GFAA	graphite furnace-atomic absorption
GIS	Geographical Database System
GMS	Geological Modeling System
GPC	gel permeation chromatography
GPR	Ground Penetrating Radar
GRO	gasoline range organics
GSA	General Services Administration
GTGS	GeoTechnical Graphics System
HCN	hydraulic acid
HECD	Hall electrolytic conductivity detector
HNO ₃	Nitric acid
HPLC	high performance liquid chromatography
HRGC/HRMS	high-resolution capillary column gas chromatography/high-resolution mass spectrometry
HRGC/LRMS	high-resolution capillary column gas chromatography/low-resolution mass spectrometry
HSA	hollow-stem auger
HTRW	Hazardous, Toxic, and Radioactive Wastes
IC	ion chromatography
ICP	inductively coupled plasma
ICV	Initial Calibration Verification
ID	Identification
IDL	instrument detection limit
IR	infrared
JEMS	Jacobs Environmental Management System
JESS	Jacobs Environmental Sampling System
LCS	laboratory control sample
LCSD	laboratory control sample duplicates
LIMS	laboratory information management system
LQMP	laboratory quality management program
LR	laboratory replicate
LUFT	leaking underground fuel tank
MB	method blank
mCi/g	millicuries per gram
mCi/L	millicuries per liter
MDL	method detection limit
MEK	methyl ethyl ketone
mg/kg	milligrams per kilogram

LIST OF ACRONYMS (Continued)

MIBK	methylisobutyl ketone
ml	milliliter
MQL	method quantitation limit
MR	mud rotary
MRL	method reporting level
MRD	Missouri River Division (of USACE)
MS/MSD	matrix spike/matrix spike duplicate
MSA	method of standard additions
MSL	mean sea level
NAPL	nonaqueous phase liquid
NFA	no further action
ng/g	nanogram per gram
ng/L	nanogram per liter
NIST	National Institute of Standards and Technology
nm	nanometer
NO2-N	nitrite nitrogen
NO3-N	nitrate nitrogen
NPD	nitrogen-phosphorus detector
OSHA	Occupational Safety and Health Administration
OVA	organic vapor analyzer
PAH	polynuclear aromatic hydrocarbon
PARCC	precision, accuracy, representativeness, completeness, and comparability
PBMS	performance based method systems
PC	program chemist
PCB	polychlorinated biphenyl
PCDD	Polychlorwaterdibenzodioxins
PCDF	Polychlorwater dibenzofuran
PE	performance evaluation
PFTBA	perfluorotributylamine
PG&E	Pacific Gas & Electric
PID	photoionization detector
PjC	project chemist
PjM	project manager
PM	program manager
POL	petroleum, oil, and lubricant
ppb	parts per billion
ppbv	parts per billion by volume
PPE	personal protective equipment
ppm	parts per million
ppmv	parts per million by volume
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QAO	quality assurance officer
QAPP	quality assurance project plan
QCR	quality control report
QCSM	quality control systems manager
QCSR	quality control summary report
RCA	recommendation for corrective action
RCRA	Resource, Conservation and Recovery Act

LIST OF ACRONYMS (Continued)

RDL	reporting detection limit
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RPD	relative percent difference
RQL	reporting quantitation limit
RRR	Records Research Report
RSD	Relative Standard Deviation
SIM	selected ion monitoring
SO4	sulfate
SOP	standard operating procedure
SOW	statement of work
SPCC	system performance calibration check
SQL	sample quantitation limit
SSHPP	site safety and health plan
SSO	site safety officer
SV	soil vapor
SVOC	semivolatile organic compound
TAT	turnaround time
TBA	Tetrabutylammonium
TCE	Trichloroethane
TCLP/WET	toxicity characteristic leaching procedure/waste extraction test
TIC	Tentatively Identified Compound
TOMs	Task Order Managers
TM	technical manager
TNT	trinitrotoluene
TPH	total petroleum hydrocarbons
TRPH	total recoverable petroleum hydrocarbons
TSDFs	Treatment, Storage, and Disposal Facilities
TVPH	total volatile petroleum hydrocarbons
USACE	United States Army Corps of Engineers
USCGS	United States Coast and Geodetic Survey
USCS	Unified Soil Classification System
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UV	ultraviolet
UXO	Unexploded Ordnance
VOC	volatile organic compound
WET	Waste Extraction Test
WI	work instruction
WIRMS	Warehouse; Industrial/Manufacture; Revetment/Explosives ,Motor Pool, Igloo/Storage Areas
XRF	x-ray fluorescence
%RSD	percent relative standard deviation
°C	degrees centigrade
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µL	microliter
µmhos/cm	micromhos per centimeter

EXECUTIVE SUMMARY

The Quality Assurance Project Plan (QAPP) for the Benicia Arsenal (Arsenal) was originally released in February 1999, with selected pages updated in September 1999. This Revision 2 is the first full update to the QAPP. This QAPP organizes and presents the responsibilities, procedures, and specific quality control (QC) and quality assurance (QA) activities designed to achieve the data quality objectives (DQO) established for the Benicia Arsenal-wide investigation. The purpose of the Benicia Arsenal-wide investigation is to characterize the nature and extent of any Department of Defense (DoD)-related contamination at the Arsenal with the collection of defensible and appropriate field data. The Arsenal is a Formerly Used Defense Site (FUDS). This Arsenal-Wide QAPP is applicable to, and governs the actions of all employees, subcontractors, suppliers, and purchasing agents, both on-and off-site, who may be involved in activities associated with investigation and/or remediation of DoD-related contamination at the Arsenal.

This QAPP shall be the primary document for FUDS activities at the Arsenal with respect to QC procedures for field, laboratory, general operations, analytical procedures, and reports to management. For each project, QAPP requirements should be reviewed for applicability to that particular activity. A workplan shall be prepared for each activity that will include environmental sampling and analysis. The QA/QC procedures specified in this QAPP are to be reviewed for applicability to that site and activity. This will be determined through the DQO process. When DQOs require changes to the default QA/QC procedures specified in this QAPP, they shall be over-ridden by specifying alternative procedures and criteria in the site-specific work plan.

Presented in this document are the project team organization, the DQO processes, and standard operating procedures (SOPs). This QAPP has been designed to provide maximum flexibility to meet the challenges of the many variables encountered during the course of working for the various agencies involved in this FUDS project. The purpose of the procedures established in this QAPP is to ensure a formal and consistent approach to data collection/production by all suppliers and laboratories, and to enable consistent data quality assessment and documentation.

The current organizational structure for this project is shown in Figure 1-1 of the main text. This organizational structure provides the Program Manager (PM) with a dedicated organization, including Project Managers (PjM), technical and administrative support staff, and subcontracting managers. Other technical resources will be accessed on an as-needed basis. This program organization is designed to provide a clear line of management responsibility and authority; facilitate delegation of authority to the management level responsible for completing work products; and maintain appropriate cost, schedule, and quality control. The organization reflects strong technical and management leadership and integration across multiple task counterparts. The team lines of authority flow from the PM to the PjM and down to the respective support staff.

Numerous subcontractors may be retained by the primary contractor for specific work assignments under separate task orders of this contract. The types of assignments to be contracted may include analytical laboratory services, drilling services, and land surveying services. With respect to chemical data quality management, the laboratory QA program will play an important part in ensuring that valid data are obtained from the field sampling activities.

QA for the laboratory's work will be overseen by in-house laboratory PjMs assigned specifically to this contract. These managers are responsible for ensuring that all analytical data generated under this contract are reviewed prior to their release (refer to Section 4.0 for data review, validation, and verification requirements).

The DQOs for this project will be provided in site-specific Field Site Investigation Plans (FSIPs), and will describe the scope of work and background information as it relates to the acquisitions of geological, geophysical, hydrogeological, and chemical data. Data quality will be evaluated relative to the DQOs, which are qualitative and quantitative statements that specify the quality of the data required to support decision-making during the project. The DQO process will be followed to select the approach for sample collection, sample analysis, and QA/QC which will result in the required chemical data. Consideration will be given to the application of QA/QC parameters: precision, accuracy, representativeness, comparability and completeness. The extent of analytical effort and data validation procedures to be required will be specified. Guidance for this requirement can be found in Guidance for the Data Quality Objectives Process (USEPA QA/G-4).

Criteria to assure data integrity during the collection and reporting process are identified throughout this document. Included in the criteria are strict adherence to procedures and protocols provided for the collection of field data and samples, and for the laboratory analyses and reporting process. Each step of the process will be detailed in the FSIP, and will be provided in sufficient detail as to form the basis for auditing of the various tasks involved throughout the process. The FSIP will also identify possible matrix interferences for laboratory analyses attributable to site characteristics, and methods of compensation for expected or unexpected interferences will be discussed with the laboratory QA Manager prior to initiating any sampling and analysis program.

QC and QA samples will be collected and analyzed by the contract laboratory and the United States Army Corps of Engineers (USACE) QA laboratory, respectively. These QC and QA samples include splits or replicates of field samples, rinsate blanks, trip blanks and background soil and ground water samples. QC samples, which represent approximately 10% of the field samples, help the prime contractor to identify and diagnose problems related to sampling and analysis. QA samples, which represent approximately 10% of the field samples, are sent to a USACE QA laboratory for government monitoring of sampling and contract laboratory performance.

The specific procedures involved in archiving laboratory data include hard copies, computer hardware and disk copies. The computer tape and hard copy for storage are to be maintained within a secured building. Each contract laboratory must store the data and reports for a period of ten years. Hard copy data over one year old generally are stored in a secure off site location and are accessible by box number on a database within the contract laboratory data management system. Electronic laboratory data backup tapes and/or disks must also be stored in a secure off-site facility. Each contract laboratory must retain the capability to reconstruct data for a period of ten years.

Raw data packages shall consist of a case narrative, chain of custody (COC) documentation, summary of results for environmental samples, summary of QA/QC results, and the raw data. Detailed descriptions of the requirements for each component of a raw data package are provided in the following sections. Raw data packages (considered equivalent to United States

Environmental Protection Agency [USEPA] Contract Laboratory Program [CLP] deliverables) shall be submitted to the contractor and USACE for 10 percent of all samples analyzed by the contract laboratory. The contractor will be informed by the USACE PM or his/her representative (after samples have been submitted to the laboratory) of the data sets for which raw data packages shall be required. Raw data packages shall be delivered with the Comprehensive Certificate of Analysis.

The FSIP will outline the proposed design of the project's site-specific investigation including the sampling network design, types of samples required, sampling frequencies, sample matrices, and measurement parameter of interest. The rationale for the design will be clearly stated in the FSIP, and include the rationale for each sample location. These sample locations will be identified on a site map. Measurement parameters to be described will include geological, geophysical, hydrogeological, and chemical parameters as applicable. If cone penetrometer locations, Hydropunch® locations, microwell, or monitoring well locations are to be chosen on the basis of field observations. The text will clearly state the evaluation criteria that will be used in the field for these determinations. Microwell and monitoring well design criteria will be clearly described to include a description of field determinations for appropriate filter packs and well screens.

SOPs are to be implemented for all routine sampling operations. The goal is that all applicable fieldwork is performed in accordance with authorized technical guidelines and will consistently be of high quality, thereby reducing the probability of error. All applicable SOPs are included in Appendix F for this document.

All analytical procedures performed under this contract shall conform to the most recently promulgated version of SW-846 (currently Update 3, December 1996). Alternate or additional procedures to those presented in this QAPP must be pre-approved by the USACE PM or his/her representative. Table 1-2 presents a summary of common methods for analysis. A summary of the practical quantitation limits and calibration requirements is presented in Appendices A and B, respectively.

A variety of QC samples are used to quantitatively assess data quality. Method blank and laboratory control samples uniquely measure the laboratory component of measurement performance. Matrix spikes (MS), matrix spike duplicates (MSD), laboratory duplicates, and surrogate spikes measure the matrix component of measurement performance, but also reflect laboratory performance. The contract laboratory shall, as a minimum, analyze internal QC samples at the frequency specified by the analytical method and in this QAPP. In the field, additional QC samples (trip blanks, equipment rinse blanks, filter blanks, and source water samples) are used to assess field sampling techniques and environmental conditions during sample collection and transportation. These quality control samples will be evaluated in terms of precision, accuracy, representativeness, completeness, and comparability (PARCC). Appropriate mechanisms, including the definition of laboratory control limits for each of these elements, have been established to ensure that control is maintained. Method-specific quality control procedures, frequencies, acceptance criteria (control limits), and corrective actions are provided in Appendix B.

Completeness will be evaluated qualitatively and quantitatively. The qualitative evaluation of completeness will be determined as a function of all events contributing to the sampling event, including items such as correct handling of COC forms, results of field duplicates, etc. The

quantitative description of completeness will be defined as the percentage of contract laboratory controlled QC parameters that are acceptable.

The contractor will execute a number of assessments during performance of this project that will include, but not be limited to, surveillance, peer review, management systems review, readiness review, technical system audits, performance evaluations, audit of data quality, and data quality assessment. The contractor is expected to maintain data quality, project schedules, and personnel management while implementing these assessments. Success criteria will include goals, performance objectives, acceptance criteria specifications, and personnel feedback.

Specific reporting mechanisms have been developed to keep USACE management informed of the status of project quality. This will be accomplished in part by including the USACE PM or his/her representative on the distribution of various reports and corrective action requests (CARs).

The contract laboratory shall provide analytical data packages to a primary contractor designated subcontractor for independent laboratory data validation. This subcontractor will submit data validation reports to USACE and the PjM within 21 days after receiving the analytical data packages from the laboratory. The subcontractor will report egregious or recurrent errors in analytical work by memorandum to the USACE Contracting Officer (CO) and PjM as soon as they are discerned. A more detailed description of the independent laboratory data validation is presented in Section 4.0 of this QAPP. Table 4-1 provides a summary of how chemical data QC will be evaluated in terms of PARCC.

1.0

1.0 INTRODUCTION

This QAPP organizes and presents the responsibilities, procedures, and specific QC and QA activities designed to achieve DQO established for the Benicia Arsenal (Arsenal). The Arsenal is a FUDS. This Arsenal-Wide QAPP is applicable to, and governs the actions of all employees, subcontractors, suppliers, and purchasing agents, both on- and off-site, who may be involved in activities associated with investigation and/or remediation of DoD-related contamination at the Arsenal. This QAPP has been prepared in accordance with the Chemical Data Quality Management Plan (CDQMP) for USACE contract DACW05-97-D-0038. The CDQMP is considered the guidance document for the contract. This QAPP shall be the primary document for FUDS activities at the Arsenal with respect to QC procedures for field, laboratory, general operations, analytical procedures, and reports to management. For each project, QAPP requirements should be reviewed for applicability to that particular activity. A workplan shall be prepared for each activity that will include environmental sampling and analysis. The QA/QC procedures specified in this QAPP are to be reviewed for applicability to that site and activity. This will be determined through the DQO process. When DQOs require changes to the default QA/QC procedures specified in this QAPP, they shall be over-ridden by specifying alternative procedures and criteria in the site-specific Workplan.

Presented in this document are the current project team organization, the DQO processes, and standard operating procedures (SOPs). This QAPP has been designed to provide maximum flexibility to meet the challenges of the many variables encountered during the course of working for the various agencies involved in this FUDS project.

The environmental investigation at the Arsenal will utilize the FUDS process as described in the Benicia Arsenal Conceptual Workplan (April 1998). Initially, limited site-specific data are gathered to determine the presence of chemicals of potential concern (COPC). The data are then evaluated to determine whether additional investigation(s) is needed. If contamination exists, subsequent focused investigation will define the horizontal and vertical extent, and the magnitude of DoD-related COPC. Methods to accelerate the investigation and any subsequent remedial action will be integrated into the process. Where and when appropriate, field screening, rapid site characterization, and innovative technologies and evaluation procedures will be utilized. An example may include real-time data collection and evaluation techniques, such as field gas chromatograph (GC) and/or x-ray fluorescence (XRF) analysis.

Following the data-gathering step, the risks to human health and the environment are evaluated on a site-specific basis. Goals are established for the recommendation of "no further action" (NFA) or for the purpose of corrective action. A recommendation of NFA is made if there is no contamination, no DoD-related COPC are identified, the landowner refuses right of entry, the risk has been eliminated, or the risk evaluation determines that there is an acceptable risk to human health and the environment. If remediation is warranted, then an appropriate course of corrective action is established.

This QAPP has been developed based on guidelines from the USACE and the USEPA, which include the following:

- Chemical Data Quality Management Plan, Contract DACW05-97-D-0038, Forsgren Associates/Brown and Caldwell 2000.
- USEPA Requirements for Quality Management Plans, USEPA QA/R-2, EPA/240/B-01/002, 2001.
- USEPA Requirements for Quality Assurance Project Plans USEPAQA/R-5, EPA/240/B-01/003, 2001.
- Data Quality Objectives Process for Superfund: Interim Final Guidance, USEPA 540-R-93-071, 1993.
- USEPA Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, USEPA/540/G-89/004, 1988.
- Test Methods for Evaluating Solid Waste, Third Edition (Update III), USEPA SW-846, 1996.
- Requirements for the Preparation of Sampling and Analysis Plans, EM 200-1-3, 2001.
- Chemical Quality Assurance for Hazardous, Toxic, and Radioactive Waste (HTRW) Projects, EM 200-1-6, 1997.
- Validation of Analytical Chemistry Laboratories, USACE, EM 200-1-1, 1994.
- Guidance for the Data Quality Objectives Process, USEPA QA/G-4, EPA/600/R-96/055, 2000.
- Guidance for Quality Assurance Project Plans, USEPA QA/G-5, EPA/600/R-98/018, 1998
- Guidance for the Preparation of Standard Operating Procedures (SOPs) for Quality-Related Documents, USEPA QA/G-6, EPA/240/B-01/004, 2001.
- Guidance on Environmental Data Verification and Validation, USEPA QA/G-8, Peer Review Draft, 2001.
- Guidance for Data Quality Assessment, USEPA QA/G-9, EPA/600/R-96/084, 2000.

1.1 QAPP OBJECTIVES AND USE

The purpose of the procedures established in this QAPP is to ensure a formal and consistent approach to data collection/production by all suppliers and laboratories, and to enable

consistent data quality assessment and documentation. Specific objectives include the following provisions:

- Criteria and guidance for determining field and analytical procedures;
- Standard references and detailed specifications for all anticipated field, sampling, analysis, and data review procedures;
- Procedures for reviewing and documenting compliance with field analytical operations; and
- Procedures for communication among all participants.

1.1.1 Project Planning Documents

In addition to this reference document, there is an Arsenal-Wide Investigation Workplan. This Workplan will include site-specific Field Site Investigation Plans (FSIPs) that will identify the rationale for and the proposed sampling locations, numbers of samples, analytical methods, and field procedures required for each individual site within the Arsenal. Each site-specific FSIP will define the problem, or the question that needs resolution. The goal of the site-specific investigation will be clearly stated in the FSIP. Included in each FSIP will be site-specific DQOs that are utilized as a data quality planning and evaluation tool for field activities.

Utilizing the QAPP procedures in the development of each FSIP will ensure consistency throughout the investigations and will reduce repetition in document preparation and review. It will also enable efficient resource utilization.

The QAPP is required reading for all personnel participating in work under this FUDS project at the Arsenal. The QAPP and accompanying SOPs are to be in the possession of field teams for all field sampling efforts. All subcontractors are required to comply with respective procedures documented herein, and compliance is required and documented in each subcontractor's statement of work (SOW).

Site and project-specific DQOs presented in the FSIPs will be used to re-evaluate the qualitative and quantitative requirements of this QAPP for applicability to the project specific DQOs (in particular, the reporting limits relative to any new or updated action or screening levels). Site-specific changes or additions to procedures and criteria contained in this QAPP will be documented in individual site-specific FSIPs. Criteria specified in the site-specific FSIPs, when different from this QAPP, shall take precedence. Changes or additions to this QAPP that may relate to the Arsenal-Wide Investigation Workplan will be made in addenda or errata and will be sent to the entire distribution list attached to the front of this document.

A site-specific safety and health plan (SSHP) will also be prepared for each individual site to establish safety procedures, required levels of personal protective equipment (PPE), and field monitoring requirements in an effort to protect those performing the field work and those in the general vicinity of the field work.

1.2 PROGRAM AND PROJECT ORGANIZATIONAL STRUCTURES

The current organizational structure for this project is shown in Figure 1-1. This organizational structure provides the Program Manager (PM) with a dedicated organization, including Project Managers (PjM), technical and administrative support staff, and subcontracting managers. Other technical resources will be accessed on an as-needed basis.

This program organization is designed to provide a clear line of management responsibility and authority; facilitate delegation of authority to the management level responsible for completing work products; and maintain appropriate cost, schedule, and QC. The organization reflects strong technical and management leadership and integration across multiple task orders, and provides a direct line of communication between team managers and their USACE counterparts. The team lines of authority flow from the PM to the PjM to the respective support staff. This section addresses all general organizational items for the contract.

1.2.1 Program Management Responsibilities

The roles and responsibilities of the USACE contractors are described in the following sections. It is the responsibility of all management personnel who may affect the quality of environmental investigations, studies, operations, or other quality-related functions to be aware of and implement the quality policies and practices set forth by this QAPP. The PjM may delegate authority to appropriate personnel to assure activities are conducted in a compliant, cost-effective and timely manner. However, responsibility for the project will remain with the PjM.

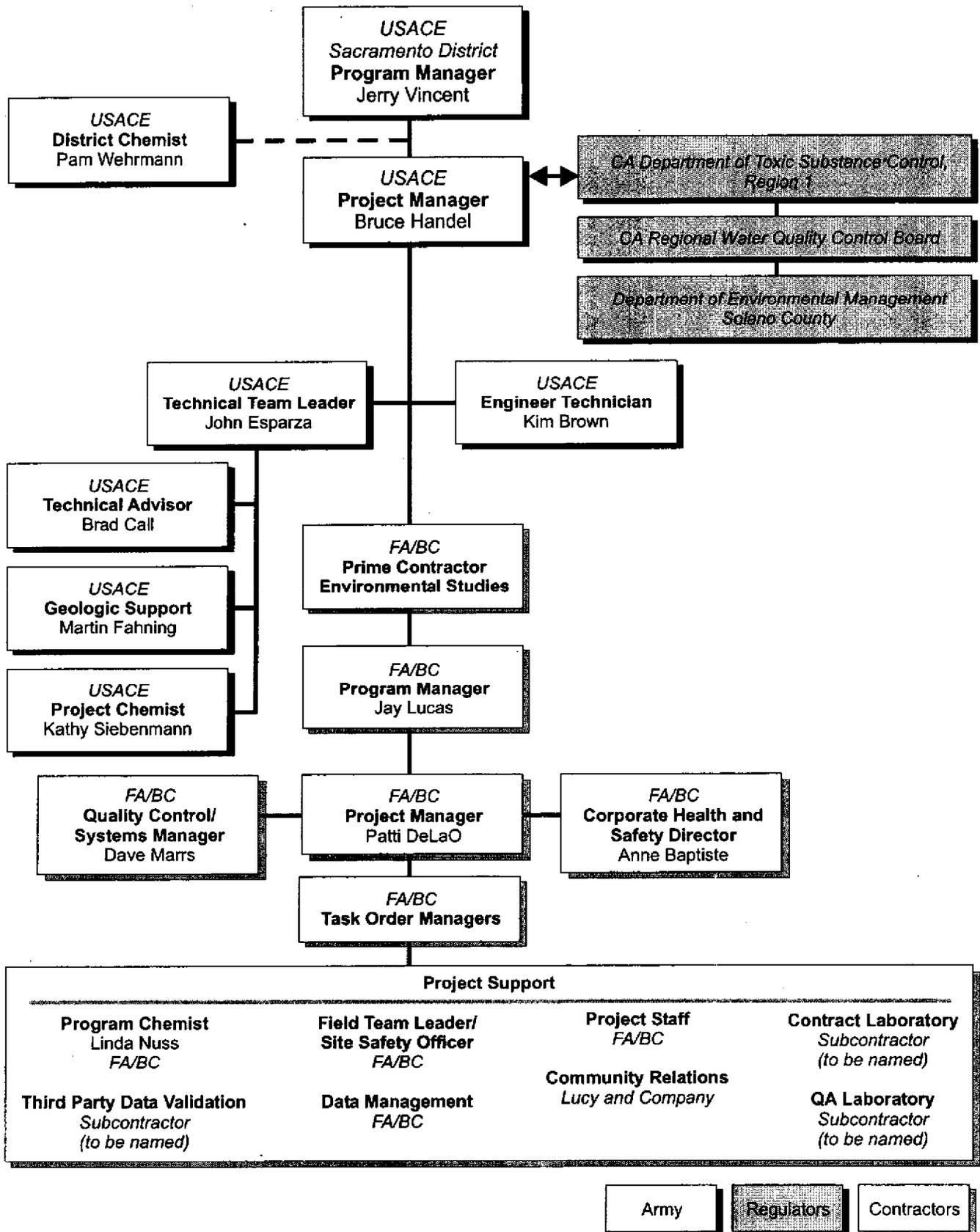
A summary of the responsibilities of project management personnel is provided below.

1.2.1.1 Program Manager

The PM is responsible for the overall direction, coordination, technical consistency, and review of the entire program. He/she will monitor the performance of all project staff through the PjM and Quality Control Systems Manager (QCSM). The PM will have the authority to select or dismiss staff; select or terminate major subcontractors; approve or disapprove budgets and schedules; stop work; and communicate with the USACE PM or his/her representative, as necessary, to evaluate the progress on any task and ensure the early resolution of any problem.

1.2.1.2 Project Manager

The PjM will report directly to the PM. The PjM will be fully responsible and accountable for all contractual activities, and will serve as the focal point and main channel of communication between USACE and the project team regarding technical, financial, and scheduling matters. Using Task Order Managers (TOMs), as appropriate, he/she will establish and interpret contractual policies; monitor schedule and cost; coordinate all reporting and other forms of communications; ensure necessary resources are made available; prepare long-range program plans; identify and resolve potential problems or conflicts; and provide for safe performance and quality of the work. Other duties, as appropriate, will include:



Project Management Organization Chart

Quality Assurance Project Plan
Benicia Arsenal

CURRENT (2001)

- Allocating work assignments, budgets, and schedules to members of the project team, and orienting the staff to the goals and objectives of the project;
- Evaluating the qualifications of project staff and critical subcontractor personnel, and identifying individuals who need additional training;
- Assigning Project Engineers to direct specific design projects and providing the necessary resources to these managers;
- Receiving, negotiating, and tracking the performance of projects;
- Reviewing, approving, and consistently implementing the contract planning documents (e.g., this QAPP, the SSHP, the FSIP, etc.);
- Assessing specific task orders for compliance with federal, state, and local regulations/laws, and directives;
- Providing overall technical, quality, and performance consistency throughout the contract;
- Identifying procurement needs and coordinating project procurements with procurement personnel for materials and services;
- Procuring and supervising subcontractors;
- Providing change order control;
- Providing document control;
- Interacting with regulatory or public agencies at the request of USACE;
- Disseminating program-related information from USACE;
- Preparing technical reports and presentations at progress meetings between the project team and USACE;
- Reporting any significant conditions adverse to quality and obtain concurrence by the QCSM on proposed resolutions;
- Selecting properly qualified and licensed Hazardous, Toxic, and Radioactive Wastes (HTRW) Transporters;

- Selecting properly qualified and licensed Treatment, Storage, and Disposal Facilities (TSDFs);
- Reviewing quality assurance audit reports and any resulting corrective action disposition; and
- Preparing and submitting Daily Quality Control Reports (DQCR) to USACE.

1.2.1.3 Quality Control Systems Manager

As part of the project organization, a QCSM will be appointed for sampling and analytical activities who will be directly responsible to the PjM. The QCSM will have knowledge of chemical QC and experience in the sampling and analysis of toxic/hazardous chemicals. The QCSM will be appointed by the PjM to be principally responsible for execution of all QC operations for field and laboratory activities.

The QCSM is responsible for the implementation of this QAPP and the site-specific FSIPs, and will provide overall direction of the contract QC function for field and laboratory activities. The QCSM, or her/his designee, will interface with the client and regulatory agencies on the quality functions of the program and will coordinate activities with the PjM. In addition, he/she will, as necessary, perform audits, surveillance, document reviews, and other quality functions as required to determine the continued effectiveness of this QAPP. The QCSM will, as necessary, audit compliance with this QAPP, and will perform QC review of select task order deliverables. Other responsibilities will include but will not be limited to:

- Adopting this QAPP for project requirements, and determining specific QC requirements with the PjM, including the selection of appropriate SOPs and other quality related procedures required to support project activities;
- Reporting regularly to the PjM on the status of QAPP implementation;
- Reviewing and approving site-specific FSIPs and procedures for quality issues;
- Providing quality orientation training and disseminating applicable quality information to the project staff;
- Maintaining the authority to stop work that is not in compliance with the contract;
- Coordinating all QC functions on the project to include assigning quality review staff and integrating the efforts of the Project Chemist (PjC) into the overall QC mission;
- Determining the project definable features of work and the required three phase inspections needed for maintaining QC on each definable feature of work;

- Conducting three phase inspections. For each inspection, provide 72 hour advance notification of preparatory and initial inspections to the USACE PM or his/her replacement; coordinate attendance of the PJM at preparatory inspections; write inspection meeting minutes; have all participants sign inspection minutes; attach the inspection minutes to the appropriate DQCR;
- Identifying the need for corrective actions, and initiating, recommending, and coordinating solutions for contract-wide quality issues. Maintain a formal corrective actions tracking system;
- Reviewing contract generated procurement documents to assure applicable quality requirements are adequately stipulated and followed;
- Performing periodic quality inspections of project records;
- Coordinating submittal of all quality related reports;
- Providing QC oversight of equipment preventive maintenance, decontamination, and calibration;
- Verifying the qualifications and licensing of HTRW transporters;
- Verifying the licensing and qualifications of TSDFs which will be used for disposal of HTRW wastes;
- Ensuring the "Complete Manifest Package" is completed and approved by USACE prior to HTRW waste shipment;
- Ensuring a certification is submitted to USACE certifying that the packaging, marking, labeling, handling, and placarding of hazardous wastes complies with federal, state, and local laws. The on-site person responsible for certification shall be trained in Department of Transportation regulations;
- Ensuring the "Hazardous Waste Manifest Annual and/or Biannual Reports" are prepared and submitted to USACE;
- Ensuring the "Transportation and Disposal Tracking Form" is properly prepared and filed;
- Ensuring there is a Manifest Tracking System being used which shows the information required in the "Exception Reports";
- Ensuring "Discrepancy Reports" and "Exception Reports" are submitted;

- Preparing SSHPs for individual sites;
- Coordinating the Program CIH Review of the SSHP and obtaining the CIH certification of the SSHP;
- Ensuring regulatory and operational compliance with Occupational Safety and Health Administration (OSHA) requirements, the SSHP, and Corporate health and safety requirements;
- Preparing site-specific SSHPs as necessary;
- Providing health and safety training and medical monitoring;
- Working with the PjM and the Field Team Leaders (FTLs) to ensure that all health and safety requirements outlined in the SSHP are implemented in the field;
- Performing assessments, monitoring, document reviews, and other health and safety functions as required to determine the continued effectiveness of the SSHP; and
- Performing random health and safety assessments in the field, and verifying resolution of any resulting corrective actions.

1.2.1.4 Task Order Manager

The Task Order Manager (TOM) will act as the primary assistant to the PjM to verify that the overall goals and objectives for the contract and specific task orders are clearly stated and communicated to participating personnel. Each TOM will be assigned to oversee and control a specific task order. They will provide technical and conceptual reviews of task order requests for proposals; advise the PjM on appropriate staffing; and will provide technical reviews of all task order cost estimates, work plans, reports and other technical documents, prior to submittal to USACE. He/she will provide direct oversight and coordination of task order operations including acting on the behalf of the PjM, as assigned. Other duties, as appropriate, include:

- Providing resolution of task order organizational, contractual, or other issues;
- Providing consultation on technical matters and maintaining consistency of technical direction across active task order projects;
- Reviewing task order project performance and project reports;
- Reviewing, approving, and implementing project planning documents and procedures;
- Coordinating resource needs with major subcontractors;

- Identifying, documenting, and notifying the PjM, the QCSM, and project staff of changes in the SOW;
- Reviewing procurement documents, design bases, specifications, drawings and final reports;
- Performing/coordinating the constructability review of design documents; and
- Reviewing QA reports and any resulting corrective action disposition.

1.2.1.5 Field Team Leader/Site Safety Officer

The FTL/Site Safety Officer (SSO) reports to the PjM and is responsible for project set-up in the field, including identifying and scheduling personnel resources, materials, and equipment. Each FTL is assigned to overview and control specific field activities, and is responsible for field cost tracking through administrators and project billing. The FTL will also conduct program control assessments and provide purchasing support for small purchases to initially start-up projects. As SSO, each FTL will provide the overall direction regarding matters of environmental protection, fire protection, occupational safety and health, industrial hygiene, personal protection from hazardous chemical exposure, and permitting for this contract. As the SSO, he/she has the organizational freedom and authority to require changes to work practices; identify problems and proposed solutions; and if necessary, stop work activities that could pose a threat to personnel or the environment. The SSO will coordinate activities with the PjM, as appropriate. Duties of the FTL/SSO include, but are not limited to:

- Starting-up field projects with the required resources, materials, and equipment;
- Directing all field activities, supervising field staff and any subcontractors, and ensuring that field procedures described in the FSIP/SSHP are implemented;
- Maintaining daily records of work performed, personnel on site, and any work stoppages or communications with other agencies pertaining to the project;
- Reviewing invoices against purchase order quantities and units;
- Obtaining appropriate signatures for purchase requisitions and invoices;
- Implementing government property controls for tracking government furnished equipment and contractor acquired equipment under this contract, by maintaining a complete and accurate listing of all government property, recording and tagging property, documenting use of government property during project operations, and conducting property inventories and final property transfers; and
- Managing equipment preventive maintenance, decontamination, and calibration programs.

1.2.1.6 Program Chemist

As part of the project organization, the contractor will appoint a Program Chemist (PC). The PC shall have general knowledge of remedial process chemistry, fate and transport of organic compounds and inorganic analytes, knowledge of chemical QC, experience in the sampling and analysis of toxic/hazardous chemicals and radiological contamination in environmental matrices. The PC will be required to have advanced expertise (senior level) in chemical data quality management of environmental analytical data. The PC will be principally responsible for oversight of all QC operations for field and laboratory activities related to sampling and analysis.

The PC will have a minimum of a 4-year college degree in Chemistry from an accredited post-secondary institution; a minimum of 10 years of professional experience in Chemistry of which a minimum of 7 years must be directly related to environmental investigations and/or remedial actions as a part of a Contractor management team (i.e., not primarily employed at a laboratory); and a minimum of 2 years experience at the level of a commercial environmental analytical laboratory with expertise in standard analytical chemistry methods common for analyzing soil, water, air and other materials for chemical contamination assessment.

The PC will take a lead role in management of project tasks associated with sampling and analysis including preparation of the CDQMP, preparation of SAPs, instruction of field personnel in sampling and preservation requirements, general oversight of field personnel involved in sampling activities, coordination with the analytical laboratory to ensure readiness to implement project specific requirements, participation in on site inspections of the Contract Laboratory, review of analytical data as it becomes available to ensure conformance with quality standards, implementation of corrective actions in accordance with these specifications when review of data uncovers deficiencies, and serve as a general point of contact for the USACE CO and/or PM for issues related to environmental chemistry. The PC will be employed or subcontracted by the contractor and will not be employed by a laboratory performing analyses for this contract. Additional duties include:

- Establish and use a correction tracking system for ensuring correction of field work and laboratory deficiencies.
- Ensure the contract laboratory is USACE validated for the expected project test methods by contacting the Project Chemist at USACE. The contractor will notify USACE three months prior to expiration of the laboratory validation.
- Ensure that the project laboratory holds current State certification for the project specific analytical test methods as applicable for the geographical location of the project site.
- Perform an audit of each contract laboratory at the beginning of the first task order to the laboratory. Thereafter, perform an audit of each laboratory every 18 months. The method specific checklists in EM200-1-1 and requirements of this QAPP will be used for these audits. Document these inspections with meeting minutes signed by participating personnel.
- Ensure the laboratory has a specific information management system for tracking the progress of each sample.

- Ensure the laboratory maintains a bound maintenance logbook for each piece of analytical equipment.
- Send a Memorandum of Findings for the above noted laboratory preparatory and initial inspections to USACE within 15 days after completing the inspections.
- Ensure the laboratory performs daily QC checks and records those checks appropriately for inclusion in data packages.
- Investigate and submit a Data Report to the USACE chemist when the USACE has identified significant deviations between the laboratory's results and those of the QA Laboratory.

1.2.1.7 Project Chemist

As part of the project organization, a PjC will be appointed. The PjC will have knowledge of environmental analytical chemistry methodologies as described in USEPA SW-846, and QC procedures as applicable to environmental analytical chemistry. The PjC will have a college degree in Chemistry, Chemical Engineering, or a related field, and have a minimum of four years of combined experience in an analytical laboratory or working as a member of a consultant project team. The PjC will report to the PjM and will interface with the QCSM for direction and support on analytical issues. All project chemistry related reports submitted to USACE will be submitted through the QCSM. Additionally, the PjC will interface with the FTL and provide direction and support for the project sampling activities including sample collection, handling, storage, preservation, and shipment. The PjC will be employed or subcontracted by the contractor and will not be employed by a laboratory performing analyses for this contract. PjC duties will include, but not be limited to:

- Assist the PC with the preparation of the project QAPP and site-specific FSIPs;
- Assist the QCSM with instruction of field personnel in the sample management techniques such as proper sampling containers, sample preservation, sample transportation, COC procedures, etc. included in this QAPP;
- Assist the QCSM in providing general oversight of field personnel involved in sampling activities;
- Keep the PjM informed of issues that affect data quality and the use of the data.
- Hold a kickoff meeting with the laboratory to discuss project requirements, schedule, contacts, etc. prior to the start of each discreet sampling activity.
- Ensure the samples taken meet the primary sampling, QC field duplicates, and QA split requirements;
- Ensure trip blanks are taken and submitted to the contract lab and the QA laboratory;

- Ensure the collection of equipment rinsate samples;
- Assist the QCSM in assuring preventive maintenance is conducted on facilities and instruments used for sampling and analysis;
- Ensure COC forms are provided to USACE whenever samples are shipped from the field site;
- Establish and use a correction tracking system for ensuring correction of field work and laboratory deficiencies;
- Ensure the contract laboratory is USACE validated for the expected project test methods and notify USACE three months prior to expiration of the laboratory validation;
- Perform an audit of each contract laboratory at the beginning of the first task order. Thereafter, perform an audit of each laboratory every 18 months. Document these inspections with meeting minutes signed by participating personnel;
- Send a Memorandum of Findings with the checklists used for the above noted laboratory preparatory and initial inspections to USACE within 15 days after completing the inspections;
- Phone or visit the contract laboratory at the beginning of each task order to ensure the laboratory is informed of impending work requirements and in making preparations to implement the methods and contract specifications required on the task order and this QAPP. Document this with meeting minutes attached to the DQCR maintained by the QCSM, and send a copy to the USACE PM or his/her replacement within ten days after completion;
- Ensure the laboratory has a specific information management system for tracking the progress of each sample;
- Ensure the laboratory maintains a bound maintenance log book for each piece of analytical equipment;
- Ensure the laboratory meets the accuracy requirements established in this QAPP;
- Ensure the laboratory submits raw data packages to USACE for 10% of all samples analyzed;
- Ensure draft Certificates of Analysis are submitted to USACE (if applicable) as soon as they are available (approximately 10 working days after sample shipment to the contract laboratory);

- Provide one comprehensive report to USACE for each distinct field sampling activity, as defined in each task order from the USACE; and
- Ensure a final Laboratory Comprehensive Certificate of Analysis is received by USACE no later than 21 days after the last sample is acquired in the field for the task order.

1.2.2 Subcontractor Responsibilities

Numerous contractors may be subcontracted by the primary contractor for specific work assignments under separate task orders of this contract. The types of assignments to be contracted may include analytical laboratory services, drilling services, and land surveying services. With respect to chemical data quality management, the laboratory QA program will play an important part in ensuring that valid data are obtained from the field sampling activities. QA for the laboratory's work will be overseen by in-house laboratory PjMs assigned specifically to this contract. These managers are responsible for ensuring that all analytical data generated under this contract are reviewed prior to their release (refer to Section 4.0 for data review, validation, and verification requirements).

1.2.2.1 Laboratory Validations

Prior to collection or analysis of any environmental samples, the contract laboratory shall be validated by the USACE HTRW-CX and certified in California, where the work will be performed. Laboratories are validated for each environmental matrix and each specific analytical method to be employed. If a selected laboratory has a current (within 18 months) validation for all analytes and matrices specific to this project, additional HTRW-CX evaluation will not be necessary. The USACE PM or his/her replacement shall be contacted to verify the status of the contract laboratory. If a selected laboratory does not have a current validation, the laboratory shall be validated prior to approval of the task order. (Note: HTRW-CX validation may take as long as three months to obtain.) A copy of the form to request certification of a laboratory by the USACE is presented in Figure 1-2. Samples will not be subcontracted by the contract laboratory to another laboratory without knowledge and approval of the USACE PM or his/her replacement, and the second laboratory must be validated. In addition, the contract laboratory shall be a participant in performance evaluation programs offered through private vendors, (i.e., WS and WP series) and similar programs if offered or mandated at the state level. Double-blind, matrix-specific performance evaluation (PE) samples shall also be submitted to participating laboratories by the contractor (refer to Section 3.2.1).

1.2.2.2 Laboratory Project Manager

Within each laboratory, the laboratory PjM shall provide direct interface with contractor personnel. This individual will have sufficient authority to assure that samples submitted from a project site are received and processed in accordance with their accepted quality management system. Responsibilities of the laboratory PjM will include, but not be limited to:

**Figure 1-2
Request for Evaluation of Commercial Laboratory**

TO: CENWO-HX-C

FROM: _____

DATE: _____

Project Name:			
Location:		State:	
Contract No:			
Type (Please indicate with an 'X' or a '✓'):			
POL Tank Removal:		HTRW:	
Program (Please indicate with an 'X' or a '✓'):			
Superfund		Army IRP	
FUDS		AF IRP	
Army BRAC		AF BRAC	
Other			
Phase (Please indicate with an 'X' or a '✓'):			
PA/SI		RFA	
RI/FS		RFI	
RD		CMS	
RA			

Approximate Sampling Dates:			
Start:		End:	
Project-Specific Sample Turnaround Time:			

USACE Technical Manager:			
Address:			
Phone:		FAX:	
USACE Chemist:			
Phone:		FAX:	

A-E/Contractor:			
City		State:	
Lab Name:			
Address:			
City, State:			
POC:			
Phone:		FAX:	

Required analytical parameters, methods (including extraction methods), and approximate number of samples to be taken for above project

PARAMETERS			No. of LIQUID SAMPLES	No. of SOLID SAMPLES
Name	Extraction Method	Instrument Method		

State or other laboratory certifications that will be required for this project: _____

Note: If the laboratory is planning to subcontract any samples to another laboratory or location, all of these laboratories shall be evaluated separately. This format should be sent for verification of laboratory status regardless of expiration date on the list of validated laboratories.

- Sample management, coordination, and tracking;
- Serving as the collection point for laboratory staff reporting and disposition of non-conformances and changes in laboratory procedures which affect project samples;
- Reporting Use-As-Is and rework non-conformances to the contractor PjM and PjC, and obtaining approval prior to implementation of disposition;
- Ensuring that all project analytical data packages are reviewed for conformance to established guidelines and data quality objectives (DQOs); and
- Maintaining established schedules for analytical results.

1.2.2.3 Laboratory Quality Assurance Officer

Within each laboratory, a laboratory Quality Assurance Officer (QAO) will be assigned, prior to the shipment of samples. The laboratory QAO is responsible for the day-to-day implementation of the laboratory quality management system and reports directly to the laboratory PjM. This individual shall have a minimum of a Bachelor's degree in Chemistry or any related scientific/engineering discipline, and a minimum of three years of laboratory experience, including at least one year of applied experience with QA principles and practices in an analytical laboratory. His/her responsibilities include, but are not limited to:

- Supervising laboratory QC activities;
- Preparation of QC standards, inserting QC samples into the laboratory sample stream, and analyzing the results;
- Performing statistical analyses utilizing the results of QC sample analyses;
- Stopping production of data in a laboratory area where the analysis of QC data indicates deviations which could adversely affect analytical data results;
- Overseeing sample storage, equipment calibration, preventative maintenance, and sample disposal protocol within the laboratory;
- Performing QA audits and surveillance of the implementation of the laboratory quality management system and reporting the results to the PC;
- Reviewing a minimum of 5 percent of project analytical data packages to verify conformance to established guidelines and DQOs; and
- Review and release of test data and results.

1.2.2.4 Subcontractor for Independent Review of Laboratory Data

A subcontractor for independent review of laboratory data will be selected based upon the qualifications and contractual requirements of the basic contract. This subcontractor shall validate laboratory data and submit validation reports to USACE and the contractor within 21 days of the time that the analytical packages are delivered to the data validation subcontractor. Egregious or recurrent errors in analytical work shall be reported by memorandum to USACE PM or his/her replacement and the contractor PjM as soon as they are discerned.

1.3 PROBLEM DEFINITION/BACKGROUND

The Benicia Arsenal was created in 1849 with a land transfer of 345 acres. Two additional land acquisitions followed several years later. The first came as a direct response to the hostilities in the Pacific in the early 1940s, and included a physical expansion of the Arsenal with the addition of 1847 acres. This expansion also included the addition of over 200 structures including machine shops, maintenance shops, fueling facilities, ordnance storage, and demolition/disposal facilities. The final expansion came in the early 1950s as a response to the Korean conflict. This final expansion included the addition of 530 leased acres and the construction of approximately 40 to 50 structures, many of which were large warehouses and transitory shelters. Over the 115-year history of the Arsenal, its primary mission was as a supply and distribution depot that stored, maintained, manufactured, repaired, distributed, and issued ordnance supplies to the United States Army as presented in Table 1-1.

Operations at the Arsenal included painting and sandblasting, engine rebuild, small arms repair, machine shop, fire control repair and maintenance, photographic laboratories, engine testing, welding, and blacksmith. These operations required the use of solvents (including Trichlorethene (TCE), Methyl Ethyl Ketone (MEK), and Stoddard Solvent), acid baths, preservatives, electroplating vats, paints, fuels, oils, and numerous other industrial chemicals. These chemicals, following their use in industrial operations, became industrial waste that was directly disposed of either into the landfill(s), storm drains, and/or sumps and sewer lines. Operations at the Arsenal also included the manufacturing, testing, and storing of ammunition throughout its history.

Following the closure of the Arsenal in 1964, and in an effort to fast-track economic recovery for the area, the City of Benicia purchased much of the land and buildings from the General Services Administration (GSA). Most of the land, buildings, and utilities were subsequently sold and/or leased to Benicia Industries, Inc. (BII), Humble Oil (presently Exxon Oil), Pacific Gas and Electric (PG&E), and Toyota Motor Sales. BII is currently developing the industrial park along the waterfront (Areas I and M). Exxon Oil operates an oil refinery in much of Areas S and M.

1.4 PROJECT DESCRIPTION

The purpose of the Arsenal-Wide investigation is to characterize the nature and extent of any DoD-related contamination at the Arsenal with the collection of defensible and appropriate field data.

For the purpose of this investigation, the Arsenal has been subdivided into the five following WIRMS areas based on the former military land uses:

- Area W Warehouse Area
- Area I Industrial/Manufacture Area
- Area R Revetment/Explosives Storage Area
- Area M Motor Pool and Historical Ordnance Storage Area
- Area S Igloo/Storage Area

**Table 1-1
Benicia Arsenal Historic Responsibilities**

Years	Military Period	Primary Responsibilities
1849-1859	Native American hostilities	Benicia Barracks, home to two Army divisions, was taken over by the Arsenal installation, first Ordnance Supply Depot in the west.
1860-1899	Civil War Spanish-American War	Proving ground for testing of various types of gunpowder manufactured on the Pacific Coast, cleaning and repairing of arms, guns and carriages; manufacturing holsters, ammo boxes and chests; packing ammunition; principal repository and distribution point of ordnance, and ordnance stores of the Pacific Coast.
1900-1939	World War I	Storage, issuance and repair of Army ordnance; principal distribution and maintenance depot for military arms and equipment on the West Coast; manufacture of targets and target materials for firing practice by seacoast artillery, mobile or field artillery and small arms; assembling powder charges and fixed ammunition; modification of armor-piercing projectiles; parts fabrication for repair or replacement of seacoast artillery material; repository for returned supplies from war efforts.
1939-1950	World War II	Major expansion of the Arsenal involved the construction of a concrete wharf capable of docking four ocean-going vessels simultaneously; 109 ammunition storage bunkers; several warehouses; shop building for rebuilding of combat and artillery vehicles; numerous shop building additions. Arsenal responsible for supplying the Pacific Ports of Embarkation with small arms, automatic weapons, light field artillery, field artillery, mobile anti-aircraft artillery, heavy field artillery, fire control instruments, tank and gun motor carriages, parts supplies, tools and equipment for weapons, tanks, and fast-moving items of fire control instruments. Rebuild, reclaim, and modify all forms of artillery and weaponry. Transshipment depot for storage and holding of all classes of ammunition and explosives for the Port of San Francisco (including 500-pound bombs). Physical Arsenal expansion from 345 acres to 2,192 acres.
1950-1953	Korean Conflict	Field Ordnance Supply operations for the West Coast following release of Stockton Ordnance Depot as Sub-Depot to Benicia; transshipment facility; maintenance of general supplies, field artillery, armored and half-track cars and combat vehicles; rapid expansion in rebuilding operations; proving ground for 155mm howitzer tubes manufactured under contract by Yuba Manufacturing Company. Peak civilian employment of nearly 7,000.
1954-1959	Far East hostilities	Shop established for the reconditioning, maintenance and repair of NIKE guided missile propellant systems and internal guidance systems; became a point of anti-aircraft defense of the San Francisco Bay area with NIKE missiles secretly placed atop the Arsenal's hills. Tire Rebuild Branch in operation rebuilding and recapping tires; extensive rebuild of artillery, as well as transport, general purpose, and combat vehicles, and general supplies requiring maintenance-in-storage; storage and issuance of missiles (less their explosive components and fuels); manufacture of "O" rings for guided missiles in Rubber Production Shop; extensive property disposal.
1960-1964	Far East hostilities and closure	Ordnance Supply Depot, involving the storage, stock control, maintenance and distribution of general ordnance supplies and equipment for Army, Air Force, National Guard, Navy and Marine Corps; made urgent shipments to South Vietnam; functional testing of artillery material and calibration of ordnance test equipment and calibration standards; W-1 and W-2 moved to new location for vehicles previously stored in open; inactivation manual established for shutdown scheduled for 30 March 1964; 30 September 1962 guided missile rebuild operations complete; Arsenal operation with skeletal force. Arsenal closed 30 March 1964.

Source: History of Benicia Arsenal
Benicia, California
Josephine W. Cowell, 1963.

- Within each of the WIRMS areas the DoD conducted activities at specific individual sites/facilities which, for the purpose of this investigation, have been grouped into the following use categories:
- Storage and Warehouse
- Ordnance and Ammunition Handling and Storage
- Maintenance, Repair, Paint-Facilities, and Carpenter Shops (Maintenance and Workshops)
- Fuel Facilities
- Landfills and Dumpsites
- Burn Sites
- Septic Sewer, and Storm Drains (points of DoD waste discharge) (Subsurface Utilities)
- Potable Water Facilities and Utilities
- Offices, Barracks, Hospital, Fire Houses (Multi-use)

Each of the above categories is expected to be associated with a definable suite of chemicals related to the DoD activity(s) identified therein. The chemicals to be investigated are identified as COPC and are categorized as follows:

- Metals
- Pesticides
- Halogenated and fuel-related volatile organic compounds (VOCs), including solvents
- Acids and bases
- Polychlorinated biphenyls (PCBs)
- Petroleum, oil and lubricants (POLs)
- Semi-volatile organic compounds (SVOCs)
- Polynuclear aromatic hydrocarbons (PAHs)
- Explosive residuals
- Reducing agents such as hydrazines

Table 1-2 presents a matrix that identifies each individual WIRMS area with the identified use category(s), and the COPC category(s). The COPC provided are conceptual, and actual analytical schedules (to be provided in site-specific FSIPs) will be based on records review and chemical-specific evidence found during preliminary on-site observations. Specifically, analyses for nonvolatile COPC (e.g., pesticides, metals, etc.) will be based on evidence of point source contamination associated with DoD operations and land usage (e.g., potential for metals found in small arms alloys, etc.). Likewise, sampling matrices will be on a site-specific basis, and may include surface soil, subsurface soil, groundwater, surface water, and near-grade soil gas, as warranted by preliminary evidence. Field investigation will not proceed until a site has been cleared of unexploded ordnance (UXO) by qualified ordnance disposal personnel.

**Table 1-2
WIRMS Area COPC Identification**

WIRMS area	Use category	COPC
Area W	<ul style="list-style-type: none"> • Storage and Warehouse • Ordnance and ammunition handling and storage • Maintenance, and workshops • Fuel facilities • Subsurface Utilities • Potable Water Facilities and Utilities • Multi-use 	Solvents, VOCs, POLs, acids and bases, reducing agents, explosives, metals
Area I	<ul style="list-style-type: none"> • Storage and Warehouse • Ordnance and ammunition handling and storage • Maintenance, and workshops • Fuel facilities • Landfills and dumpsites • Subsurface Utilities • Potable Water Facilities and Utilities • Multi-use 	Solvents, VOCs, POLs, acids and bases, reducing agents, explosives, metals
Area R	<ul style="list-style-type: none"> • Storage and Warehouse • Ordnance and ammunition handling and storage • Landfills and Dumpsites • Burnsites • Subsurface Utilities • Potable Water Facilities and Utilities 	Explosives, metals, solvents, VOCs
Area M	<ul style="list-style-type: none"> • Storage and Warehouse • Ordnance and ammunition handling and storage • Maintenance, and workshops • Fuel facilities • Landfills and dumpsites • Burnsites • Subsurface Utilities • Potable Water Facilities and Utilities • Multi-use 	Solvents, VOCs, POLs, acids and bases, reducing agents, explosives, metals
Area S	<ul style="list-style-type: none"> • Storage and Warehouse • Ordnance and ammunition handling and storage • Maintenance, and workshops • Landfills and Dumpsites • Multi-use 	Explosives, metals

POLs = Petroleum, oils and lubricants

VOCs = Volatile organic compounds

As described in Section 1.1, an FSIP will be prepared for each site. The FSIPs will include a discussion of the specific scope of work to be performed, including a description of the problem(s) at each site, and how the project will resolve the problem.

A specific description of the sampling to be carried out for each site-specific project shall be included. The following items will be described in each FSIP:

- Measurements that are expected during the course of the site-specific investigation and the approach that will be used;
- Applicable technical, regulatory, or program specific quality standards, criteria, or objectives;
- Any special personnel and equipment requirements that may indicate the complexity of the project;
- Description of the work site including an area map, location map, and site map, site history as it relates to the current work, and any unusual conditions;
- Diagrams detailing areas to be sampled as relevant to the definition of the investigative goals; and
- Sufficient information about the problem, the past history, pertinent previous work or data to present a clear description of the project objectives.

Refer to Section 2.1, Sampling Process Design, for more detail regarding FSIP requirements.

1.5 DATA QUALITY OBJECTIVES

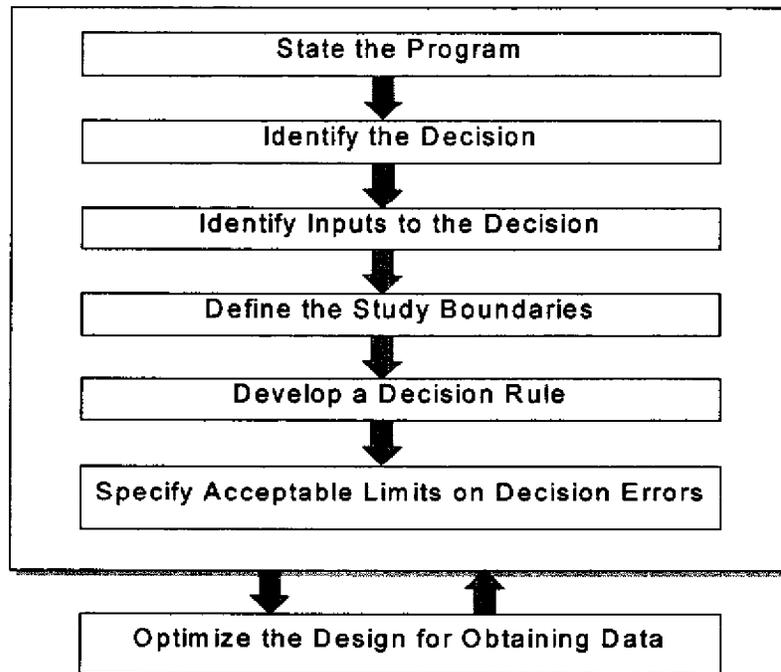
The DQOs for this project will be provided in the site specific FSIPs. The development of DQOs will follow the seven-step planning process outlined in "Guidance for the Data Quality Objectives Process," USEPA QA/G-4. This process will generate a series of qualitative and quantitative statements that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decision-making. These DQOs will also be used to select the approach for sample collection, sample analysis, and QA/QC which will result in the required chemical data. Consideration will be given to the application of QA/QC parameters: precision, accuracy, representativeness, comparability and completeness. The extent of analytical effort and data validation procedures to be required will be specified. The DQOs seven steps will address the following topics in the following order:

- Problem Statement: Summarize the problem that requires environmental data acquisition, and identify the resources available to resolve the problem. The statement of the problem shall be defined quantitatively if possible.

- Decision Identification: Identify the decision that requires acquisition of environmental data to address the problem. Identify the intended uses of data projected to be acquired. Data uses shall be prioritized. The identification of decisions and descriptions of data use shall be described with text and supported with tables and lists that describe: (1) the data needs, measurement parameters, compounds, and sample matrices, (2) the action levels or standards upon which decisions will be made, including the quantitation limits and data reporting units for relevant parameters if the quantitation limits or units differ from those parameters in this QAPP, and (3) the acceptable level of confidence in the data needed for the stated purposes, or the acceptable amount of uncertainty.
- Identification of Inputs to Decisions: Identify the information needed to support the decision, and specify the inputs requiring environmental measurements.
- Definition of Study Boundaries: Specify the spatial and temporal aspects of the environmental media that the data must represent to support the decision.
- Development of Decision Rules: Develop a logical statement that defines the conditions that would cause the decision-maker to choose among alternative actions.
- Specification of Limits on Decision Errors: Specify the decision-maker's acceptable limits on decision errors, which are used to establish appropriate performance goals for limiting uncertainty in environmental data. The specification of limits on decision errors shall be described quantitatively wherever possible for all categories of environmental data.
- Optimization of Investigation Design for Obtaining Data: Identify the most resource effective sampling and analysis design for generating data that are expected to satisfy project DQOs. Specifications for data quality shall describe exactly how such quality shall be measured and interpreted. The text shall describe in quantitative terms the sensitivity (e.g., quantitative, qualitative, screening), precision, accuracy, and completeness goals for each major measurement parameter and for each matrix to be sampled. A qualitative discussion shall be presented regarding representativeness and comparability.

The DQO seven-step process is iterative, and as such, outputs from one step may influence prior steps and cause them to be redefined. This process necessarily leads to a more efficient data collection design. The seven distinct steps are summarized in Figure 1-3.

**Figure 1-3
DQO Seven-Step Process**



Statements of the problem will be defined quantitatively, as applicable. Identification of decisions and descriptions of data use will be described with text and supported with tables and lists that describe the following:

- Data needed. Measurement parameters, compounds and sample matrices;
- The action levels or standards upon which decisions will be made, including the quantitation limits and data reporting units for relevant parameters if the quantitation limits or units differ from those presented in this QAPP;
- The summary statistic(s) which specify the form the data will be in when compared against action levels or standards; and
- The acceptable level of confidence in the data needed for stated purposes; or the acceptable amount of uncertainty.

The USEPA has defined quality levels (USEPA/540/G-93/071) for consistency in the field and laboratory activities. Data quality levels (analytical levels based on the end use of the data) are determined by the methods of analysis and the level of QC and documentation used to produce the data. To guide analytical planning during DQO development, two general analytical data quality categories have been defined by the USEPA: (1) screening data with definitive

confirmation and (2) definitive data (encompassing analytical levels 2 through 5 as defined in the USEPA's previous version of the DQO Guidance).

Screening data with definitive confirmation includes data produced by rapid field-screening methods that are less accurate than standard analytical methods, often with less rigorous sample preparation. A screening-level method, such as total petroleum hydrocarbons (TPH) determination by immunoassay, may be used. However, for this project, at least 10 percent of the samples analyzed by field-screening methods must be confirmed by analysis using definitive methods and accompanying QA/QC procedures. Confirmation samples must be selected to include both detected and non-detected screening method results.

The use of screening data with definitive confirmation allows for collecting large numbers of samples cost effectively, while confirming identification and quantitation of any contaminants detected and the absence of contamination. In many cases, a larger number of less accurate screening results can better minimize the total error or uncertainty associated with characterizing a site than can a smaller number of more accurate, definitive results. Most importantly, field-screening data without accompanying confirmation data are not considered data of known quality. Appropriate uses for confirmed field-screening data include initial risk assessment, site characterization, preliminary engineering design alternatives and on-site worker exposure. If the agreement between the screening data and the definitive confirmation analyses is very good, the combined data set may be treated as definitive data and used for final risk assessments and site closures as well.

Definitive data are typically produced using standard USEPA or other reference methods, usually in an off-site laboratory. (Some laboratories are certified to perform definitive analyses in a mobile laboratory.) However, Performance Based Measurement Systems (PBMS) may be used to produce definitive data in some instances. PBMSs may employ completely different chemistries or detection systems from those identified in current standard reference methods; may alter sample preparatory or determinative procedures that enhance or inhibit extraction/digestion or signal efficiency; or may encompass only minor modifications to a standard method instrument configuration.

Due to this inherent flexibility, additional effort is necessary in the planning and executing phases to ensure successful implementation of performance-based methods. ***This may include any or all of the following: establishing and maintaining proper PBMS documentation (i.e., method standard operating procedures (SOPs), records of data analyses/results); USACE and regulatory agency review/approval; evaluation of method performance via DQOs; and comparison of PBMS data to data generated from a standard reference method.*** Before implementation of performance-based methods, the analytical service provider must establish the capabilities of the method/technique, to include selectivity, sensitivity, range of detection, precision, and bias. These are evaluated against performance criteria established by USEPA, State regulatory agencies, or the technical project planning team to assess the usability of the PBMS or performance-based method.

In the event that the method capabilities do not meet project requirements, differences shall be reconciled prior to project execution. Reconciliation may require modifying the selected method, choosing an alternative method or techniques, or modifying the project DQOs.

Definitive data are analyte specific, and both identification and quantitation are confirmed. These methods have significant QC and documentation requirements, providing the information to verify all results. Definitive data are not restricted for any use unless quality problems are documented and result in specific data use limitations (qualification) or data rejection. Data uses include risk assessment, site characterization, evaluation of remedial alternatives, and engineering design.

1.6 DOCUMENTATION AND RECORDS

The following section describes field and laboratory record-keeping procedures.

1.6.1 Field Documentation

Field records will be recorded daily in permanently bound and numbered notebooks. Covers will indicate the project name and number, start date, and end date. All entries are dated and initialed by the individual making the entry. Information to be included in the logbook is specified in SOP 1.0, Field Logbook. Additional documentation may include project notes, conversation documentation and accident reports/safety violations. Site and field activity photographs will be taken and included as part of the project record. The following information is recorded for all activities:

- Location
- Date and time
- Personnel
- Weather conditions
- Sample type and sampling method
- Sample description/location
- Description of special conditions that might affect representativeness of sample
- Calibration activities, with reference to appropriate calibration forms
- Field measurements

A single field notebook may be used by all field personnel. Calibration information for field instruments may be recorded in the field notebook or on Equipment Calibration Forms that are filed with documents from each field event, at the preference of the contractor. If separate forms are used, these forms shall be referenced in the field notebook.

Each soil boring will be documented by means of a standardized boring log. The lithology of all boreholes will be recorded on a standard boring log form in accordance with SOP 2.0, Boring Log Development and SOP 3.0, Field Classification and Description of Soils.

1.6.2 Data Reduction, Validation and Documentation

The following will be provided for each analytical method and major measurement parameter:

1.6.2.1 Calculations

In most cases, calculations from raw data are addressed directly in the analytical procedures. For this reason, details regarding the data analysis scheme, including units and equations required to calculate concentrations or the value of the measured parameter, will not be presented in this document. However, details of data reduction and documentation are discussed below.

All information used in the calculations (e.g., raw data, calibrations, tuning records, results of standard additions, interference check results, and blank or background-correction protocols) and all information regarding the preparation of the sample (e.g., weight or volume of sample used, percent dry weight for solids, preparation ratio, dilution factor used) are maintained in order to reconstruct the final result at a later date, if necessary.

Calculations not present on standard reporting forms include computer-based data reduction programs. Computer programs and spreadsheets developed at the laboratory to aid in the reduction of data must be validated, with appropriate documentation, prior to use. The laboratory is responsible for maintaining a list of these data reduction programs and for being able to demonstrate their validity. The complete calculation procedures used in computer-based data reduction programs (e.g., GC/MS and GC analyses) are based on the calculation procedures specified in each method.

Some instruments are configured to operate independently, without computer download of data. For these, the signal is recorded as a strip chart trace, numerical output on a printer strip, or direct reading from a digital or analog dial. In such cases, additional work is required by the analyst to reduce the data to a reportable format. The original signal must be multiplied by a calibration factor or compared with a standard curve. The aliquot result must be divided by the mass or volume of sample to produce a concentration-based final result. Most calculations are carried out on hand-held scientific calculators; simple programs (e.g., spreadsheets) are used for some. All of these data are recorded in a dedicated laboratory notebook or bench sheet for the particular determination in question. Results for single or multiple component tests are hand entered by the analyst in the assigned book.

Some laboratory tests, such as titrations or sensory evaluations, do not have instrument raw data. For these, the quantitative result or observation is recorded directly in a bound laboratory notebook or bench sheet by the assigned analyst. Calculations like those described above may be needed; these are also recorded in the same laboratory notebook.

1.6.2.2 Procedures to Ensure Data Integrity

Criteria will be used to assure data integrity during the collection and reporting process as identified throughout this document. Included in the criteria are the strict adherence to procedures and protocols provided for the collection of field data and samples, and for the laboratory analyses and reporting process. Each step of the process will be detailed in the FSIP, and will be provided in sufficient detail as to form the basis for auditing of the various tasks involved throughout the process. The FSIP will also identify possible matrix interferences for laboratory analyses attributable to site characteristics, and methods for compensating for expected or unexpected interferences will be discussed with the laboratory QA Manager prior to initiating any sampling and analyses program.

1.6.2.3 Treatment of Outliers and Corrective Action Plans

The following section describes the specific mechanisms employed when outlier data are identified:

Field Data. Field data that fall outside of the historic range for a given parameter, show in excess of 50% departure from a historically established trend, or show disagreement with duplicate measurements beyond allowable tolerances in field instrument precision, will be followed up at the direction of the QCSM or the USACE with one or more of the following corrective actions:

- Datum is annotated;
- FSIP documentation is reviewed for adherence to QA/QC procedures;
- Measurement is repeated to check the error;
- Duplicate sample is measured;
- Equipment calibrations are checked and/or repeated;
- Measuring device is repaired or replaced; and/or
- Sample is re-collected and analyzed.

This process will be documented in the field logbooks and noted in the QCRs, and in the quality control summary reports (QCSRs).

Laboratory Data. Outlier data generated during the contract laboratory analysis process are identified by the numerous QA/QC procedures built into the sample data management systems utilized throughout the tracking process. An effective QA program requires rapid, effective, and thorough correction of QA and QC issues. Effective action minimizes the possibility of providing data of unknown or insufficient quality. Corrective actions are described in general terms below. Method-specific corrective actions are discussed in relevant sections.

The contract laboratory(s) direct the corrective action when problems that affect product or service quality are identified and are ultimately responsible for developing solutions that are consistent with accepted scientific practices and which produce data of known and acceptable quality.

Once a situation has been identified as producing marginal or non-compliant data, the cause of the problem will be identified. Corrective action requires defined responsibilities for scheduling, performing, documenting, and demonstrating the effectiveness of the action. It is the responsibility of the contract laboratory to work with the QCSM to develop a plausible corrective action plan. The plan is tested, if possible, to determine whether the action results in the production of compliant data by eliminating the problem.

A Corrective Action Report (CAR) is used to document all corrective action plans. The form may be initiated by the contract laboratory. CARs will be kept on file.

If the non-conformance has affected any data and it is not possible to complete the corrective action plan and produce compliant data, the contract laboratory and the QCSM will contact the USACE PM [or his designee] and the PjC who will then decide what further action, if any, need be taken. If further action is technically warranted but is out of contract scope, the USACE CO must be contacted for approval prior to starting work.

1.6.2.4 QA Samples

The QC and QA samples will be collected and analyzed by the contract laboratory and the USACE QA laboratory, respectively. These QC and QA samples include splits or replicates of field samples, rinsate blanks, trip blanks and background soil and ground water samples. QC samples, which represent approximately 10%-15% of the field samples, help the prime contractor to identify and diagnose problems related to sampling and analysis. QA split samples, which represent approximately 10% of the field samples, are sent to a USACE QA laboratory for government monitoring of sampling and contract laboratory performance.

1.6.2.5 Laboratory Data Management

The selected contract laboratory(s) will use an integrated local area network of computer hardware. The system will collect, reduce, and distribute information and data within the laboratory. The laboratory information management system will utilize technology between several operating systems. The information management system will utilize a network which provides sample tracking, results database, custom electronic and hard copy reporting and data management services.

All analytical records, including QC data, are generated and stored as described in the following subsections. At a minimum, all steps of sample preparation and analysis must document the laboratory sample number, the responsible analyst, date, sample weight or volume information with appropriate units, and any cross references, such as QC, necessary to fully reconstruct the documented analytical trail. Detailed SOPs for all methods that include data handling procedures are maintained and are available to each analyst. The contract laboratory is responsible for ensuring adherence to these procedures. The contract laboratory is responsible for routinely auditing all records and logs and reporting deficiencies for corrective action.

Organic Analyses Data Reduction. The sample preparation (extraction) associated with organic analyses shall utilize method-specific bound notebooks to record all data associated with sample extraction and/or preparation. Alternatively, the process can be documented in a computerized database and a batch report used as documentation of the preparation process. In either case a copy of the record is transferred to the appropriate analyst with the sample extracts and becomes part of the permanent record.

The GC and GC/MS analyses may utilize either computer generated sequence files or instrument-specific bound logbooks for injection data. Computer generated quantitation reports, chromatograms, and/or mass spectra are filed by analytical batch number. The analytical and QC results are transferred to work sheets and reviewed by the analyst before submittal to the Group Leader, or designee, who approves the data and transfers it to the appropriate project file where it is maintained. Data generated using an infrared (IR) spectrometer are maintained in a similar manner.

Metals and General Chemistry Analyses Data Reduction. A bound notebook issued to record all data associated with sample designation and preparation associated with metals analyses. A method number designation of inductively coupled plasma (ICP), flame atomic absorption (FLAA), and/or graphite furnace atomic absorption (GFAA) digestion performed is recorded by batch in the notebook. A separate logbook is maintained for all cold vapor atomic absorption (CVAA) spectroscopy sample preparation. A copy of the appropriate digestion logbook is transferred with the digested samples to the analyst and after that, with the analytical data to the Group Leader.

Records for tests using non-automated general chemistry techniques are maintained in method-specific notebooks. A copy of the notebook pages is submitted to the Group Leader for review along with the reduced final result, which is recorded on an analytical worksheet.

1.6.2.6 Data Archiving

The specific procedures involved in archiving laboratory data include hard copies, computer hardware and disk copies. The computer tape and hard copy for storage are to be maintained within a secured building. Each contract laboratory must store the data and reports for a period of ten years. Hard copy data over a year old generally are stored in a secure off site location and are accessible by box number on a database within the contract laboratory data management system. Each contract laboratory must retain the capability to reconstruct data for a period of ten years.

Magnetic Tape or CD-ROM Storage (GC and GC/MS Data). Each participating laboratory will be required (where applicable) to retain and archive all project GC and gas chromatograph/mass spectrometer (GC/MS) data on magnetic tape or compact disk-read only memory (CD-ROM) under secure conditions, including controlled access and protection from fire and water damage, for a minimum of ten years. The laboratory shall provide the tapes to the USACE or USEPA, upon request, for review and evaluation. Laboratory audits by the contractor (both quality systems and project-specific audits) will include verification of laboratory compliance with QA/QC requirements for archiving/retrieving GC and GC/MS data stored on magnetic tape or CD ROM.

1.6.3 Summary Certificate of Analysis

The Laboratory will address the following requirements in preparing a Comprehensive Certificate of Analysis (considered equivalent to USEPA Level III and definitive analyses).

- A Cooler Receipt Form (Figure 1-4) or it's equivalent shall be completed by the laboratory documenting sample conditions on arrival at the laboratory. Original copies of Cooler Receipt Forms, as well as original copies of COC forms, will be provided with the Certificate of Analysis.
- For each analytical method, the laboratory will report all analytes as a detected concentration or as less than the specified detection limit. All samples with out-of-control spike recoveries being attributed to matrix interference will be designated as such. All soil samples will be reported on a dry-weight basis with the percentage moisture

reported for each sample. Dilution factors, date of preparation, date of analysis, and practical quantitation limits will be reported for each analyte and method.

- Reports of method blanks will include all analytes for each analytical method. Analytical results for each sample will be clearly associated with a particular method blank. Any detected concentration found in method blanks will be reported. Reports of concentrations below the technical detection limit are necessary to evaluate low level determinations of target compounds in samples.
- Surrogate spike recoveries will be reported for all applicable methods. The report will also specify the control limits for surrogate recoveries agreed to for that specific project. Any out-of-control recoveries will require that the corrective actions listed in Appendix B be initiated. If subsequent analyses result in out-of-control recoveries, both results will be reported and the data flagged.
- Matrix Spike/Matrix Spike Duplicate (MS/MSD) recoveries and Relative Percent Differences (RPDs) will be reported for all analyses. MS/MSD analyses not meeting QC criteria specified in this QAPP will require that the corrective actions listed in Appendix B be initiated. If subsequent analyses result in out-of-control recoveries, both results will be reported and the data flagged. Only Benicia task order samples will be used for MS/MSD analyses when required. The contract laboratory will not use samples from other projects for MS/MSD analyses to meet the 1 in 20 MS/MSD requirement. However, batches that do not contain a Benicia sample MS/MSD may include samples from other projects for MS/MSD analyses. The report will also specify control limits for spike recoveries and RPDs for each spiked analyte agreed to for that specific project.
- Results for laboratory duplicates will be reported with RPD limits for duplicate analyses agreed to for that specific project;
- LCS results will be reported with recovery and RPD control limits for these analyses agreed to for that specific project;
- Analytical results for each sample will be clearly associated with that particular sample;
- Analytical results for each sample will be clearly associated with the appropriate preparation (where applicable) and analytical batch.
- Results of initial and continuing calibration analyses for all analyses will be included in the data package. Continuing calibration results will be organized such that sample results will be clearly correlated with the calibration check samples that bracket the sample results. Inclusion of an injection record with the data package will facilitate compliance with this requirement. Summaries of calibration data should be provided as contract laboratory program (CLP) Form VI and VII or equivalent for organics analyses and Form II modified for SW-846 analyses for inorganics. Copies of pages of handwritten laboratory notebooks will be unacceptable to fulfill the requirements of these specifications.

**Figure 1-4
Sample of a "Cooler Receipt Form"**

COOLER RECEIPT FORM

Project: _____ Date Received: _____

PRELIMINARY EXAMINATION PHASE:

Date cooler was opened: _____ By (print): _____ Sign: _____

1. Did cooler come with a shipping slip (airbill, etc.)? Yes No

If YES, enter carrier name and air bill number here: _____

2. Were custody seals on outside of cooler? Yes No

How many & where: _____, seal date: _____, seal name _____

3. Were custody seals unbroken and intact at the date and time of arrival? Yes No

4. Were custody papers sealed in a plastic bag and taped inside to the lid? Yes No

5. Were custody papers filled out properly (ink, signed, etc.)? Yes No

6. Did you sign custody papers in the appropriate place? Yes No

7. Was project identifiable from custody papers? Yes No

If YES, enter project name at the top of this form.

8. If required, was enough ice used? Type of ice: Yes No

9. What was the cooler temperature upon receipt? Yes No

10. Have designated person initial here to acknowledge receipt of cooler _____ Date: _____

LOG-IN PHASE:

Date samples were logged in: _____ By (print): _____ Sign: _____

1. Describe type of packing in cooler _____

2. Did all containers arrive unbroken and were labels in good condition? Yes No

3. Were all container labels complete (ID, date, time, preservative, etc.)? Yes No

4. Did all container labels agree with custody papers? Yes No

5. Were correct containers used for the tests indicated? Yes No

6. Were correct preservatives added to the samples? Yes No

7. Was a sufficient amount of sample sent for the tests indicated? Yes No

8. Were bubbles absent in VOA samples? If NO, list by QA#: _____ Yes No

9. Was the Project Chemist called and status discussed? Yes No

If YES, who was called? _____ By whom? _____

Provide details on the back of this form.

- The Comprehensive Certificate of Analysis will contain a narrative section identifying samples not meeting QC criteria and any other out-of-control condition. The narrative will describe the corrective action taken. If "matrix effects" are invoked as a cause for out-of-control recoveries, a subsection of the narrative will present a detailed justification for this assertion including, but not limited to, a summary of all relevant QC data.
- For dual column or dual detector methods, a summary of both results, the reported result, and the RPD between the results must be presented. When the RPD exceeds 40%, the higher result must be reported, in compliance with SW-846 unless chromatographic interference can be shown on the column/detector with the higher results. When the RPD exceeds 40% for values above the PQL, the reason for the high variability should be discussed in the case narrative (see Table 2-3).
- Chromatograms for all fuels, PAH and pesticides analyses, presented at an attenuation where features of the chromatography are clearly visible, will be submitted for all projects involving those analyses by gas chromatography. Chromatograms of standards used for identification of fuels must also be included in the data package.
- For TPH analyses, the analyte ranges used for quantitation (e.g., C10-C24) shall be listed in the report, preferably on the 'Form 1s'.
- For 8260 and 8270 analyses, when requested, a library search shall be executed for the 10 largest non-target sample components (Tentatively Identified Compounds [TICs]) for the purpose of tentative identification. For this purpose, the NIST/EPA/NIH library shall be used (May 1992 version, or later).

1.6.4 Raw Data Packages

Raw data packages shall consist of a case narrative, COC documentation, summary of results for environmental samples, summary of QA/QC results, and the raw data. Detailed descriptions of the requirements for each component of a raw data package are provided in the following sections. Raw data packages (considered equivalent to USEPA CLP deliverables) shall be submitted to the contractor and USACE for 10 percent of all samples analyzed by the contract laboratory. The contractor will be informed by the USACE PM or his/her representative (after samples have been submitted to the laboratory) of the data sets for which raw data packages shall be required. Raw data packages shall be delivered with the Comprehensive Certificate of Analysis.

1.6.4.1 Organic Analyses

The raw data package for organic compounds analyses will consist of a case narrative, COC documentation, summary of results for environmental samples, summary of QA/QC results, and the raw data. Detailed descriptions of the requirements for each component of an organic compounds raw data package are provided in the following sections.

Case Narrative. The case narrative will be written on laboratory letterhead and the release of data will be authorized by the Laboratory Manager or designee. Items to be included in the case narrative are the field sample identification (ID) with the corresponding laboratory ID,

parameters analyzed for in each sample and the methodology used (USEPA method numbers or other citation), a statement on the status of samples analyzed with respect to holding times (met or exceeded), detailed description of all problems encountered including, if appropriate, a thorough description of the rationale for dilution, when dilution is performed for reasons other than target analytes exceeding the calibration range, discussion of possible causes and corrective actions taken for out-of-control QA/QC criteria, and observations regarding any occurrences which may effect sample integrity or data quality. The date and time of preservation for Encore® samples should be documented within the report (e.g., in the narrative, on the COC, on the Cooler Receipt Form, etc.).

Chain-of-Custody Documentation. Original copies of COC forms for each sample will be maintained in the data package. Cooler receipt forms will be associated with the corresponding COC(s) form. Any internal laboratory tracking documents will be included.

Summary of Environmental Results. For each environmental sample analysis, this summary should include field ID and corresponding laboratory ID, sample matrix, date of sample preparation (if applicable), date and time of analysis, identification of the instrument used for analysis, GC column and detector specifications (if applicable), weight or volume of sample used for analysis/preparation, dilution or concentration factor used for sample preparation, percentage of moisture in the sample method detection limit and sample quantitation limit, definitions of any data qualifiers used, and analytical results.

Summary of QA/QC Results. The following QA/QC results will be presented in summary format on standard forms. Acceptance limits for all categories of QC criteria shall be provided with the data. Submission of standard instrument output alone is unacceptable to satisfy requirements for raw data packages:

- **Instrument Calibration.** The order of reporting for each standard concentration will follow the temporal order in which standards were analyzed.
- **Initial Calibration.** The concentrations of the standards for analysis and the date and time of analysis. The instrument performance check (tune) response factor, percent relative standard deviation (% RSD), and retention time for each analyte (as applicable, GC and GC/MS analyses) will be included in initial calibration summaries. A statement should also be made regarding the samples or dates for which a single initial calibration applies.
- **Daily Calibration and Mid-level Standard.** The concentration of the calibration standard used for daily calibration and/or the mid-level calibration check will be reported. The response factor, percent difference, and retention time for each analyte will be reported (GC and GC/MS). Daily calibration information will be linked to sample analyses by summary or by daily injection or analysis logs.
- **Method Blank Analyses.** The concentrations of any analytes found in method blanks will be reported. The environmental samples and QA/QC analyses associated with each method blank will be stated.

- **Surrogate Standard Recovery.** The name and concentration of each surrogate compound added will be detailed. The percent recovery of each surrogate compound in the samples, method blanks, MS/MSD and other QA/QC analyses will be summarized with sample IDs such that the information can be linked to sample and QA/QC analyses.
- **Precision and Accuracy.** For MS/MSD analyses, the parent sample results, spiked sample results, percent recovery, and RPD with the associated control limits will be detailed. For laboratory duplicate analyses, the RPD between duplicate analyses will be reported as applicable. For MS/MSD and laboratory duplicate report forms, the parent sample will be clearly identified with the client sample number. For laboratory QC Check and/or laboratory control sample analyses, true value concentrations, detected concentrations, the percent recovery, RPD (when an LCSD is present) and acceptable control limits for each analyte will be reported. All batch QC information will be linked to the corresponding sample groups.
- **Retention Time Windows (GC, GC/MS).** The retention time window for each analyte for both primary and confirmation analyses will be reported. Retention time windows are to be updated daily per USEPA SW-846.
- **Compound Identification (GC, GC/MS).** The retention times and the concentrations of each analyte detected in environmental and QA/QC samples will be reported for both primary and confirmation analyses.
- **Method Detection Limits.** Results of the most current detection limit study or quarterly detection limit standard check, whichever is more current, shall be presented in the first raw data package delivered for each method for a specific field sampling effort and again if any MDLs change during a field sampling effort.
- **Injection Record.** Injection logs for all instruments used for analysis of project samples will be provided indicating the date and time of analysis of project samples and the associated laboratory QA/QC samples.
- **Chromatograms.** For TPH, PAH, and pesticide analyses, chromatograms for all positive detectable quantities for samples and associated calibration standards will be provided by the laboratory at an appropriate attenuation.
- **Confirmation Summary.** For dual column or dual detector methods, a summary of both results, the reported result, and the RPD between the results must be presented. When the RPD exceeds 40%, the higher result must be reported, in compliance with SW-846 unless chromatographic interference can be shown on the column/detector with the higher results (see Table 2-3).

Raw Data. Legible copies of all raw data will be organized systematically on numbered pages. The raw data for compound identification and quantitation must be sufficient to support all results presented in other sections of the raw data package.

- **GC Analyses.** This section of the data package will include legible copies of the raw data for environmental samples (arranged in increasing order of field ID, primary and confirmation analyses), instrument calibrations, QA/QC analyses, sample preparation and cleanup logs, instrument analysis logs (injection record) for each instrument used, and GC/MS confirmations if applicable. The raw data for each analysis will include chromatograms (preferably with target compound, internal standard, and surrogate compounds labeled by name) with a quantitation report and/or area print out. When manual integration is performed, a brief explanation, the date, and the analyst's initials and the supervisors initials shall appear next to the revised value on the quantitation report. In addition, a (quantitation ion) chromatogram of the peak before and after manual integration should be included with the area integrated in both cases clearly identified on the chromatogram. When compounds are deleted for any reason, both the original quantitation report (prior to deletion) and the revised quantitation report should be included. For those compounds that will not be reported, a brief explanation should be included next to each compound (e.g., <DL, not confirmed by 2nd column, etc.). For those not reported due to incorrect spectra, the spectra and originally identified compound spectra should be presented so that the reviewer can ensure that deletion of that compound from reporting was appropriate.
- **GC/MS Analyses.** This section of the data package will include legible copies of the raw data for environmental samples (arranged in increasing order of field ID, spectrometer tuning and mass calibration reports, initial and continuing instrument calibrations, QC analyses, sample preparation logs, and instrument analysis logs (injection record) for each instrument used. The raw data for each analysis will include chromatograms (preferably with target compound, internal standards, surrogate compounds, and target analyte mass spectra with comparison to the standard spectra. Such comparison should include an ion chromatogram of the quantitation ion, and two distinctive ions for that compound together, and/or tentatively identified compounds with the associated best-matched spectra). Quantitation reports for all analyses will be included in the data package. When manual integration is performed, a brief explanation, the date, and the analyst's initials and the supervisors initials shall appear next to the revised value on the quantitation report. In addition, a (quantitation ion) chromatogram of the peak before and after manual integration should be included with the area integrated in both cases clearly identified on the chromatogram. When compounds are deleted for any reason, both the original quantitation report (prior to deletion) and the revised quantitation report should be included. For those compounds that will not be reported, a brief explanation should be included next to each compound (e.g., <DL, spectra not confirmed, not confirmed by 2nd column, etc.). For those not reported due to incorrect spectra, the spectra and originally identified compound spectra should be presented so that the reviewer can ensure that deletion of that compound from reporting was appropriate.

1.6.4.2 Inorganic Analyses

The raw data package for inorganic analyses will consist of a case narrative, COC documentation, summary of results for environmental samples, summary of QA/QC results, and the raw data. Detailed descriptions of the requirements for each component of an inorganic raw data package are provided in the following sections.

Case Narrative. The case narrative will be written on laboratory letterhead and the release of data will be authorized by the laboratory manager or designee. Items to be included in the case narrative are the field sample ID with the corresponding laboratory ID, parameters analyzed for in each sample and the methodology used (USEPA method numbers or other citation), a statement on the status of samples analyzed with respect to holding times (met or exceeded), detailed description of all problems encountered, discussion of possible causes and corrective actions taken for out-of-control QA/QC criteria, and observations regarding any occurrences which may effect sample integrity or data quality. The case narrative will be sufficiently detailed such that the process of analysis can be reconstructed (i.e., if samples are diluted to bring results into the linear dynamic range, or re-prepared for QC failures, the course of analysis will be detailed in the case narrative).

COC Documentation. Original copies of COC forms for each sample will be maintained in the data package. The date of receipt must be described on the cooler receipt forms will be associated with the corresponding COC form. Any internal laboratory tracking document will be included.

Summary of Environmental Results. For each environmental sample analysis, the raw data package should include field ID and corresponding laboratory ID, sample matrix, date of sample digestion/preparation (as applicable), date and time of analysis, identification of the instrument used for analysis, instrument specifications, weight or volume of sample used for analysis/digestion, dilution or concentration factor used for the sample preparation, percentage of moisture in the sample, method detection limit and sample quantitation limit, definitions of any data qualifiers used, and analytical results.

Summary of QA/QC Results. The following QA/QC results will be presented in summary form on standard forms. Acceptance limits for all categories of QC criteria shall also be provided with the data. Submission of standard instrument output alone is unacceptable to satisfy the requirements for raw data packages.

- **Instrument Calibration.** The order of reporting of calibrations for each analyte will follow the temporal order in which standards were analyzed.
- **Initial Calibration.** The source of the calibration standards true value concentrations, found concentrations, the percent recovery for each element analyzed and the date and time of analysis will be reported.
- **Continuing Calibration Verification.** The source of the calibration standards, true value concentrations, found concentrations, the percent recovery for each element analyzed, and the date and time of analysis will be reported.

- **Method Blank Analyses.** The concentrations of any analytes found in initial calibration blanks, continuing calibration blank, and in the preparation blank will be reported. The date and time of analysis will also be reported.
- **Interference Check Sample.** The source of the interference check sample, true value concentrations, found concentrations, the percent recovery for each element analyzed, and the date and time of analysis will be reported.
- **Precision and Accuracy.** Matrix spikes (MS) and matrix spike duplicates (MSD). For MS analyses the parent sample results, spiked sample results, percent recovery, the spiking solution used, and the control range for each element will be detailed. For post digestion spikes, the concentration of the spiked sample, the sample result, the spiking solution added, percent recovery and control limits will be detailed. For laboratory duplicates, the original concentration, duplicate concentration, relative percent difference, and control limits will be detailed. For MS/MSD and laboratory duplicate report forms, the parent sample will be clearly identified with the client sample number. Date and time for all analyses will be recorded.
- **Precision and Accuracy.** Laboratory control samples (LCS). The source of the LCS, true value concentrations, detected concentrations, the percent recovery for each element analyzed, and the date and time of analysis will be reported.
- **Method of Standard Addition.** This summary must be included when method of standard addition analyses are required. The absorbency values and the corresponding concentration values, the final analyte concentrations, and correlation coefficients will be reported for all analyses. Date and time of analysis will be recorded for all analyses.
- **Inductively Coupled Plasma (ICP) Serial Dilution.** The initial and serial dilution results with percent difference will be reported. Those concentrations that are at least 50 times the detection limit in the undiluted sample will be identified separately from those that are less than 50 times the detection limit, since the RPD requirement only applies to those analytes at concentrations exceeding 50 times the MDL in the undiluted sample.
- **ICP Linear Ranges.** For each instrument and wavelength used, the date on which the linear range was established, the integration time, and the upper limit concentration will be reported.
- **ICP Inter-element Correction Factors.** For each instrument and wavelength used, the date on which correction factors were determined will be detailed. Specific correction factors for Al, Ca, Fe, Mg, and any other element and the analytes to which they are applied will be detailed.
- **Instrument Detection Limits.** Results of the most current detection limit or quarterly detection limit standard check, whichever is more current, study will be provided in the first raw data package delivered for each method for a specific field sampling effort and again if any MDLs change during a field sampling effort.

- **Analysis Record.** Analysis logs for all instruments used for analysis of task order project samples will be provided indicating the date and time of analysis of project samples and the associated laboratory QA/QC samples (initial calibration, continuing calibration check, method blank, matrix spikes, etc.).

Raw Data. Legible copies of all raw data will be organized systematically on numbered pages. The raw data will be sufficient to support all results presented in other sections of the raw data package. This section of the data package will include legible copies of the raw data for environmental samples (arranged in order of field ID), instrument calibrations, QA/QC analyses, sample preparation and cleanup logs, and instrument analysis logs for each instrument used. Instrument analysis logs are particularly important since they provide the basic link between all sample analyses and QC information (calibrations, MS, etc.). Instrument analysis logs for all instruments used for sample analyses for a task order project will be provided for all days on which analysis was performed. The raw data for each analysis will include measurement print outs and quantitation reports for each instrument used. Records of absorbency, titrimetric or other measurements for wet chemical analysis will be recorded.

1.6.5 Training Documentation

As specified in the Arsenal-Wide General Site Safety and Health Plan (Benicia Arsenal General SSHP), all contractor staff working on-site will have completed training in hazard recognition and basic health and safety issues as required by the occupational safety and health regulations contained in 29 CFR 1910.120. The SSO will have completed the 8-hour Site Supervisor course, have current training in first aid and CPR, and any additional training appropriate to the level of site hazards. Before fieldwork begins, all field personnel, including subcontractor employees must be briefed on their work assignments and safety procedures contained in this document. Each person must be provided with and read a copy of the Benicia Arsenal General SSHP. No person shall be allowed to enter the work area until they have signed a Site Safety & Health Plan Employee Acknowledgement provided as Attachment A of the SSHP. If site specific Health and Safety training is required, it will be addressed in the site-specific SSHP. Copies of records and certifications for health and safety training of contractor staff will be kept in the project files.

Technical training and certification requirements for project personnel are described in Section 1.2.1 Program Management Responsibilities. Procedures and requirements for specific technical tasks are presented in the appropriate SOPs in Appendix F of the QAPP. Task specific training and documentation requirements for activities not described in this QAPP (for example training for use of field test kits) will be described in individual site specific FSIPs.

2.0

2.0 MEASUREMENT/DATA ACQUISITION

This section describes sampling method requirements, analytical methods and QC requirements, instrument calibration, and data acquisition requirements.

2.1 SAMPLING PROCESS DESIGN

The FSIP will outline the proposed design of the project's site-specific investigation including the sampling network design, types of samples required, sampling frequencies, sample matrices, and measurement parameter of interest. The rationale for the design will be clearly stated in the FSIP, and include the rationale for each sample location. These sample locations will be identified on a site map. Measurement parameters to be described will include geological, geophysical, hydrogeological, and chemical parameters as applicable. If cone penetrometer locations, Hydropunch[®] locations, microwell, or monitoring well locations are to be chosen on the basis of field observations the text will clearly state the evaluation criteria that will be used in the field for these determinations. Microwell and monitoring well design criteria will be clearly described to include a description of field determinations for appropriate filter packs and well screens.

When screening analytical techniques are used with a percentage of samples analyzed by a definitive analytical method, the required percentage and the rationale for selection of confirmation samples will be stated in the site specific FSIP.

Sampling strategies will be dictated by the DQOs developed for each specific site. At each site, the list of COPC identified on the basis of historical site usage (Benicia Arsenal Records Research Report [RRR], 1998) will be further refined on the basis of site walks, field screening, and field analysis.

2.2 SAMPLING METHODS REQUIREMENTS

Detailed specific descriptions of the sample collection procedures are included as an appendix to this QAPP. Any variances from the SOPs provided in the QAPP will be presented in the site-specific FSIPs. Each sampling method will include any support facilities needed. The discussion will focus on procedures for addressing failures in the sampling system and responsibilities for corrective action. SOPs are to be implemented for all routine sampling operations. The goal is that all applicable field work is performed in accordance with authorized technical guidelines and will consistently be of high quality, thereby reducing the probability of error. All applicable SOPs are included in Appendix F. Field forms to be used in sampling activities are presented in Appendix G.

Following are brief descriptions of standard field operations. These descriptions will be modified in the site specific FSIPs as needed in order to detail the procedures proposed for the specific field operations.

2.2.1 Surface Geophysical Investigation

Surface geophysical procedures include electromagnetic (EM), ground penetrating radar (GPR), and magnetometry techniques. Soil boring and well locations will be investigated using geophysical techniques prior to drilling to identify subsurface utilities, drain lines, tanks, and other subsurface obstructions that could interfere with drilling operations. Any identified utilities and/or anomalies are marked on the ground surface according to standard industry code. These procedures are outlined in SOP 6.0, Utility Clearance.

2.2.2 Borehole Drilling Procedures

Several drilling procedures may be used during field sampling at the Arsenal. The choice of drilling procedures is influenced by three significant factors (1) the need to minimize the introduction of foreign material that may influence the results of chemical analyses, (2) the need to penetrate diverse geologic materials, and (3) the need to drill in areas and/or buildings of limited access. Prior to any drilling activities, all boring locations will be hand-augered to 5 feet below ground surface (bgs). The drilling methods that may be utilized during field operations are briefly discussed following:

2.2.2.1 GeoProbe® Borings

Shallow subsurface soil samples are collected using specialized, direct-push equipment mounted on a small truck. If the boring location is on asphalt, the rig will be used to drill or cut through the asphalt prior to hand-augering to 5 feet bgs. Soil samples are collected utilizing the GeoProbe® tool, which consists of either a 7/8-inch or 1½-inch diameter stainless steel liner assembly of four 6-inch long liners contained within a stainless steel sampler tube. (The needed diameter of the sampling tube used for the borings is determined in the field based on the substrate composition). The stainless steel liners may be replaced with a clear acetate tube. A piston tip attached at one end of the sample tube is connected to a drive head and piston stop-pin at the other end of the tube by a 12-inch stainless steel probe rod in the tube center. The sampler tube apparatus is driven into the ground, piston tip first, to the top of the desired sampling depth. The stop-pin is removed and the sampler tube apparatus driven 2 feet into the substrate. The sampler tube apparatus is then retracted from the borehole and the stainless steel sample liners removed from the sampler tube. Teflon® sheet covers are placed on the ends of the liners and held in place by clean plastic caps. The caps are then sealed to the liners using Teflon® tape. Strapping tape may be placed over the Teflon® tape if needed to keep the caps in place. The liners are labeled, placed in a zipper lock-type plastic bag, and stored in coolers for shipment to the laboratory. The remaining liners are used for logging and/or field analysis. Sampling procedures for the GeoProbe® tool are presented in SOP 7.0, Collection of Soil Samples.

2.2.2.2 Hollow-Stem Auger

The hollow-stem auger (HSA) drilling method employs a hollow helical steel drill pipe that is rotated to advance the boring and return cuttings to the surface. The flights for the HSA are welded onto steel pipe and a cutter head is attached to the lead (bottom) auger to cut the hole.

The top head drive of the HSA rig is powered by a rig-mounted engine that mechanically rotates the entire flight of augers. The hollow opening allows the insertion of sampling tools (e.g., split-

spoon sampler, continuous soil coring device, in situ groundwater samplers, and soil gas probes) and well completion materials, while the augers are in place supporting the borehole.

2.2.2.3 Dual-Tube Percussion

The dual-tube percussion (DTP) method utilizes a small-diameter drill pipe and a larger diameter drive casing with high pressure air as the circulating medium. Air is forced down the annular space between the inner drill pipe and outer drive casing and cuttings are returned to the surface through the inner drill pipe. The drill pipe and casing is advanced by repeated blows of an above ground percussion hammer. The drive casing keeps the borehole open and, as in the air rotary casing drive method, diminishes the potential for cross contamination of water-bearing zones. The cuttings are discharged into a cyclonic separator.

2.2.2.4 Air Rotary Casing Hammer

The air rotary casing hammer (ARCH) drilling method uses a drilling bit attached to the lower end of a rotating drill pipe that is placed within a non-rotating outer drive casing. The drill bit advances the boring simultaneously as the non-rotating drive casing is driven into the ground. Air is forced under pressure downward through the drilling rods and bit, and back to the ground surface through the annulus between the drive casing and the smaller rotating drill rod. The returning air continuously moves cuttings and groundwater from the area of the drill bit to the surface, where they are discharged into a cyclonic separator.

2.2.2.5 Mud Rotary

The mud rotary (MR) drilling method employs a bit that attaches to the lower end of a drill pipe and advances the boring in an uncased hole as the drill pipe is rotated. In direct circulation rotary drilling, a drilling mud is pumped down through the drill pipe and out through the ports or jets in the drill bit. The drilling mud typically consists of a mixture of water and bentonite powder. The mud then flows upward in the annular space between the hole and drill pipe carrying the cuttings in suspension to the surface. At the surface the mud is channeled across a shaker to a settling pit or pits where most of the remaining cuttings drop out. The mud is then re-circulated down the borehole.

The functions of the mud are to transport the cuttings to the surface; support and stabilize the borehole; seal the borehole to prevent fluid loss; and clean and lubricate the bit.

2.2.2.6 Sonication

The sonication method employs a hydraulically activated drill head that imparts high frequency sinusoidal wave vibrations normal to the ground surface through the drill string. At optimum frequencies (between 120 and 150 hertz) the vibration breaks the cohesive bonds in soil and rock at the face of the drill bit. A split-spoon sampler or a solid drive point can be latched into the bottom of the drill string to collect core samples or drill to a desired sampling depth. Soil is either forced into the split-spoon sampler or aside as the drill string is advanced. In hardpan or bedrock the bit is rotated to cut through the material.

2.2.2.7 Cone Penetrometer Testing

Cone penetrometer testing (CPT) is a hydraulic penetration method which provides geologic data without generation of cuttings. This is achieved through the use of sensors attached to the inside of the drive cone at the base of the drive rod. The differences in resistance pressure and friction as the drill rod and cone are pushed through the geologic materials is electronically delivered to a computer inside the drill rig. The electronic signal is then converted to an analog curve with the analog curve peak response being correlative to the different types of geologic materials encountered by the drive cone. The CPT can be used for collecting confirmatory geologic samples and environmental soil and groundwater samples, but its primary use is in obtaining geologic or lithologic data, not in generating samples.

The disadvantages to the CPT are that it is restricted by its depth penetration and the type of geologic material. Typically, CPT can provide reliable geologic analog data to about 30 to 50 feet bgs. Under ideal conditions CPT can be successfully employed to 70 feet bgs. CPT cannot be used where hardpan, coarse gravel or cobbles, or hard rock will be encountered. Additionally, the CPT cannot retrieve undisturbed core samples.

2.2.3 Lithologic Sampling and Logging

The following section discusses the geologic classification from drill cuttings by different drilling techniques.

2.2.3.1 Sampling Unconsolidated Materials for Geologic Classification

The quality of geologic data from unconsolidated drill cuttings is dependent upon the drilling method. ARCH and DTP methods provide the most reliable geologic information from drill cuttings if sufficient air pressure is used to provide rapid and complete cuttings return through the casing. If air pressure is insufficient, geologic particle segregation by density will occur in the air column.

MR follows ARCH and DTP as a reliable method for evaluating unconsolidated materials. However, since the return of cuttings with MR is not rapid (as with the air methods), it is important to calculate the cuttings return based on lag time. Lag time can be formulated by knowing the strokes per minute of each piston in the mud pump (whether or not the mud pump is single or double stroke), knowing the volume of the piston chamber in the mud pump, and the hole diameter and depth from the ground surface to hole bottom. If the lag time is calculated correctly, cuttings can be reliably evaluated as to depth in place. Adequate mud weight and viscosity will be used to prevent weight stratification of geologic materials in the mud column. Also, it is important to periodically clean the shakers and sediment filters, and recirculate the mud to minimize cross contamination of geologic materials in the mud column.

The least reliable drilling method for evaluating drill cuttings is the HSA, since cuttings from different stratigraphic horizons are continuously mixed together by the rotating action of the helical auger flight. Evaluating drill cuttings for geologic characterization by this method should be avoided.

2.2.3.2 Lithologic Logging

Soil samples will be visually examined by a certified geologist experienced with the local lithology. The ASTM D-2487 United Soil Classification System (USCS) and the Munsell Color Chart will be used as guidelines for classifying and describing lithology of soils (SOP 3.0) and rocks (SOP 31.0).

2.2.4 Well Construction (First Water Zone)

Groundwater wells are typically used to measure depth to groundwater, groundwater flow, groundwater gradient, determine the presence of suspected contaminants, and track their movement in and through aquifers. In general, monitoring well design and construction depend on the intended purpose of the well (temporary microwell, long-term monitoring well, extraction well, or injection well), the geologic conditions present at the site, the amount of water needed for sampling, and the local and state regulations that control design and construction parameters (SOP 21.0).

Microwell and monitoring well components fall into three categories: well screen; well casing; and annular space materials, which typically include filter pack, bentonite seal, and grout seal. In special circumstances, fine-grain sand can be used in place of the bentonite seal when quick-setting grout is employed. In other situations, Volclay[®] or Enviroplug[®] can be used to replace both the bentonite seal and the grout seal.

Microwells will be constructed out of polyvinyl chloride (PVC). Monitoring wells will be constructed out of PVC or metal (i.e., stainless steel, low carbon steel). Occasionally, a combination of PVC and metal is used. Temporary microwells are typically 1 to 2 inches in diameter. Monitoring wells are typically 4 inches in diameter; 2-inch wells may be used when frequent water level measurements and infrequent sampling are required. The well screen length depends on formation condition, the amount of water needed for sampling, and the method to be used for purging and collecting groundwater samples from the well. Filter pack material for the well screen is selected on the basis of the finest grain size fraction of the formation within the interval to be screened. Typically, the filter pack size-grading is selected so that 90 percent of the formation is retained in the interval to be screened. The well slot size is then selected on the basis of the 90 percent retained fraction of the filter pack by the well screen.

If the presence of denser-than-water nonaqueous phase liquids (DNAPLs) is suspected or known, the lower end of the well screen will extend into (1 foot minimum) the lower confining layer to allow collection of DNAPLs. If light nonaqueous phase liquids (LNAPLs) are suspected or known, the upper screen interval will extend a minimum of 1 foot into the upper confining layer to allow collection of light LNAPLs. In either case, the well screen will not penetrate into the next water-bearing zone. This will prevent cross contamination from one water-bearing zone into the next.

When a temporary microwell or a monitoring well is installed, the well screen and casing will be inspected for damage and then decontaminated before being placed into the borehole. It is advisable to use flush-threaded screen and casing with O-rings to provide the best seal and strength between well sections. An end cap will be installed below the screen on the lowest casing section. It will capture any sediment buildup. As the sections are screwed together, it is

extremely important in the case of metal wells to suspend the bottom of the well casing about 6 inches off the bottom, otherwise the weight of an unsupported metal well may crush or collapse the well screen if constructed with a less rigid material (i.e., pvc). Centralizers are located below the bottom and above the top of the well screen and at 40-foot intervals along the well casing.

For placement of the filter pack through water as the borehole, a tremie pipe will be used. It may be necessary to place the filter pack as a slurry with clean water through a tremie pipe for long water columns. The well is bailed, surged and swabbed at least once in order to achieve the tightest packing of the filter pack. More filter pack material is added if the filter pack settles as a result of this procedure. The top of the filter pack must extend at least 2 feet above the top of the well screen, and may extend as much as 5 feet.

After the filter pack is bailed, surged, and swabbed, a bentonite seal is emplaced on top of filter pack. Typically, the bentonite can be introduced as pellets or chips, or as a slurry for deeper wells. When using chips or pellets, it is advisable not to use a tremie pipe in order to avoid plugging the pipe. The bentonite should be allowed to hydrate for at least ½ hour before introducing the grout. The bentonite seal should be at least 2 feet thick.

Grout used in well construction should always be free of lumps. When preparing grout with a bentonite cement mixture, bentonite should always be added to the water first, followed by the cement powder. This will ensure proper mixing of the bentonite into a lump-free suspension. A paddle or shear mixer should be used when preparing the grout for the best consistency. Sometimes, for deep wells requiring large amounts of grout, it may be necessary to use premixed and prepared grout from a cement plant close to the site. In relatively shallow wells, slow-setting grout can be typically emplaced in one lift. However, in deep wells, if slow-setting grout is used it will likely be necessary to place the grout in multiple lifts. Otherwise, excessive grout weight at one time (before curing is complete) may displace the bentonite seal, or for PVC constructed wells the heat from curing may collapse the well casing. The minimum setting time for slow-setting grout is typically 24 hours. The type of grout mixture may be regulated by local or state regulatory agencies.

Under special conditions, quick-setting (calcium chloride) grout can be used. Quick-setting grout is normally used for deep well construction to reduce construction associated with emplacement of grout in multiple lifts. PVC should never be used with quick setting cement, since the heat of hydration could melt the PVC.

If well extension above surface is not acceptable, surface completions will be flush with the existing grade. The casing is cut about 3 inches below land surface and a water-tight casing cap provided to prevent surface water from entering the well. A freely draining valve box with a locking cover is placed over the casing. The top of the casing will be at least 1 foot above the bottom of the box. The valve box lid is centered in a 3-foot-diameter, 4-inch thick concrete pad that slopes away from the box or appropriate surface completion for site. The well identification number is permanently marked on the valve box lid and the casing cap.

If an aboveground-surface completion is used, the well casing is extended 2 or 3 feet above land surface. A casing cap is provided for each well. The extended casing is shielded with a steel sleeve that is placed over the casing and cap and seated in a 2-foot by 2-foot by 4-inch concrete surface pad or appropriate for site. The pad is shaped to slope away from the well

sleeve. A lockable cap or lid is installed. The well identification number is permanently marked on the casing cap and the protective sleeve. Three 3-inch-diameter, concrete-filled steel guard posts are installed if it is determined that the well is in an area where it needs such protection. The guard posts will be 5 feet in total length and installed radially from the well head. The guard posts will be set in concrete approximately 2 feet into the ground.

The elevations of boring locations, and the top of the well casings located outside of buildings will be surveyed to an accuracy of 0.01 foot. Horizontal locations will be established to an accuracy of 0.1 foot. The surveys are tied to mean sea level (msl) data. All locations will be traceable to a U.S. Coast and Geodetic Survey (USCGS) or U.S. Geological Survey (USGS) survey marker. In addition, all horizontal coordinates will be tied to the state plan coordinate system. All coordinates are reported using the x-y standard coordinate system. The x coordinate will denote easting and the y coordinate will denote the northing. Permanent ground surface elevation markers will be surveyed and reported along with the top of casing elevation for each well.

2.2.5 Well Construction (Second Water Zone)

To prevent cross-contamination between separate waterbearing zones, second zone and deeper monitoring wells will be constructed according to the following protocol when warranted.

A 12-inch or greater diameter borehole will be drilled to the confining layer beneath the first zone, and an outer casing (8-inch minimum diameter) is driven one to two feet into the confining layer. Cement-bentonite grout is tremied into the annulus to seal the borehole wall, and allowed to set for at least 24 hours prior to drilling through to the next zone.

After the grout has set, drilling fluid and cuttings are removed from the casing and the inside is flushed with at least three well-volumes of potable water. Drilling into deeper zones continues with smaller bits inside the outer casing. Two-inch wells are constructed using 8-inch outside diameter (OD) augers and 4-inch wells are constructed using 10- or 12-inch OD augers.

2.2.6 Well Development

Well development serves to remove the finer grained material from the well screen and filter pack that may otherwise interfere with water flow and water quality analyses. Development restores the groundwater properties disturbed during the drilling process and improves the hydraulic characteristics of the filter pack and hydraulic communication between the well and the hydrologic unit adjacent to the well screen. Methods of well development vary with the physical characteristics of hydrologic units in which the well is screened and with the drilling method used.

Well development generally should not occur less than 24 hours following surface completion. Any well(s) completed using mud rotary drilling will be developed within 72 hours. In addition, development is to be completed at least 72 hours before baseline or routine quarterly well sampling.

Following installation and construction of a microwell, monitoring well, extraction well, or injection well, the following procedures should be followed to ensure proper development of the well.

2.2.6.1 Decontamination

Before development, all water level measurement probes, meters, bailers, pumps, and other development devices will be decontaminated. Each piece of development equipment will be decontaminated prior to and between development operations and wells. The procedures specified in the SOP 11.0, Sampling Equipment Decontamination, will be followed.

2.2.6.2 Water Level Measurement

The static water level and well depth measurements will be conducted following procedures outlined in SOP 25.0, Field Measurement of Water Levels. The volume of water in the well casing will be calculated.

2.2.6.3 Meters

Electronic equipment used during development includes a water level measurement probe, a pH meter, a temperature meter, a conductivity meter, and may include the use of dissolved oxygen (DO), oxidation/reduction potential (REDOX), and turbidity meter(s). Before going into the field, the equipment will be checked to ensure that they are operating properly. The pH, and conductivity meters will be calibrated prior to use everyday.

2.2.6.4 Development – Microwells/Monitoring Wells

For development of microwells/monitoring wells the following procedures will be performed at each well:

- Bail groundwater using a sand bailer or similar device to remove the majority of sediment from the bottom of the well;
- Surge the screened section of the well in 5-foot increments with a surge block;
- Bail approximately one to three casing volumes of water to remove the dislodged sediments following surging;
- Pump the well until representative water, free of the drilling fluids, cuttings, or other materials introduced during well construction is obtained. All water introduced to the well during the installation to control heaving sands will be removed. As such, this volume of water introduced is not to be used to determine the number of casing volumes actually removed for development purposes;
- Well development will be considered complete when the following parameters have stabilized in three consecutive readings and relatively sediment free water is being produced from the well:

- pH levels ± 0.1 pH units
- Specific conductance $\pm 5\%$
- Temperature $\pm 0.5^\circ\text{C}$
- Dissolved Oxygen (DO), oxidation/reduction potential (REDOX), and/or turbidity, if measured $\pm 10\%$
- Field parameters should be measured at 5 to 15 minute intervals until well development has achieved the minimum requirements outlined above.

Should the well bail/pump dry prior to removal of the required water volume, the well will be allowed to recover, and bailing/pumping will resume. The process will be repeated until relatively sediment free water is produced; and

Water removed from the development will be handled in accordance with the Investigative Derived Waste Plan.

2.2.6.5 Well Development - Extraction/Injection Wells

For well development of extraction/injection wells the following procedures will be performed at each well:

- Following initial sand bailing, the well will be swabbed with a surge block starting just below the static water level until free movement of water through the screen is initiated. All water added during the drilling and installation of the well will be removed;
- More aggressive surging will continue as the surge block is gradually lowered in through the screened interval(s). The amount of material (i.e., sediment) will be measured and recorded periodically (for example every half hour), and removed using a sand bailer;
- Upon completion of the swabbing and bailing, a temporary submersible pump should be installed and operated at above the design discharge rate for a specified period of time.

Extraction wells are considered developed when:

- Relatively sediment free water is produced; and
- All of the water added during the installation and a minimum of three to five well pore volumes (well casing plus gravel pack pore space) have been removed.

2.2.7 Soil Vapor Well Construction and Materials

In general, the same rules for well design and construction that apply to groundwater wells also apply to soil vapor (SV) wells, there are some key differences however. SV wells may be temporary or permanent. SV wells are always constructed in the vadose zone. Well diameters are typically smaller (usually in the 1- to 2-inch range, but sometimes 4 inches). When using the small diameter casings, it is common practice to place as many as three SV wells, each at a

different depth, in one boring to economize on construction cost while simultaneously being able to monitor different strata. Multiple well completions (nested wells) within a single boring are somewhat more complex than a single well completion. They require special attention to detail and caution during the construction phase. Especially important is to track each casing in the hole for depth identification. It is important to place the well seals properly to prevent short-circuiting in the well between different zones and to prevent leakage of sealant materials into filter packs through voids. SV wells can be constructed of either PVC, steel, or of a combination of the two.

2.2.8 Borehole and Well Abandonment

At the completion of each borehole drilling activity, the borehole will be grouted to the surface by pumping a mixture of 4 pounds of powdered non-benificated (pure) bentonite, 8 gallons of water, and one 94-pound sack of Type 1 Portland[®] cement or neat cement grout. This mixture maybe adjusted to comply with regulatory requirements. The amount of bentonite added to the cement will be weighed using a scale, and provisions will be made to meter the water. Bentonite will be thoroughly mixed with water, producing a lump-free mixture prior to adding cement. The grout will be mixed using a high shear mixer and weighed using a mud scale. The final grout mixture should weigh approximately 13 to 14 pounds per gallon (verify with a grout scale), and will be installed using a tremie pipe or pumped. The bottom of the drill pipe will always be positioned below the top of the grout seal to prevent possible "caving" from overlying formation.

Any well abandonment must follow applicable federal, state, and county regulatory guidelines. Criteria and procedures for well abandonment will be addressed and written after the well inspection, and will be integrated with the project document. Generally, the following procedures will be used:

- Check the well to see if debris has filled the well;
- Remove any dedicated equipment which will interfere with abandonment;
- Determine the depth of the well or borehole with a sounding weight and line;
- A grout mixer and a positive-displacement pump to deliver the mixture with positive pressure to the bottom of the hole is required;
- A tremie pipe of greater than 1-inch-diameter will be used to allow for adequate flow of bentonite or neat cement grout;
- Place abandonment material; and
- In any large diameter or deep hole, sound the hole at pre-determined intervals to fill the hole completely (SOP 14.0).

2.2.9 Groundwater Sampling Procedures

Groundwater samples can be collected from temporary microwells and monitoring wells. Groundwater sampling will follow techniques described in the RCRA Ground Water Monitoring Technical Enforcement Guidance Document (USEPA, 1986). These procedures are summarized in the following paragraphs and included in SOP 17.0.

Prior to any groundwater sampling, and each time a well casing cap is removed, the air in the breathing zone will be measured for total organic vapors with an organic vapor analyzer (OVA) or equivalent. If organic vapors or explosive gases are detected, procedures provided in the SSHP must be followed.

2.2.9.1 Well Purging

A purge method is selected depending on the volume of water to be purged from the well before sampling and the expected rate of recharge. Traditional multivolume purging or low-flow purging can be used until parameter stabilization is obtained. A submersible electric pump may be used to purge deep wells, or wells that have large calculated purge volumes. The purge pump will be equipped with check valves to prevent purge water from flowing back into the well. For low volume wells and slowly recharging wells, either a Teflon[®] or a disposable polypropylene or polyethylene (but not PVC) bailer is used. Well purging and sampling is performed in a manner that minimizes agitation of sediment in the well and formation. Equipment must be kept from falling into the well.

Well purging is an integral step in recovering samples representative of groundwater chemistry. Each well is purged immediately prior to sample collection. Purging provides samples that consist of fresh formation water rather than stagnant water that has been stored in the well casing.

For wells equipped with dedicated pump systems, well purging is accomplished using a positive gas displacement purge pump or a bladder pump. If a well is not equipped with a dedicated pump system, it is purged with a bailer or electric submersible pump.

A minimum of three well-bore water volumes is purged, with exceptions for wells with low recharge rates. The well-bore volume is defined as the volume of submerged casing and screen, and the volume of water in the filter pack (assume 30 percent porosity). Low recharge wells are defined as those wells that cannot recharge 80 percent of the original volume within 8 hours. Low recharge wells will be purged dry and then sampled as soon as sufficient water to fill the sample containers has reentered the well.

The temperature, pH, and electrical conductivity (plus salinity where appropriate) are measured and recorded after removing each one-half well bore volume during purging. Temperature, pH, and conductivity are monitored during the purging to ensure that they have stabilized. Stabilization is normally defined as follows:

- Temperature +/- 0.5°C
- pH +/- 0.1 units
- EC +/- 5%

If parameters have not stabilized by the time that the three bore volumes have been removed, the sample will be collected immediately after two consecutive measurements indicate stabilization. If these parameters do not stabilize, the sample is collected after six well bore water volumes have been removed. If a monitoring well is pumped dry before three well-bore water volumes can be removed, the sample will be collected as soon as sufficient water to fill the sample containers has reentered the well. Details for field parameter meter use, calibration, and duplicate measurements are provided in SOP 17.0.

2.2.9.2 Sample Collection

Groundwater samples are not to be collected within 24 hours of well development. Samples will be collected in order of decreasing analyte volatility. For example, samples destined for volatile organic compounds (VOC) analysis will be collected before those for semi-volatile organic compounds (SVOC) analysis. Wells are sampled using stainless steel or Teflon® submersible pumps, bladder pumps, or bottom-filling bailers and Dacron bailing line. Pumps used for purging are equipped with a check valve to prevent purge water from flowing back into the well. Purging and sampling will be performed in a manner that minimizes the agitation of sediments in the formation and reduces the potential for organic chemical volatilization. Bailers and other sampling equipment must never be allowed to fall freely into the well.

2.2.9.3 Groundwater Sampling with Bladder Pump

This sampling method uses a positive gas displacement bladder pump to recover groundwater samples. The bladder pump consists of a stainless steel body with an internal flexible Teflon® bladder. The bladder serves to isolate the groundwater from the drive gas. The gas would otherwise promote volatilization of any VOCs in the water sample. Samples are collected from the discharge line of the dedicated bladder pump (or from a flow control valve) after the flow is steady and no air bubbles can be observed.

2.2.9.4 Groundwater Sampling with Bailer and Submersible Pump

If wells are not equipped with a dedicated sampling system, either an electric submersible pump or a Teflon® or stainless steel bailer will be used to purge the well. Typically, the submersible pump will be used to purge deeper wells having a large water column. When purging is complete and the pump has been removed, the wells will be sampled using a bailer and a braided stainless steel or disposable monofilament line. Shallow wells with a small water column, or wells that produce insufficient water to allow using a pump, will be purged using only a bailer. Before either a submersible pump or bailer is used to purge and sample a well, it must be decontaminated. Samples are collected from bailers using a flow control valve by attaching the valve to the bailer after purging is completed, and then slowly opening the valve until a smooth, steady flow is obtained.

2.2.9.5 In Situ Groundwater Sampling

At selected sites, groundwater samples can be collected using an in situ sampling device (such as a HydroPunch®) described in SOP 13.0. This type of sampler typically enables one-time collection of a representative groundwater sample without loss of volatile constituents. A special, larger diameter drive rod may be used to collect larger sample volumes by successive filling of a 1-inch-diameter bailer. This approach provides sufficient sample volumes for multiple analyses and also allows for analysis of duplicate samples.

In situ sampling devices consist of a drive shoe, a sample intake chamber and port(s) with either a screen or a filter, a sample collection tube, and a drive pipe. The sampler has a retractable sleeve that is pulled up to expose a screen and allows entry of groundwater into the device. The sampler is driven to the desired sampling depth using a downhole hammer, or it is pushed into place with the rig hydraulics.

2.2.10 Surface Water Sampling Procedures

Surface water samples are collected from ponds, drainages, streams, springs, and seeps. Different methods may be used to collect the samples depending on the size and depth of the surface water source. All samples will be collected in a manner that does not cause cross-contamination. The sample that is farthest downstream will be collected first.

Surface water samples from surface runoff, streams, or ponds will be collected using a pond sampler with a Teflon[®] beaker attached to the end or equivalent. Efforts will be made to collect required surface samples during the rainy season. Upgradient surface waters will be collected, where possible, to obtain ambient information or identify alternate possible sources of contamination. Samples collected from shallow depths will be obtained by submerging a stainless steel, Teflon[®], or glass container into the pond, stream, or drainage or by holding the container under the water discharge point of a seep or spring (SOP 16.0).

2.2.11 Surface Soil Sampling Procedures

Surface soil samples are collected from soils that are 0- to 6-inches bgs, or at the surface interval specified for a particular project (i.e., to satisfy risk assessment DQOs). Samples are collected using a decontaminated stainless steel scoop, trowel, or disposable plastic scoop. Soil layers will be removed to the desired depth and the sample collected. The soil is transferred to the appropriate sample containers. Gravel, rock, and vegetation are excluded from samples. Surface scraping may be used to collect soil samples from the ground surface; side walls and bottom of trenches or excavations; and scale or sediment from tanks, ponds, impoundments, or streams. The samples are collected by scraping a thin layer of soil directly into the sample container using a stainless steel spoon. This should be done quickly and with as little disturbance as possible in order to minimize the loss of volatile and semivolatile organics. Surface samples coincident with soil borings may be collected by using the drill rig to push 2.5-inch-diameter by 6-inch long stainless steel sleeves directly into the soil. This method may be used when soil is too hard for the stainless steel spoon method. However, care should be taken so as to not interfere or connect with underground utilities or any other unknown underground foreign body. The push sleeve method generates a less-disturbed sample more suitable for volatiles analysis.

Samples may be composited for all analyses except volatile organic compounds and purgeable petroleum hydrocarbons. Samples collected for these 2 analyses must be collected using the Encore[®] sampling device (SOP 33.0) unless otherwise specified in the site-specific workplan. For laboratory composited samples, discrete samples are collected at each location and sent to the laboratory, where each is homogenized and an equal weight of each is combined to form the composite for analysis. For field-composited samples, an equal amount of soil from each location (to be included in the composite) is placed in a stainless steel bowl and homogenized by thoroughly mixing using a stainless steel spoon. The homogenized soil is divided into four equal quarters and the composited sample collected from one of the quarters (SOP 7.0).

2.2.12 Subsurface Soil Sampling Procedures

Soil samples are collected using a hand auger or core barrel sampler to a maximum depth of 5 to 10 feet bgs, depending on the hardness of the soil (SOP 7.0). Subsurface soil samples from below 10 feet bgs can be collected by using a drill rig or by digging test pits and sampling with a backhoe. Soil subsamples collected for analysis of VOCs or purgeable petroleum hydrocarbons must be collected using the Encore[®] sampling device (SOP 33.0) unless otherwise specified in the site-specific workplan.

2.2.12.1 Hand Auger Sampling

Hand augering can be used to collect soil samples to a maximum depth of 10 feet bgs. This method is not appropriate for collecting samples for VOC analysis because volatile compounds may be lost when the soil is disturbed during sample collection. The hand auger is driven to the desired sampling depth where soil is collected in the bit, withdrawn from the boring, emptied into a stainless steel bowl, and then packed into a sample container (brass or stainless steel sleeve or glass jar) as described in SOP 7.0.

2.2.12.2 Core Sampling

Core samplers lined with brass or stainless steel sleeves are used to collect soil samples to a depth of up to 10 feet. The core sampler with slide hammer handle is designed to collect relatively undisturbed soil samples by driving a cylindrical cup (similar to the bit of a split-spoon sampler) into the ground using a sliding, weighted handle. This method is appropriate for collecting samples for VOC, SVOC, or nonvolatile parameter analysis.

2.2.12.3 Subsurface Soil Sampling by Drill Rig

MR, HSA, sonication, and DTP are the drilling methods that can be used in conjunction with split-spoon sampling techniques to collect subsurface soil samples. Two split-spoon sampling techniques can be used for the following:

- A continuous soil coring system
- A surface drop hammer or wire-line downhole drop hammer

These techniques are useful for depths greater than 10 feet bgs (SOP 27.0).

2.2.12.4 Continuous Coring

Continuous coring techniques are used to collect soil when using the direct circulation MR, sonication, or HSA drilling methods. To collect 5-foot or smaller cores, a 5-foot long split-spoon sampler, a 2-foot long Shelby[®] tube, or a 2.5-foot long Moss[®] sampler is lowered on a wireline down the hollow opening of the drill stem and latched into place or attached to the head of the drill string. The sampler is pushed along by the drill stem and advanced into undisturbed soil ahead of the drill stem by a drill rod system. The sampler may either be lined with 2- or 2.5-inch-diameter sleeves (3- or 6-inch long stainless steel or brass), or a split-spoon dry core sampler may be used. If the dry core sampler is used, samples to be submitted for analysis must be sleeved at the surface after sample selection. When collecting samples during MR

drilling, uphole velocities of the drilling mud will be determined to ensure that samples are obtained from desired depths, or 2-foot Shelby[®] tubes will be used.

Continuous cores from 5- to 20-feet long can be obtained using a sonication drilling rig and drill rod system. A solid (not split) core sampler is lowered down an open borehole or down the hollow opening of an outer casing and vibrated into the soil.

2.2.12.5 Surface or Wireline Downhole Drop Hammer

The surface drop hammer system normally includes an 18- to 24-inch long split-spoon sampler to collect core samples. The drop hammer sampler, lined with sleeves, is attached to a small diameter, flush-threaded pipe and lowered to the bottom of the hole. The 140-pound surface drop hammer mounted on the drill rig is dropped repeatedly until it drives the sampler approximately 18 inches into the ground. Blow counts are measured every 6 inches to determine the physical characteristics of the material encountered. Fifty blows is considered formation refusal. Samplers can hold various diameter (2-inch, 2.5-inch, or 3-inch) brass or stainless steel sleeves, as well as different length (1-inch, 3-inch, or 6-inch) sleeves.

For sampling of unconsolidated and uncemented sands or gravel deposits, a split-spoon sample device equipped with a sample catcher is used to prevent sample loss. The catcher is placed in the lower portion of the sampler (between the sample body cutting tip and the body of the sample device). As the sampler is pulled to the surface, the catcher prevents unconsolidated or uncemented materials from falling out of the open end of the sample device.

2.2.13 Sediment Sampling Procedures

Sediment samples are collected from dry stream beds and drainage ditches by surface scraping, hand augering, and core sampling. Stockpiles of untreated or treated material can be sampled using a scoop or hand corer as described for sediment. Sediment samples can be collected in stream channels and drainage ditches that have water in them using one of the following devices:

- Scoop or trowel
- Hand corer
- Gravity corer
- Ponar dredge

2.2.13.1 Scoop/Trowel

A decontaminated or disposable scoop or trowel is inserted into the material and a sample is removed. In the case of sludges exposed to air, the first 1 to 2 centimeters of material is removed prior to collecting the sample. If compositing a series of grab samples, a stainless steel mixing bowl or Teflon[®] tray is used for mixing. Samples to be analyzed for VOCs are not composited. The scoop method is more applicable to sludges but it can be used for sediments, provided the water depth is very shallow (a few centimeters). This method can be disruptive to the water/sediment interface and might cause substantial alteration.

2.2.13.2 Hand Corer

The hand corer has the advantage over the scoop method in that an undisturbed sample is collected. The sampler barrel is forced into material with a smooth continuous motion, twisted, then withdrawn in a single smooth motion. A nosepiece is removed and the sample deposited into a stainless steel or Teflon® tray.

2.2.13.3 Gravity Corer

The gravity corer has a check valve that allows water to pass through the corer on descent but prevents sample washout during recovery. The device has a tapered nosepiece that facilitates cutting and reduces core disturbance during penetration.

2.2.13.4 Ponar Dredge

A Ponar dredge can be used to collect sediment samples from impoundments or flowing streams. This type of sampler has a jaw-type mechanism that is tripped from above to collect the sediment sample. The dredge is lowered through the liquid to the sediment with the jaws in the open position. The dredge is lowered slowly to minimize disturbance of the sediment upon contact. As the dredge is retrieved, the jaws close and the isolated sediment is brought to the surface, where the sample is transferred to the sample container or stainless steel bowl.

Sediment samples will be collected after surface water sampling has been completed. The order of sediment sampling will begin with the farthest downgradient sample and move progressively upgradient to avoid cross contamination between locations and media. Where appropriate, samples are collected from the active streambed on the streamside nearest the contamination source.

2.2.14 Soil Gas Sampling Procedures

Soil gas samples are collected to survey and screen target areas of VOC-contaminated soil to aid in the placement of soil vapor extraction or groundwater wells and to provide supplemental data to evaluate remedial action effectiveness. Following is a summary of soil gas sampling procedures (SOP 19.0).

The soil gas sample collection system consists of a soil gas probe, a vacuum pump and gauge, Teflon® tubing, and a sample collection device. Analysis of soil gas samples for screening data is typically performed by collecting the samples in a glass-lined syringe and directly injected into a gas chromatograph (GC), OVA, or other analytical device. Screening analyses may also be performed off-site and/or using samples collected in a Tedlar® bag or evacuated Summa® canister. Analysis of soil gas samples for definitive data is typically done by collecting the samples in a Tedlar® bag or evacuated Summa® canister with analysis performed by dual column GC or GC/MS in an off-site laboratory. Definitive analysis can also be performed on-site. The probes used for collecting soil gas samples consist of hollow rods constructed of a chrome/molybdenum steel alloy attached to a perforated stainless steel retractable probe tip. Teflon® tubing extends from the retractable probe tip inside of the rod and exits at the top. A vacuum pump is used to evacuate the Teflon® tubing of ambient air before a representative soil gas sample can be collected. The vacuum gauge is used to ensure that the appropriate

vacuum is applied and that the tubing is free of obstructions. Three types of soil gas sampling can be conducted:

- Shallow soil gas surveys
- Downhole soil gas sampling
- Passive soil gas

With the exception of the equipment used to drive the soil gas probes into the ground, the procedures for collecting soil gas samples from shallow soils and deep soils are similar. In shallow soils, soil gas probes are driven a maximum of 10 feet into the ground using a pneumatic hammer. In some cases, a hard or semi-consolidated shallow soil layer (such as hardpan) may require the use of an engine-driven hand-operated auger (post hole digger) to pre-drill holes for the soil gas probes. The auger bit will be 2 inches in diameter and will be stopped about 2 feet above the desired soil gas probe depth. The probe will then be driven in the usual manner to collect the 5- and 10-foot samples.

At depths greater than 10 feet, a power driven sampler (sonication or HSA drill rig) is used to drill to the appropriate depth. At the required depth, the 140-pound slide hammer attached to the rig (or the sonication drive unit) is used to drive the soil gas probe to a depth 2 feet beyond the auger head. Once the probe is driven to the required depth, it is retracted a minimum of 3 inches to open the perforated probe tip to the soil. The vacuum pump is then attached and three to five tubing volumes are purged prior to sample collection.

2.2.15 Miscellaneous Sampling Procedures

The following sections describe methods not covered under the previous sections.

2.2.15.1 X-Ray Fluorescence (XRF) Soil Sampling

Surface soil samples (0-3 inches bgs) to be collected for analysis by XRF will be collected with a clean stainless steel trowel and placed in a 4-ounce glass jar. Samples will then be analyzed via XRF in the field. SOPs 7.0 and 8.0 outlining soil sample collection and XRF analysis, respectively, are included in Appendix F. If field analysis results show that a surface sample contains metal concentrations above ambient levels, then a deeper soil sample will be taken from that same location. In such a case, a subsurface soil sample will be collected from 6- to 9-inches in depth with a small (2½-inches) clean, stainless steel hand auger and placed in a 4-ounce glass jar for XRF analysis. For both surface and subsurface samples, enough will be collected to fill a 4-ounce jar with loosely packed soil. This will ensure that sufficient material is collected for those samples that are sent to the laboratory for confirmatory analysis. All jars will be labeled, placed in a zipper lock-type plastic bag, and stored in coolers prior to analysis. Split samples for laboratory analysis will be handled and packaged in accordance with SOP 9.0, Sample Packaging and Shipment, and SOP 10.0, Sample Preservation and Analysis Methods. After collection of each sample, the hole will be filled with native soil and all equipment decontaminated according to the procedures outlined in SOP 11.0, Sample Equipment Decontamination.

2.2.15.2 Sampling for Test Kit Screening

During field investigation or remedial action activities, field test kits for rapid field or screening analysis of total petroleum hydrocarbons (TPH), explosives and polychlorinated biphenyls (PCBs) in soils and in groundwater using immunoassay, colorimetric, and/or turbidimetric methods may be used. The test kits come with all materials, equipment, and supplies to perform tests at two different detection levels preset by the factory. Higher detection limits, other than as specified, can be achieved by additional dilution. The field analytical or screening data can be used for two primary purposes (1) to identify the potential extent of contamination and locate downgradient samples and (2) to help select samples for laboratory analysis.

2.2.15.3 Sampling for Immunoassay Field Test Kit for PAHs

Surface soil samples (0-3 inches bgs) for immunoassay analysis of polynuclear aromatic hydrocarbons (PAHs), trinitrotoluene (TNT), hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), or other analyte for which immunoassay field screening technology exists will be collected using a clean stainless steel trowel and placed in a 4-ounce glass jar. Enough sample volume will be collected to fill a 4-ounce jar with loosely packed soil. This will ensure that sufficient material is collected for those samples that are sent to the laboratory for confirmatory analysis. The jars are labeled, placed in a zipper lock-type plastic bag, and stored in a cooler maintained at 2-4 degrees Centigrade (°C) prior to analysis. Split samples for definitive laboratory analysis will be handled and packaged in accordance with SOP 9.0 and 10.0, respectively. After collection of each sample, the hole will be filled with native soil, and all equipment decontaminated according to the procedures outlined in SOP 11.0. The sample coolers are then carried to the field laboratory for screening analysis by immunoassay. Soil sample collection will be in accordance with procedures presented in SOP 7.0, Collection of Soil Samples. The procedure for screening analysis by immunoassay is described in SOP 12.0.

2.2.15.4 Drum Sampling Procedure

Drums containing unknown liquids or solids can be sampled using the following steps:

- Drum intact, no bulging from pressure: open 2-inch bung and monitor off-gas for volatiles. If none, then visually determine physical state of contents.
 - If liquid: using Coliwasa tube, determine the presence of phase/layers. If none, sample with a bailer.
 - If liquid and presence of phases/layers: sample each phase with Coliwasa tube.
 - If solid: determine if top can be safely removed for coring. If so, proceed to remove the top and use a hand corer to sample. If the top cannot be removed, use 1-inch sample tubes to retrieve the sample.
- If drums are not intact or split open, monitor off gassing for volatiles. If none, sample residual solids using a scoop or hand corer.

Any time monitoring indicates the presence of hazardous vapors, sampling will be discontinued and proper safety equipment will be ascertained and engaged. Sampling will resume only after proper safety procedures are adopted.

2.2.16 Decontamination

During sampling activities, appropriate decontamination measures will be taken to minimize sample contamination from sources including sampling equipment and equipment associated with the sampling process.

2.2.16.1 Drilling and Associated Equipment Decontamination

A centrally located decontamination station will be established for steam cleaning of drilling equipment. This decontamination system includes a pad on which the drilling rigs and other large drilling equipment, such as auger flights, can be steam cleaned. The drilling/direct push rigs and associated equipment will be steam cleaned between use on each hole. The decontamination procedures for non-sampling equipment are as follows:

- Rigs are decontaminated prior to mobilizing to the Arsenal, prior to demobilization from the Arsenal, and between site locations at the Arsenal;
- Augers, bits, and rods are decontaminated with high-pressure hot water, rinsed thoroughly by steam cleaning, and allowed to air-dry; and
- All casings, screws, and other downhole equipment will be steam cleaned prior to installation.

2.2.16.2 Sampling Equipment Decontamination

All reusable field equipment used to collect, handle, or measure samples will be decontaminated before coming into contact with any sample. The decontamination procedure must match the degree of sampling tool contamination. For example, steam cleaning is necessary to remove dirt from auger flights and to prepare well screens and casings for installation into the borehole. Brushes and soap will be used to remove dirt from split-spoon samplers. As a routine, sampling equipment that has come in contact with oil or grease must be cleaned with methanol, followed by a hexane rinse to remove the oily material, and a final rinse with deionized (DI) water.

Before dedicated pumps are installed or submersible pumps used, they will be steam cleaned. The intake check valve area will receive extra cleaning efforts. Steam will be forced through the pump to clean the interior. The exterior of the pump and discharge hose will also be steam cleaned. Clean, disposable gloves will be worn during and after decontamination so as not to re-contaminate the equipment.

Decontamination of sampling equipment such as bailers and hand augers can also be performed at a centrally located decontamination station. After decontamination, the clean, covered equipment will be transferred to remote sampling locations. For remote project

sampling locations, portable decontamination stations will be established for equipment cleaning.

The general decontamination procedures for sampling equipment (SOP 11.0) are as follows:

- Using copious amounts of tap water and a phosphate-free detergent, wash and brush all dirt from the sampling item;
- Rinse sampling item thoroughly with tap water, check item for any residual dirt, and rewash if necessary;
- Rinse item with DI water (ASTM Type II);
- Rinse item with solvent (methanol) to remove residual organics. Solvents must be pesticide grade or better. Follow with a hexane rinse (use a liberal amount to remove and break down the methanol) if testing for pesticides, PCBs, VOCs, or fuels. Final, liberal rinse with DI water; and
- Allow item to completely air-dry prior to any use. Enclose item completely with clean aluminum foil if not intended for immediate use. Place larger items on a clean plastic sheet.

2.2.16.3 Field Measurement Equipment Decontamination

Field measurement equipment will be kept free of contamination. Instruments, such as the water level indicator will be decontaminated following procedures for sampling equipment. Instruments that are sensitive to soap and solvents, like the combination pH meter, will be rinsed using potable water and ASTM Type II reagent-grade water. The probes will be cleaned daily and stored overnight according to the manufacturer's instructions.

2.2.17 Waste Handling

The potential wastes generated from work performed during field activities are drill cuttings, personal protective equipment (PPE), decontamination waters, and well purge waters. Procedures for waste handling are described in the Investigation Derived Waste Plan of the Arsenal-wide Investigation Workplan.

2.3 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Following is a general description of the sample handling and custody requirements. Table 2-1 describes sample containers, preservation methods, and analytical holding times for environmental samples. Holding times shall be calculated from the time of sampling to the time of COMPLETION of the sample handling process. For organic extraction methods, this needs to include the removal of the analytes from the matrix (i.e., the end of the extraction time) but does not include blowdown and/or solvent exchange. For instrumental analyses, use of the instrument documented run time (which may often be the start of the analysis) will be allowable

**Table 2-1
Sample Containers, Preservation Methods, and Analytical Holding Times (1 of 2)**

Parameter	Matrix	Container	Lid	Preservation	Maximum Holding Times	
					Preparation ^a	Analysis ^b
Metals	Water	500 ml polyethylene	Cap with Teflon® seal	HNO ₃ to pH<2; None (Ice to 4°C for Hg)	-	6 months (Hg: 28 days)
	Soil	4 oz. glass jar	Teflon®-lined lids	None (Ice to 4°C for Hg)	-	6 months (Hg: 28 days)
	Soil	Stainless steel sleeve	Teflon®-lined plastic end-caps	None (Ice to 4°C for Hg)	-	6 months (Hg: 28 days)
Volatiles	Water	40 ml glass vials X 3	Cap with Teflon® septum	Ice to 4°C	-	7 days
	Water	40 ml glass vials X 3	Cap with Teflon® septum	HCl to pH<2; Ice to 4°C	-	14 days
	Soil	EnCore sampler X 4 (separate samples must be submitted for moisture analysis)	o-ring cap	Ice to 4°C; 48 hours to analyze or preserve with methanol or sodium bisulfate ^d	-	14 days
	Soil	Stainless steel sleeve	Teflon®-lined plastic end-caps	Ice to 4°C	-	48 hours
Purgeable Hydrocarbons	Water	40 ml glass vials X 3	Cap with Teflon® septum	Ice to 4°C	-	7 days
	Water	40 ml glass vials X 3	Cap with Teflon® septum	HCl to pH<2; Ice to 4°C	-	14 days
	Soil	EnCore sampler X 2 (separate samples must be submitted for moisture analysis)	o-ring cap	Ice to 4°C; 48 hours to analyze or preserve with methanol or sodium bisulfate ^d	-	14 days
	Soil	Stainless steel sleeve	Teflon®-lined plastic end-caps	Ice to 4°C	-	48 hours
Extractable Hydrocarbons	Water	1 liter glass amber jar X 2	Teflon®-lined caps	Ice to 4°C	7 days	40 days
	Soil	4 oz. glass jar	Teflon®-lined lids	Ice to 4°C	14 days	40 days
	Soil	Stainless steel sleeve	Teflon®-lined plastic end-caps	Ice to 4°C	14 days	40 days
Total Recoverable Petroleum Hydrocarbons	Water	1 liter glass amber jar X 2	Teflon®-lined caps	H ₂ SO ₄ to pH<2; Ice to 4°C	C	28 days
	Soils	4 oz. glass jar	Teflon®-lined lids	Ice to 4°C	C	28 days
	Soil	Stainless steel sleeve	Teflon®-lined plastic end-caps	Ice to 4°C	C	28 days
Phenols	Water	1 liter glass amber jar X2	Teflon®-lined caps	Ice to 4°C	7 days	40 days
	Soil	4 oz. glass jar	Teflon®-lined lids	Ice to 4°C	14 days	40 days
	Soil	Stainless steel sleeve	Teflon®-lined plastic end-caps	Ice to 4°C	14 days	40 days
Organochlorine Pesticides, Chlorinated Herbicides or PCBs	Water	1 liter glass amber jar X2	Teflon®-lined caps	Ice to 4°C	7 days	40 days
	Soil	4 oz. glass jar	Teflon®-lined lids	Ice to 4°C	14 days	40 days
	Soil	Stainless steel sleeve	Teflon®-lined plastic end-caps	Ice to 4°C	14 days	40 days
Organophosphorus Compounds	Water	1 liter glass amber jar X2	Teflon®-lined caps	Ice to 4°C; adjust to pH 5-8 upon laboratory receipt	7 days	40 days
	Soil	4 oz. glass jar	Teflon®-lined lids	Ice to 4°C	14 days	40 days
	Soil	Stainless steel sleeve	Teflon®-lined plastic end-caps	Ice to 4°C	14 days	40 days
Semivolatiles or Polynuclear Aromatic Hydrocarbons	Water	1 liter glass amber jar X2	Teflon®-lined caps	Ice to 4°C	7 days	40 days
	Soil	4 oz. glass jar	Teflon®-lined lids	Ice to 4°C	14 days	40 days
	Soil	Stainless steel sleeve	Teflon®-lined plastic end-caps	Ice to 4°C	14 days	40 days

**Table 2-1
Sample Containers, Preservation Methods, and Analytical Holding Times (Page 2 of 2)**

Parameter	Matrix	Container	Lid	Preservation	Maximum Holding Times	
					Preparation	Analysis ^b
Dioxins and Furans	Water	1 liter glass amber jar X2	Teflon®-lined caps	Ice to 4°C	30 days	45 days
	Soil	4 oz. glass jar	Teflon®-lined lids	Ice to 4°C	30 days	45 days
	Soil	Stainless steel sleeve	Teflon®-lined plastic end-caps	Ice to 4°C	30 days	45 days
Nitroaromatics and Nitroamines Or nitroglycerine	Water	1 liter glass amber jar X2	Teflon®-lined caps	Ice to 4°C	7 days	40 days
	Soil	4 oz. glass jar	Teflon®-lined lids	Ice to 4°C	14 days	40 days
	Soil	Stainless steel sleeve	Teflon®-lined plastic end-caps	Ice to 4°C	14 days	40 days
Alkalinity	Water	250 ml polyethylene	Teflon®-lined caps	Ice to 4°C	none	14 days
Anions (Cl, NO ₂ -N, NO ₃ -N, & SO ₄)	Water	250 ml polyethylene	Teflon®-lined caps	Ice to 4°C (Cl: none)	none	28 days
	Soil	4 oz. glass jar	Teflon®-lined lids	Ice to 4°C (Cl: none)	28 days	(NO ₂ /NO ₃ :48 hrs) 28 days
	Soil	Stainless steel sleeve	Teflon®-lined plastic end-caps	Ice to 4°C (Cl: none)	28 days	(NO ₂ /NO ₃ :48 hrs) 28 days
Hexavalent Chromium	Water	500 ml polyethylene	Teflon®-lined caps	Ice to 4°C	c	24 hours
	Soil	4 oz. glass jar	Teflon®-lined lids	Ice to 4°C	30 days	4 days
	Soil	Stainless steel sleeve	Teflon®-lined plastic end-caps	Ice to 4°C	30 days	4 days
Ignitability	Water	250 ml polyethylene	Teflon®-lined caps	none	none	none
	Soil	4 oz. glass jar	Teflon®-lined lids	none	none	none
	Soil	Stainless steel sleeve	Teflon®-lined plastic end-caps	none	none	none
Total Organic Carbon	Water	250 ml polyethylene	Teflon®-lined caps	H ₂ SO ₄ or HCl to pH<2; Ice to 4°C	none	28 days
	Soil	4 oz. glass jar	Teflon®-lined lids	Ice to 4°C	None	
	Soil	Stainless steel sleeve	Teflon®-lined plastic end-caps	Ice to 4°C	none	
Total Cyanide	Water	1 liter polyethylene	Teflon®-lined caps	NaOH to pH>12; Ice to 4°C	c	14 days
	Soil	4 oz. glass jar	Teflon®-lined lids	Ice to 4°C	c	14 days
	Soil	Stainless steel sleeve	Teflon®-lined plastic end-caps	Ice to 4°C	c	14 days
pH	Water	250 ml polyethylene	Teflon®-lined caps	none	-	48 hours
	Soil	4 oz. glass jar	Teflon®-lined lids	none	c	28 days
	Soil	Stainless steel sleeve	Teflon®-lined plastic end-caps	none	c	28 days
Total Dissolved Solids	Water	250 ml polyethylene	Teflon®-lined caps	Ice to 4°C	none	7 days
Soil gas	Soil gas	Tedlar bag	None	none	-	3 days
	Soil gas	Summa Canister	None	none	-	14 days

Abbreviations:
ml = milliliter
oz = ounce

a = Starting from the date of collection

b = Starting from the date of preparation; if no preparation, starting from the date of collection

c = preparation may occur any time prior to analysis. Only the analysis holding time is monitored.

d = Backup samples may be frozen within 48 hours of collection. The hours from collection to freezing must be documented. When removed from the freezer, the sample must be preserved or analyzed within whatever time remains in the 48 hours.

as typical analyses take less than one hour to perform. Preparation and analysis times shall be documented on a sample specific basis. When only a batch time is recorded, the time must be indicative of the time when ALL samples in the batch have been processed, not the start time of the processing of the batch.

For each shipment of water samples provided to the contract laboratory, one sample will be provided in sufficient quantity for MS/MSD analyses and re-preparation (if necessary). Care will be taken in the transport of sample containers, particularly glass containers. Use of sturdy shipping containers with padded dividers or other packaging materials will be used to minimize the possibility of breakage. When possible, the sample cooler along with the sample containers and labels will be provided by the contract laboratory. Field personnel will include the appropriate copies of the COC with all samples collected for analyses.

Sample container labels will include the sample number, the date and time of collection, whether the sample is a grab or composite, the analyses to be performed, and the sampler's initials. Indelible ink will be used for all labels.

2.3.1 Decontamination

During sampling activities, appropriate decontamination measures will be taken to minimize sample contamination from sources including sampling equipment and sample containers. To monitor the effectiveness of these decontamination procedures and the potential effects of ambient conditions, each sampling program will include provisions for collecting the appropriate field QA/QC samples. These samples will include trip blanks, rinsate samples, and field blanks. Pre-cleaned and certified sample containers will be used. The cleanliness of sample containers will be verified by the supplier or the contract laboratory.

2.3.2 Preservation

Preservation procedures are established in accordance with USACE and USEPA protocols and are included in Table 2-1. Sample preservation will be performed immediately upon sample collection except when specifically allowed by the selected method. The contract laboratory will be responsible for inspecting preservation documentation at the time of sample receipt to assure samples are properly preserved. Samples that do not meet preservation requirements will be re-sampled at no additional expense to USACE.

Appropriate measures will be taken to ensure that storage requirements with respect to temperature are maintained in the field, during transport to the laboratory, and during storage at the laboratory. Temperature blanks will be used for all coolers containing samples requiring preservation at reduced temperature.

Encore® Samplers. All soil samples for volatiles analysis will be taken in Encore® sampler tubes. At least 4 tubes will be collected for SW8021B and SW8026B (VOC) analyses and at least 2 shall be collected for SW8015B-volatiles (GRO) analyses. If Encore® samples are collected by taking punches out of a stainless steel sleeve, the remainder of the sleeve must be capped and sent to the laboratory. If Encore® samples are taken by directly pushing the sampling device into shallow exposed soils or the bottom or sidewall of an excavation, a

separate sample must be collected in a separate sealed container. The additional sample or the remaining sample in the sleeve is needed for a moisture analysis, in order to perform a dry weight correction on the data.

Upon receipt, one tube from each sample for GRO analysis will be preserved in methanol for mid-level analysis. Upon receipt, one tube from each sample for VOC analysis should be preserved with sodium bisulfate for low level analysis unless analysis can be performed within 48 hours of sampling. A second tube from each sample should be preserved with sodium bisulfate in a second batch as a backup for possible required re-runs. (The short 48-hour holding time will not allow waiting for the evaluation of primary analyses to evaluate the need for a second sample, so preservation must be performed in advance as a precaution). Additional tubes from each sample (2 for VOCs and 1 for GRO) may be frozen for use in case additional mid-level analyses are required. A freezer log must be kept to show when samples are put into and taken out of the freezer. The total holding time for mid-level samples shall be 14 days. The total un-frozen time (including sampling to freezing and thawing to preservation in methanol or analysis) shall not exceed 48 hours.

2.3.3 Transportation

All samples will be collected, transported, and received under strict COC protocols consistent with procedures established by USACE and USEPA for litigation-related materials. Copies of COC forms will be provided to the USACE PM or his designee whenever samples are shipped from the field. The completed forms may be submitted by facsimile.

Environmental samples will be transported to the contract laboratory using the most rapid means available. Depending on the distance between the project site and laboratory(s), the samples may be delivered by field personnel, a courier service, or an overnight delivery service. Transportation will be scheduled to ensure that the samples arrive within the required holding times and within the specified temperature range. The specific mode of transportation will be identified in each site specific FSIP. All samples will be packaged and transported according to USEPA, USACE, and U.S. Department of Transportation (USDOT) regulations. If coolers containing samples are lost during shipment, the contractor will contact the USACE to determine the appropriate corrective action. If coolers are found in sufficient time such that the temperature of all samples within the cooler would not require qualification of the data and all holding times for analysis can be met, no corrective action need be taken. If the coolers are found with elevated temperatures that would result in data qualification or with expired holding times, the laboratory must notify the contractor who in turn will notify the USACE to determine the appropriate corrective action.

2.3.4 Sample Naming/Numbering Scheme

The following sample numbering system will be used to identify each sample collected at the Arsenal, unless otherwise specified in the FSIP. These numbers will be used to complete sample documentation including: sample labels; COC records; sample collection logs, and field notebooks.

The sample ID is comprised of two parts. The first section of the sample ID consists of the location ID for the place where the samples were collected from. The first part of the location ID describes the site, using three to six characters. For example:

B118A	Building 118A
B056	Building 56
L002	Landfill 2

The next two characters of the location ID designate the sample point descriptor according to the following codes:

DR	drum
GR	grab sample (field blanks)
HA	hand auger
HP	insitu sampling (e.g., Hydropunch [®])
MW	monitoring well
P	piezometer
SB	soil boring
SL	surface location
SP	stockpile
TW	temporary well

The last three characters in the location ID represent the sequential location of that type for that site. All three characters must be filled in. For example, monitoring well #1 would be expressed as "MW001".

The location ID is followed by a dash (-).

The remainder of the sample ID includes information about the specific sample, with the next indicating QC type as:

- A** a normal environmental sample
- B** a field duplicate sample
- C** a USACE split sample
- or
- D** a field blank sample

The D designation will be used for trip blanks, field blanks, rinsates and material blanks. Blind PE samples will be designated as normal environmental samples.

The next placeholder designates the sample type according to the following codes:

- A** ambient air sample
- D** sludge sample
- G** soil gas sample
- L** liquid from the vadose zone
- M** sediment
- O** other sample
- P** wipe sample
- S** soil sample
- W** water sample
- X** waste sample

The last two placeholders represent the sequential sample number for all samples collected at that location.

For example, the sample ID **B118AHA003-A-S02** represents the second primary soil sample collected from the third hand auger at the Building 118A site.

2.4 ANALYTICAL METHODS REQUIREMENTS

All analytical procedures performed under this contract shall conform to the most recently promulgated version of SW-846 (currently Update 3, December 1996). The methods discussed in this QAPP are listed in Table 2-2. Alternate or additional procedures must be pre-approved by the USACE PM or his/her representative prior to use.

If appropriate, colorimetric, immunoassay, or other field screening methods may be used to provide a preliminary indication of contamination at various sampling locations. The use of such a method is subject to review and approval by the USACE PM or his/her representative, and the mobile laboratory or temporary field unit must meet the requirements for a contract laboratory as outlined in Section 1.0. In particular, if either Level III or Level IV data are required, work performed by a mobile laboratory must meet all of the requirements in this QAPP as they relate to sample analysis performed by a fixed site laboratory. In addition, all field screening methods shall be described in the FSIP to the level of detail required for fixed site laboratory analyses.

This section contains a brief description of each laboratory analytical method to be used for the acquisition of chemical data, and includes relevant aspects of laboratory procedures (general preparation methods, analytical detectors, instrumentation, etc.). Analytical quality control requirements, with tables summarizing method/instrument detection limits (MDLs), method quantitation limits (MQLs), analytical control parameters, acceptance values, corresponding corrective actions, calibration procedures, and flagging guidelines are included in tables in Appendices A through D.

**Table 2-2
Summary of Common Environmental Analytical Methods (1 of 3)**

Parameter	Analytical			Extraction/Preparation	
	Matrix	Method	Procedure	Method	Procedure
Metals ^(a)	Water	SW6010B	Inductively Coupled Plasma	SW3005A	Acid Digestion
	Soil	SW6010B	Inductively Coupled Plasma	SW3050B Mod.	Acid Digestion
Metals ^(b)	Water	SW6020	Inductively Coupled Plasma / Mass Spectrometry	SW3010A	Acid Digestion
	Soil	SW6020	Inductively Coupled Plasma / Mass Spectrometry	SW3050B	Acid Digestion
Antimony	Water	SW7041	Graphite Furnace Atomic Absorption	SW3005A	Acid Digestion
	Soil	SW6010B	Inductively Coupled Plasma	SW3050B Mod.	Acid Digestion
Arsenic	Water	SW7060A	Graphite Furnace Atomic Absorption	Within Method	Acid Digestion
	Soil	SW7060A	Graphite Furnace Atomic Absorption	SW3050B	Acid Digestion
Cadmium	Water	SW7131A	Graphite Furnace Atomic Absorption	SW3020A	Acid Digestion
	Soil	SW7131A	Graphite Furnace Atomic Absorption	SW3050B	Acid Digestion
Hexavalent Chromium	Water	SW7196A	Colorimetric	---	---
	Soil	SW7196A	Colorimetric	SW3060A	Alkaline Digestion
Organic Lead	Water	SW7420/LUFT	Flame Atomic Absorption	Within Method	Solvent Extraction
	Soil	SW7420/LUFT	Flame Atomic Absorption	Within Method	Solvent Extraction
Lead	Water	SW7421	Graphite Furnace Atomic Absorption	SW3020A	Acid Digestion
	Soil	SW7421	Graphite Furnace Atomic Absorption	SW3050B	Acid Digestion
Mercury	Water	SW7470A	Cold Vapor Atomic Absorption	SW7470A	Acid Permanganate digestion
	Soil	SW7471A	Cold Vapor Atomic Absorption	SW7471A	Acid Permanganate Digestion
Selenium	Water	SW7740	Graphite Furnace Atomic Absorption	Within Method	Acid Digestion
	Soil	SW7740	Graphite Furnace Atomic Absorption	SW3050B	Acid Digestion
Silver	Water	SW7761	Graphite Furnace Atomic Absorption	SW3020A	Acid Digestion
	Soil	SW7761	Graphite Furnace Atomic Absorption	SW3050B	Acid Digestion
Thallium	Water	SW7841	Graphite Furnace Atomic Absorption	SW3020A	Acid Digestion
	Soil	SW7841	Graphite Furnace Atomic Absorption	SW3050B	Acid Digestion
Purgeable Hydrocarbons (gasoline)	Water, Soil	SW8015B	Gas Chromatography/Flame Ionization Detector	SW5030B	Purge and Trap
	Soil	SW8015B	Gas Chromatography/Flame Ionization Detector	SW5035	Closed System Purge and Trap
Extractable Hydrocarbons (diesel)	Water	SW8015B	Gas Chromatography/Flame Ionization Detector	SW3510C	Separatory Funnel Liquid/Liquid
	Water	SW8015B	Gas Chromatography/Flame Ionization Detector	SW3520C	Continuous Liquid/Liquid
	Soil	SW8015B	Gas Chromatography/Flame Ionization Detector	SW3545	Pressurized Fluid
	Soil	SW8015B	Gas Chromatography/Flame Ionization Detector	SW3550B	Ultrasonic

**Table 2-2
Summary of Common Environmental Analytical Methods (2 of 3)**

Parameter	Analytical			Extraction/Preparation	
	Matrix	Method	Procedure	Method	Procedure
Aromatic and Halogenated Volatile Organics	Water, Soil	SW8021B	Gas Chromatography/Photoionization Detector/Hall Electrolytic Conductivity Detector	SW5030B	Purge and Trap
	Soil	SW8021B	Gas Chromatography/Photoionization Detector/Hall Electrolytic Conductivity Detector	SW5035	Closed System Purge and Trap
Phenols	Water	SW8041	Gas Chromatography/Flame Ionization Detector	SW3510C	Separatory Funnel Liquid/Liquid
	Water	SW8041	Gas Chromatography/Flame Ionization Detector	SW3520C	Continuous Liquid/Liquid
	Soil	SW8041	Gas Chromatography/Flame Ionization Detector	SW3540C	Soxhlet
	Soil	SW8041	Gas Chromatography/Flame Ionization Detector	SW3550B	Ultrasonic
Organochlorine Pesticides	Water	SW8081A	Gas Chromatography/Electron Capture Detector	SW3510C	Separatory Funnel Liquid/Liquid
	Water	SW8081A	Gas Chromatography/Electron Capture Detector	SW3520C	Continuous Liquid/Liquid
	Soil	SW8081A	Gas Chromatography/Electron Capture Detector	SW3540C	Soxhlet
	Soil	SW8081A	Gas Chromatography/Electron Capture Detector	SW3550B	Ultrasonic
Polychlorinated Biphenyls	Water	SW8082	Gas Chromatography/Electron Capture Detector	SW3510C	Separatory Funnel Liquid/Liquid
	Water	SW8082	Gas Chromatography/Electron Capture Detector	SW3520C	Continuous Liquid/Liquid
	Soil	SW8082	Gas Chromatography/Electron Capture Detector	SW3540C	Soxhlet
	Soil	SW8082	Gas Chromatography/Electron Capture Detector	SW3550B	Ultrasonic
Organophosphorus Pesticides	Water	SW8141A	Gas Chromatography/Flame Photometric Detector	SW3510C	Separatory Funnel Liquid/Liquid
	Water	SW8141A	Gas Chromatography/Flame Photometric Detector	SW3520C	Continuous Liquid/Liquid
	Soil	SW8141A	Gas Chromatography/Flame Photometric Detector	SW3540C	Soxhlet
	Soil	SW8141A	Gas Chromatography/Flame Photometric Detector	SW3550B	Ultrasonic
Chlorinated Herbicides	Water	SW8151A	Gas Chromatography/Electron Capture Detector using Methylization or Pentafluorobenzoylation derivatization	Within Method	Separatory Funnel Liquid/Liquid
	Soil	SW8151A	Gas Chromatography/Electron Capture Detector using Methylization or Pentafluorobenzoylation derivatization	Within Method	Ultrasonic/Shaker
Volatile Organic Compounds	Water, Soil	SW8260B	Gas Chromatography/Mass Spectrometry	SW5030B	Purge and Trap
	Soil	SW8260B	Gas Chromatography/Mass Spectrometry	SW5035	Closed System Purge and Trap
Semivolatile Organic Compounds	Water	SW8270C	Gas Chromatography/Mass Spectrometry	SW3510C	Separatory Funnel Liquid/Liquid
	Water	SW8270C	Gas Chromatography/Mass Spectrometry	SW3520C	Continuous Liquid/Liquid
	Soil	SW8270C	Gas Chromatography/Mass Spectrometry	SW3540C	Soxhlet
	Soil	SW8270C	Gas Chromatography/Mass Spectrometry	SW3550B	Ultrasonic
Dioxins and Furans	Water, Soil	SW8280A	Gas Chromatography/Mass Spectrometry (low resolution)	Within Method	---
	Water, Soil	SW8290	Gas Chromatography/Mass Spectrometry (high resolution)	Within Method	---

**Table 2-2
Summary of Common Environmental Analytical Methods (3 of 3)**

Parameter	Analytical			Extraction/Preparation	
	Matrix	Method	Procedure	Method	Procedure
Polynuclear Aromatic Hydrocarbons	Water	SW8310	Liquid Chromatography/UV and Fluorescence Detection	SW3510C	Separatory Funnel Liquid/Liquid
	Water	SW8310	Liquid Chromatography/UV and Fluorescence Detection	SW3520C	Continuous Liquid/Liquid
	Soil	SW8310	Liquid Chromatography/UV and Fluorescence Detection	SW3540C	Soxhlet
	Soil	SW8310	Liquid Chromatography/UV and Fluorescence Detection	SW3550B	Ultrasonic
Polynuclear Aromatic Hydrocarbons	Water	SW8270 SIM	Gas Chromatography/Mass Spectrometry in selective ion mode	SW3510C	Separatory Funnel Liquid/Liquid
	Water	SW8270 SIM	Gas Chromatography/Mass Spectrometry in selective ion mode	SW3520C	Continuous Liquid/Liquid
	Soil	SW8270 SIM	Gas Chromatography/Mass Spectrometry in selective ion mode	SW3540C	Soxhlet
	Soil	SW8270 SIM	Gas Chromatography/Mass Spectrometry in selective ion mode	SW3550B	Ultrasonic
Nitroaromatics and Nitroamines	Water	SW8330	Liquid Chromatography/UV and Fluorescence Detection	Within Method	Salting out
	Soil	SW8330	Liquid Chromatography/UV and Fluorescence Detection	Within Method	Ultrasonic
Nitroglycerine	Water	SW8332	Liquid Chromatography/UV and Fluorescence Detection	---	---
	Soil	SW8332	Liquid Chromatography/UV and Fluorescence Detection	Within Method	Ultrasonic
Total Recoverable Petroleum Hydrocarbons	Soil	SW8440	Infrared Spectrometry	SW3560	Supercritical Fluid (carbon dioxide)
	Soil	E1664	Gravimetric	E1664	Hexane Extraction
Ignitability	Water	SW1010	Pensky-Martens Closed-Cup Flash Point	---	---
	Soil	SW1030	Propane Ignition Source	---	---
Total Cyanide	Water	SW9012A	Automated Colorimetric with Off-Line Distillation	Within Method	Distillation
	Water	SW9014	Manual Colorimetric	SW9010B	Distillation
	Soil	SW9014	Manual Colorimetric	SW9013	Distillation
	Soil	SW9012A	Automated Colorimetric with Off-Line Distillation	SW9013	Distillation
Total Dissolved Solids	Water	E160.1	Gravimetric	---	---
Total Organic Carbon	Water	SW9060	Carbonaceous Analyzer	---	---
	Soil	Walkley Black	Titrimetric with calculation	Within Method	Acidic Dichromate Digestion
Anions (Cl, NO ₂ -N, NO ₃ -N, SO ₄)	Water	E300/SW9056	Ion Chromatography/Conductivity Detection	---	---
	Soil	E300/SW9056	Ion Chromatography/Conductivity Detection	Within Method	Deionized Water Extraction
Alkalinity	Water	E310/SM2320C	Electrometric Titration	---	---
pH	Water	SW9040B	Electrometric	---	---
	Soil	SW9045C	Electrometric, Slurry	---	---
Moisture	Soil	D2216	Gravimetric	D2216	heating
Volatile Organic Compounds	Soil Gas	TO-15	Gas Chromatography/Mass Spectrometry	---	---

^(a) Al, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Li, Mg, Mn, Mo, Ni, K, Ag, Na, Sn, V, Zn

^(b) Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Ag, Na, Ti, Sn, Zn

Note: All extraction, preparation, and analytical procedures shall conform to the most recently promulgated version of SW-846.

2.4.1 Digestion Methods for Metals

This section describes the digestion methods for metal analysis.

2.4.1.1 Waste Extraction Test—California Administrative Code

The Waste Extraction Test (WET) described in the California Administrative Code, Title 22, Article 11, Section 66700, can be used to determine the amount of extractable substance in a waste or other material. This procedure can also be modified and used with a deionized water extract to evaluate the water soluble/leachable substance in a soil or waste. This method does not meet USEPA requirements, but may be used for samples subject to California waste disposal regulations.

2.4.1.2 SW1311—Toxicity Characteristic Leaching Procedure

This method is used to prepare samples for determination of the concentration of organic (semivolatile and volatile) and inorganic constituents extractable from waste or other material.

QC is accomplished by preparing a toxic characteristic leaching procedure (TCLP) blank at a rate of one blank for every 20 leachings conducted in the leaching vessel. Additional leachate is prepared so that one MS is performed for each analytical batch. These QA measures are in accordance with requirements in USEPA Method SW1311, Section 8.0. Digestion, extraction, and analysis of the TCLP leachates are carried out as per SW-846 protocols.

2.4.1.3 SW3005A—Digestion of Aqueous Samples for Total Recoverable or Dissolved Metals for Analysis by FLAA or ICP

This digestion Procedure is used to prepare aqueous samples for analysis by flame atomic absorption (FLAA) or ICP. For total recoverable metals, the entire sample is preserved at the time of collection with nitric acid. For dissolved metals, the sample is filtered through a 0.45 µm filter at the time of collection and the liquid phase is then preserved with nitric acid. A mixture of nitric and hydrochloric acids and the material to be analyzed is refluxed in a covered beaker. After the digestate has been brought to reduced volume, it is filtered, if necessary, and brought to volume.

2.4.1.4 SW3010A—Acid Digestion of Aqueous Samples and Leachates for Total Metals for Analysis by FLAA or ICP

This digestion procedure may be used to prepare aqueous samples, leachates, and wastes that contain suspended solids for analysis by FLAA or ICP. A mixture of HNO₃ and the material to be analyzed is refluxed in a covered Griffin[®] beaker or equivalent. This step is repeated with additional portions of HNO₃ until the digestate is light in color or until its color has stabilized. After the digestate has been brought to a low volume, it is refluxed with hydrochloric acid and brought up to volume.

2.4.1.5 SW3020A—Acid Digestion of Aqueous Samples and Leachates for Total Metals for Analysis by GFAA Spectroscopy

This digestion procedure is used for the preparation of aqueous samples and leachates for analysis by GFAA. A mixture of HNO₃ and the material to be analyzed is refluxed in a covered Griffin® beaker or equivalent. This step is repeated with additional portions of HNO₃, and subsequent additions of hydrogen peroxide, until the digestate is light in color or until its color has stabilized. After the digestate has been brought to a low volume (approximately 10 to 20 mLs), it is cooled and brought up to volume with dilute HNO₃ such that the final dilution contains three percent by volume HNO₃. If the sample contains suspended solids, it must be centrifuged, filtered, or allowed to settle. Methods SW7060 (arsenic) and SW7740 (selenium) call for the addition of hydrogen peroxide and the reduction in volume to 10 to 20 mLs, rather than 5 mLs, as specified in the method.

2.4.1.6 SW3050B—Acid Digestion of Sediments, Sludges, and Solids

This digestion method is used to prepare sediment and soil samples for analysis by ICP, ICP/MS, FLAA, and GFAA. A representative portion of the sample is digested in 1:1 HNO₃. A final reflux procedure is performed using concentrated hydrochloric acid for FLAA and ICP, or concentrated HNO₃ for GFAA. Hydrogen peroxide is added during the digestion procedure. The final volume is adjusted to 10 mL.

2.4.1.7 SW3050B Modification—Acid Digestion of Sediments, Sludges, and Solids

Due to potential loss of antimony which occurs partially through volatilization during the rigorous acid digestion and precipitation of oxides, a minor modification to ensure a proper antimony recovery will be used, if necessary. The modification is as follows:

- Add 5 mL of concentrated hydrochloric acid (HCl) at step 7.2 of EPA SW846, Method 3050B. This is in addition to the written procedure.
- Add an additional 5 mL of HCl at step 7.3 (10 mL is specified in the method).

2.4.1.8 SW3060A—Alkaline Digestion for Hexavalent Chromium

This preparation method uses an alkaline digestion to solubilize both water-insoluble and water soluble Cr(VI) compounds in solid waste samples. The samples are pH adjusted and then digested using 0.28M Na₂CO₃/0.5M NaOH solution and heating at 90-95°C for 60 minutes, followed by additional pH adjustment prior to sample analysis.

2.4.1.9 SW7060 (As) and SW7740 (Se)—Digestion of Aqueous Samples and Leachates for GFAA Spectroscopy Analysis of Arsenic and Selenium

A representative aliquot of sample is heated with nitric acid and peroxide until the digestion is complete or until the volume is reduced to one half the original aliquot volume. The sample is cooled, filtered and brought up to original aliquot volume.

2.4.1.10 LUFT—Organic Lead

A rapid organic extraction technique is applied to separate the organic lead from the matrix using xylene, followed by reaction with one percent aliquot of 336/MIBK in I_2 solution. Soils are extracted by mixing 50g of sample with 100 ml of xylene, and shaking for ½ hour on a mechanical shaker. Waters are extracted 3 times in a separatory funnel. The extract is analyzed for lead by Flame AA.

2.4.2 Analytical Methods for Metals

This section describes the analytical methods for metals analysis.

2.4.2.1 SW6010B—Inductively Coupled Plasma (ICP)

ICP determines sample elements in the acid digestate of a sample. All matrices including ground water, surface water, aqueous samples, industrial wastes, soils, sludges, and sediments require digestion by Methods SW3020A (water) or SW3050B (soil) prior to analysis. Method SW6010B uses simultaneous or sequential multi-element atomic emission spectroscopy to identify and quantify metals simultaneously or sequentially. Samples are nebulized and the resulting aerosol is transported to a plasma torch. Element-specific atomic emission spectra are produced by radio-frequency inductively coupled plasma. The spectra are dispersed and the intensities of the lines are monitored by photomultiplier tubes. Background correction is required for trace element determination.

2.4.2.2 SW6020—Inductively Coupled Plasma/Mass Spectrometry (ICP/MS)

This digestion procedure is used to prepare aqueous samples for analysis by flame atomic absorption (FLAA) or ICP. For total recoverable metals, the entire sample is preserved at the time of collection with nitric acid. For dissolved metals, the sample is filtered through a 0.45 μ m filter at the time of collection and the liquid phase is then preserved with nitric acid. A mixture of nitric and hydrochloric acids and the material to be analyzed is refluxed in a covered Griffin[®] beaker or equivalent. After the digestate has been brought to a reduced volume, it is filtered, if necessary, and brought up to volume.

2.4.2.3 SW7000 Series—Graphite Furnace Atomic Absorption (GFAA)

GFAA determines metals present in the acid digestate of a sample, and is often used in order to achieve the required detection limits where interferences are encountered. Prior to analysis, soil samples will be prepared using the Method SW3050B digestion procedure, and water samples may be prepared using Method SW3020A for total recoverable metals. A representative aliquot of the sample is placed into a graphite tube "furnace," electrothermally dried, charred, and the elements present atomized. A light beam from a hollow cathode lamp or electrodeless discharge lamp is directed through the furnace, into a monochromator, and onto a detector that measures absorbance. The resulting absorption of a specific light beam from the hollow cathode or electrodeless discharge lamp will be proportional to the metal concentration. Background correction will be used for all analyses. Dilution will be performed for samples with concentrations outside the linear calibration range. The matrix may be modified by the addition of certain compounds or elements, as recommended by the determinative methods, to reduce interferences. The absence of interferences will be verified.

2.4.2.4 SW7470A and SW7471A—Cold Vapor Atomic Absorption (CVAA)

This digestion procedure is used to prepare aqueous samples for analysis by FLAA or ICP. For total recoverable metals, the entire sample is preserved at the time of collection with nitric acid. For dissolved metals, the sample is filtered through a 0.45 µm filter at the time of collection and the liquid phase is then preserved with nitric acid. A mixture of nitric and hydrochloric acids and the material to be analyzed is refluxed in a covered Griffin® beaker or equivalent. After the digestate has been brought to a reduced volume, it is filtered if necessary and brought up to volume.

2.4.2.5 SW7196A—Hexavalent Chromium (Colorimetric)

This digestion procedure is used to prepare aqueous samples for analysis by FLAA or ICP. For total recoverable metals, the entire sample is preserved at the time of collection with nitric acid. For dissolved metals, the sample is filtered through a 0.45 µm filter at the time of collection and the liquid phase is then preserved with nitric acid. A mixture of nitric and hydrochloric acids and the material to be analyzed is refluxed in a covered Griffin® beaker or equivalent. After the digestate has been brought to a reduced volume, it is filtered if necessary and brought up to volume.

2.4.3 Preparation Methods for Organic Compounds

This section describes extraction, cleanup, and purge and trap methods for organic compounds.

2.4.3.1 SW3510C—Separatory Funnel Liquid-Liquid Extraction

This procedure is applicable to the isolation and concentration of organic compounds from aqueous samples. A measured volume (usually one liter) of sample is placed into a separatory funnel, adjusted if necessary to a specific pH, and serially extracted with methylene chloride. The extract is then dried with anhydrous sodium sulfate, exchanged (as necessary) into a solvent compatible with the determinative method, and concentrated to the appropriate volume.

2.4.3.2 SW3520C—Continuous Liquid-Liquid Extraction

This procedure is applicable to the isolation and concentration of organic compounds from aqueous samples. A measured volume (usually one liter) of sample is placed into a continuous liquid-liquid extractor, adjusted if necessary to a specific pH, and extracted with Freon or methylene chloride for 18 to 24 hours. The extract is then dried, exchanged (as necessary) into a solvent compatible with the determinative method, and concentrated to the appropriate volume.

2.4.3.3 SW3540C—Soxhlet Extraction

This procedure extracts nonvolatile and semivolatile fuels from solids such as soils, sludges, and wastes. It is applicable to the isolation of water-insoluble and slightly water soluble organic compounds for further analysis by gas chromatography. The solid sample is mixed with anhydrous sodium sulfate to form a free-flowing powder, placed in an extraction thimble, and extracted using an appropriate solvent in a Soxhlet extractor. The extract is then dried, exchanged (as necessary) into a solvent compatible with the determinative method, and concentrated to the appropriate volume.

2.4.3.4 SW3545—Pressurized Fluid Extraction

This procedure extracts nonvolatile and semivolatile fuels from solids such as soils, wastes, and sludges. The solid sample is mixed with anhydrous sodium sulfate to form a free-flowing powder and loaded into an extraction cell. The extraction cell is heated, pressurized with the appropriate solvent, and extracted for 5 minutes. The solvent is then collected from the heated extraction vessel, dried, exchanged (as necessary) into a solvent compatible with the determinative method, and concentrated to the appropriate volume.

2.4.3.5 SW3550B—Sonication Extraction

This procedure extracts nonvolatile and semivolatile fuels from solids such as soils, wastes, and sludges. The sonication process ensures intimate contact of the sample matrix with the extraction solvent. A weighed sample of the solid material is mixed with the anhydrous sodium sulfate, ground to form a free-flowing powder, then sonicated sequentially with three solvent aliquots. Freon and methylene chloride are typically used as solvents, although other solvents may be used for specific analytical applications. For example, Methods 3550B and SW3540 require 1:1 acetone/methylene chloride or 1:1 acetone/hexane for soil and sediments. The extract is separated from the sample by vacuum or gravity filtration, or centrifugation, and then dried with anhydrous sodium sulfate and concentrated to the appropriate volume. The resulting solution is analyzed using the appropriate method.

2.4.3.6 SW3560—Supercritical Fluid Extraction of Total Recoverable Petroleum Hydrocarbons

This procedure extracts total recoverable petroleum hydrocarbons (TRPHs) from solids such as soils, sediments, and wastes. The solid sample is transferred to the extraction vessel and extracted using supercritical carbon dioxide. The extracted TRPHs are collected in a small volume of tetrachloroethene for later analysis by infrared spectrophotometry.

2.4.3.7 SW3630C—Silica Gel Cleanup

Silica gel is a weakly acidic adsorbent that effectively removes polar and semipolar organic materials such as fats and oils from nonpolar materials such as hydrocarbons and PCBs. The procedure can be used for the column cleanup of sample extracts containing diesel-range organics, PAHs, organochlorine pesticides, and PCBs. Prior to use, the activity of the silica gel must be adjusted to the level appropriate to its intended use. The silica gel is packed into a glass column using a nonpolar solvent. A concentrated extract is added to the top of the column. The components of the extract are eluted by gravity by adding a series of solvents of increasing polarity, depending on the separation that is to be performed. Nonpolar components elute first while very polar materials are eluted only with very polar solvents. Solid-phase extraction cartridges are available as a convenient option for simple separations such as separating hydrocarbon fuel residues from fats and oils. All sample extracts for Methods SW8015 (extractables) shall receive silica gel cleanup prior to initial analysis.

2.4.3.8 SW3640A—Gel Permeation Chromatography (GPC)

GPC is a size-exclusion cleanup procedure using organic solvents and polymeric hydrophobic gels to effect separation on the basis of molecular size. High molecular weight materials are too large to be captured within the pores of the stationary phase and so elute with the solvent front.

Lower molecular weight materials are retarded to a degree depending on their molecular size. GPC is recommended for the elimination of lipids, polymers, proteins, natural resins, and asphaltenes from the sample extract. It can be used whenever the presence of high molecular weight materials in the extract interferes with the analysis. Cyclohexane and methylene chloride are typical eluents. The method is particularly applicable to the cleanup of pesticides, PAHs and SVOCs.

2.4.3.9 SW3660B—Sulfur Cleanup

Molecular sulfur is encountered in many sediment samples and industrial wastes. It is soluble in common organic solvents and commonly appears as an interfering substance in pesticide analyses. Sulfur is removed from solvent extracts by shaking with activated copper reagent or tetrabutylammonium (TBA) sulfite reagent. Following mixing, the reagent is removed by centrifugation (copper) or partitioning into an aqueous phase (TBA sulfite). The technique is applied only when sulfur is suspected or demonstrated to be present. It is most often used in conjunction with the analysis of pesticides by SW8081A or SVOCs by SW8270C.

2.4.3.10 SW5030B—Purge and Trap

This procedure extracts VOCs and purgeable aromatic compounds from liquid matrices. An aliquot of the sample is placed in the purge chamber and an inert gas is bubbled through the sample at ambient temperatures. The volatile components are then transferred from the aqueous matrix to a sorbent column where they are trapped. After purging is completed, the sorbent column is heated and backflushed with an inert gas to desorb the components onto a gas chromatographic column. The gas chromatographic column is heated to elute the components that are detected by the appropriate detector.

This procedure is routinely used for the analysis of gasoline range organics (GRO) by Method SW8015B. Twenty-five mL of a sample are typically purged when performing low-level aqueous analyses.

An extraction method (such as Method SW5035) can also be employed in conjunction with Method SW5030B for analysis of non-aqueous and solid samples when high concentrations of VOCs and/or GRO are expected. This involves transfer of a sample collected with an Encore® sampling device into methanol within 48 hours of collection. An aliquot of this methanol extract is then added to reagent water and purged as discussed above. Twenty-five mL of a sample are typically purged when performing low-level aqueous analyses.

2.4.3.11 SW5035—Closed-System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples

SW5030 for the extraction of volatile organics from soil and water slurries has been largely supplanted by Method SW5035 in order to reduce losses due to volatilization and biodegradation (SW5030 remains in effect for analyzing water samples, mid level VOCs, and GROs). The new procedure involves headspace-free sampling in the field coupled with preservation or shortened holding times. Low-level analysis is accomplished with the use of a special syringe-type subsampling device such as the patented Encore® sampler. Mid-level preparation (with detection limits about 50 times higher than those by the low-level technique) may be performed using field methanol preservation. Alternatively, the sample for mid-level

analysis may be collected in the special sampler and preserved in methanol upon receipt by the laboratory. When cleanup criteria are established, the mid-level preservation in methanol procedure may be utilized if detection limits are less than 1/2 of the cleanup criteria. If soils can not be penetrated using the special sampling device or an on-site laboratory is available, cohesive soils contained in stainless steel sleeves will be shipped to the laboratory and analyzed within 48 hours of sample collection. Method SW5035 is applicable to the preparation of volatiles by Methods SW8021B and SW8260B (low level), and as a preservation technique for Method SW8260B (mid-level) and Method SW8015B-Gasoline.

2.4.4 Analytical Methods for Organic Compounds

Compound identification is based on the time it takes a compound to travel through a column. The retention time of a compound is determined during instrument calibration with target analytes. Since not all compounds have unique retention times, GC and HPLC methods not utilizing mass spectrometry require sample extracts to be analyzed on a second, dissimilar column or detector when detectable quantities are indicated to decrease the probability of false positives. Second column confirmation for all GC sample analyses involving identification of discrete peaks with detectable concentrations will be required. Second column confirmation requirements are discussed in detail in Section 2.5.3.3.

Method SW8270C may also be used in the selected ion monitoring (SIM) mode to increase sensitivity. Rather than performing full mass spectral scans, the instrument is programmed to monitor ion masses for select compounds. The SIM method may be required to meet target detection limits based on cleanup goals for highly toxic or carcinogenic chemicals, including some PAH compounds. It may be used in place of Method SW8310, which is commonly subject to sample matrix interference. MQLs for PAH compounds by Method SW8270C in the SIM mode are listed in Appendix A.

Halogenated compounds are detected by a Hall Electrolytic Conductivity Detector (HECD), placed in series after the nondestructive PID.

2.4.4.1 SW8015B—Total Petroleum Hydrocarbons by GC/FID

This method determines total petroleum hydrocarbons as gasoline or diesel fuel by Method SW8015B. Volatile hydrocarbons (e.g., gasoline) are prepared by Method SW5035 or by purge-and-trap Method SW5030B if analysis can be performed within 48 hours. SVOCs (e.g., diesel fuel or motor oil) are analyzed after extraction by SW3510C or SW3520C for aqueous samples, or by SW3540C or SW3550B for soils. The sample, after purge-and-trap or extraction, is injected into a temperature-programmed gas chromatograph, and component detection is achieved by a flame ionization detector (FID).

Purgeable hydrocarbons will be compared to the retention times established for GRO established in SW-846 (i.e., between 2-methylpentane [~C6] and 1,2,4-trimethylbenzene [~C10]). Hydrocarbons falling within this range will be quantitated against gasoline and designated as GRO.

Extractable hydrocarbons will be compared to the retention times established for diesel range organics (DRO) between C10 and C24. Hydrocarbons falling within this range will be

quantitated against diesel fuel #2 and designated as DRO. Hydrocarbons falling within the range of C20 to the end of the chromatogram (~C36) will be quantitated against SAE10W30 or other motor oil that elutes after C20 and referenced as residual range organics "RRO." Quantitation of heavy petroleum hydrocarbons in the RRO range against a motor oil standard will replace the use of USEPA Method 418.1 for total recoverable petroleum hydrocarbons at locations with the possible presence of waste oil. The other analyses required for potential waste oil sites may be requested on a contingent basis (i.e., analyses required only if TPH is detected) as long as analyses can be performed within holding time limits.

Generally, GRO in aqueous samples can be determined directly by purge-and-trap, and injection into the gas chromatograph. Medium level contaminated soils may require methanolic extraction, as described in Methods 5030B and 5035, prior to purge-and-trap. Samples to be analyzed for DRO require extraction with methylene chloride/acetone (1:1) prior to analysis. The extract may be concentrated prior to injection into the gas chromatograph.

Occasionally, a chromatogram may suggest that a mixture of fuels with overlapping carbon ranges is present in the field sample. If the chromatographic pattern(s) are representative of known fuel standards, the identity of the fuel should be noted in the case narrative. Peak areas from individual compounds greater than 5% of the total area (without the area of any surrogate standards) are to be manually subtracted from the area used for quantitation by the laboratory prior to calculating the concentration of GRO, DRO, and/or RRO and the identity and/or retention times of those compounds are to be included with the analytical data package. Chromatograms for samples and standards should be included in all data packages, regardless of the documentation level requested for the remainder of the package.

In the future, if a site(s) is identified that requires the quantitation of a petroleum product that spans the DRO and RRO ranges, the possibility of quantitation against a matching standard will be investigated at that time. No provision for other quantitation scenarios will be included at this time.

2.4.4.2 SW8021B—Aromatic and Halogenated VOCs by GC/PID/HECD

Method SW8021B uses gas chromatography to determine the presence of aromatic and halogenated VOCs. Volatile compounds in water or low-level contaminated soils can be introduced directly into the gas chromatograph by purge-and-trap Method SW5030B. Medium-level contaminated soils may require methanolic extraction, as described in Method SW5030B, prior to purge-and-trap. A temperature program is used in the gas chromatograph to effect an efficient separation of the organic sample components. Aromatic compounds are detected by a photoionization detector (PID). Halogenated compounds are detected by a hall electrolytic conductivity detector (HECD) placed in series after the nondestructive PID.

Compound identification is based on the time it takes a compound to travel through a column. The retention time of a compound is determined during instrument calibration with target analytes. Since not all compounds have unique retention times, GC methods not utilizing mass spectrometry require sample extracts to be analyzed on a second, dissimilar column when detectable quantities are indicated to decrease the probability of false positives. Second column confirmation for all GC sample analyses involving identification of discrete peaks with detectable concentrations will be required. Second column confirmation is not required for concentrations reported between the MDL and the MQL.

2.4.4.3 E1664—Total Recoverable Petroleum Hydrocarbons by Extraction and Gravimetry

This method is applicable to the determination of extractable petroleum hydrocarbons in water, wastewaters, and solids. Compounds such as motor oil, mineral hydrocarbons, or any material recovered as a substance soluble in hexane with a boiling point greater than 85°C can be determined by these procedures. Petroleum fuels from gasoline through #2 fuel oil may be partially lost in the solvent removal operation. Water samples are acidified with hydrochloric acid to a pH less than 2, and serially extracted with hexane three times in a separatory funnel, and then the extracts collected. The combined extracts are filtered through sodium sulfate, and brought up to a final volume with hexane. Silica gel is added to the dried extract to remove polar materials such as fatty acids/biological lipids. Soil samples are refluxed with hexane using a Soxhlet apparatus. The dried extract is then weighed.

2.4.4.4 SW8041—Phenols by GC/FID

Method SW8041 uses gas chromatography to detect phenolic compounds. Prior to using this method, soil samples must be prepared using Soxhlet extract (SW3540C), and water samples must be prepared using separatory funnel (SW3510C) or continuous liquid/liquid extract (SW3520C) techniques. A two to five microliter sample is injected into a gas chromatograph using the solvent flush techniques, and compounds in the GC effluent are detected by a FID.

2.4.4.5 SW8081A—Organochlorine Pesticides by GC/ECD

Method SW8081A is a gas chromatograph/electron capture detector (GC/ECD) method for the detection of organochlorine pesticides. Water samples are extracted at a neutral pH with methylene chloride by Methods SW3510C or SW3520C. Soil samples are extracted with methylene chloride and acetone using Method SW3540C, a Soxhlet extraction procedure. Extracts are solvent exchanged into hexane and undergo clean up procedures as deemed necessary for the sample. Identification is based on the comparison of a resulting sample chromatogram to that of a standard. Quantitation is performed relative to the initial calibration.

2.4.4.6 SW8082—Polychlorinated Biphenyls (PCBs) by GC/ECD

Method SW8082 is a GC/ECD method for the detection of polychlorinated biphenyls (PCBs, commonly referred to as Aroclors). Sample extraction and analysis are similar to Method SW8081A, but the more rigorous clean up procedures may tend to break down some single component pesticides. Identification of Aroclors requires detection of multiple peaks in a recognizable chromatographic pattern.

2.4.4.7 SW8141A—Organophosphorus Pesticides by GC/FPD

Method SW8141A is a gas chromatographic method for the detection of various organophosphorus pesticides. Water samples are extracted at a neutral pH with methylene chloride by Method SW3010C or SW3520C. Soil samples are extracted with methylene chloride and acetone using Method SW3540C, a Soxhlet extraction procedure. Extracts are solvent exchanged into isooctane and undergo clean up procedures as deemed necessary for the sample. A temperature program is used in the gas chromatograph to effect an efficient separation of the organic sample components. These sample components produce chromatograms with single peaks. Identification is based on the comparison of a resulting chromatogram to that of a standard. Quantitation is performed relative to the initial calibration.

2.4.4.8 SW8151A—Chlorinated Herbicides by GC/ECD

Method SW8151A provides extraction, esterification and gas chromatographic conditions with electron capture detection for the analysis of chlorinated acid herbicides. The herbicides are extracted from soil by shaker with ethyl ether, and from water by partitioning in a separatory funnel with ethyl ether. Extracts are hydrolyzed with aqueous potassium hydroxide, acidified, and then extracted into ethyl ether. The extracts containing the protonated herbicides are concentrated by rotary evaporation and nitrogen blow-down. The concentrates are methylated with diazomethane and solvent exchanged into isooctane. These sample components produce chromatogram with single peaks. Identification is based on the comparison of a resulting chromatogram to that of a standard. Quantitation is performed relative to the initial calibration. Spiked samples are used to verify the applicability of the chosen extraction technique to each new sample type.

2.4.4.9 SW8260B—Volatile Organic Compounds by GC/MS

This method is based upon a purge-and-trap, GC/MS procedure, and is used to determine volatile organic compounds in a variety of matrices. Volatile compounds in water or low-level contaminated soils can be introduced directly into the gas chromatograph by the purge-and-trap method (SW5030B). Medium-level contaminated soils may require methanolic extraction, as described in Method SW5030B, prior to purge-and-trap. The components are separated via the gas chromatograph and detected using a mass spectrometer, which provides both qualitative and quantitative information. Mass spectrometry detects target analytes in the column effluent by providing a characteristic ion pattern for fragmented target analyte molecules, therefore providing a high level of confidence in compound identification.

2.4.4.10 SW8270C—Semivolatile Organic Compounds by GC/MS

Method SW8270C is used to quantify most neutral, acidic, and basic organic compounds that are soluble in methylene chloride (solvent is 1:1 acetone/methylene chloride). Such compounds include polynuclear aromatic hydrocarbons, chlorinated hydrocarbons, pesticides, phthalate esters, organophosphate esters, nitrosamines, haloethers, aldehydes, ethers, ketones, anilines, pyridines, quinolines, aromatic nitro compounds, and phenols. Prior to using this method, soil samples must be prepared using Soxhlet extraction (SW3540C) or sonication (SW3550) and water samples must be prepared using separatory funnel (SW3510C) or continuous liquid/liquid extraction (SW3520C) techniques. Mass spectrometry detects target analytes in the column effluent by providing a characteristic ion pattern for fragmented target analyte molecules, therefore providing a high level of confidence in compound identification.

2.4.4.11 SW8280A, SW8290—Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by GC/MS

These methods are appropriate for the determination of tetra-, penta-, hexa-, hepta and octa-, chlorinated dibenzo-p-dioxins (PCDDs) and dibenzo-furans (PCDFs). Method SW8280A uses matrix-specific extraction, analyte specific cleanup, and high-resolution capillary column gas chromatography/low resolution mass spectrometry (HRGC/LRMS) techniques. Method SW8290 uses matrix-specific extraction, analyte specific cleanup, and HRGC/HRMS techniques. Methods SW8280A and SW8290 use additional QC to allow more sophisticated determinations of detection limits and matrix spike recoveries than other routine GC and GC/MS methods. The sensitivity of these methods is dependent upon the level of interference within a given matrix. Actual values have been shown to vary by homologous series and, to a lesser

degree, by individual isomer. All PCDD and PCDF analyses performed for USEPA since 1982 have used a technique for calculating the detection limit for each of the chlorination levels and each congener by using the noise level present in the elution window and the height of the chromatographic peak of the internal standard. Both the signal-to-noise ratio and peak height are determined by the GC/MS data system and the result of the calculation is a detection limit that is specific to the homologous series and sample.

Methods SW8280A and SW8290 require isotopically labeled analogs of target analytes to be spiked into each sample before extraction to assess matrix effects on method performance. Method SW8280A uses six C-13 analogs. Method SW8290 uses ten C-13 analogs, one furan and one dioxin at each chlorination level. These isotopically labeled analogs elute and behave as target analytes do, without interfering with the analysis. Target analytes are quantitated relative to the isotope analog and therefore their calculated concentration is compensated for extraction efficiency.

2.4.4.12 SW8310—Polynuclear Aromatic Hydrocarbons (PAHs) by HPLC

Method SW8310 is a high performance liquid chromatography (HPLC) method with ultra-violet and fluorescence detection for the analysis of PAHs. Water samples are extracted with methylene chloride by Method SW3510C or SW3520C. Soil samples are extracted with methylene chloride and acetone using Method SW3550 or SW3540C, a Soxhlet extraction procedure. Soil extracts are solvent exchanged and undergo a silica gel clean up procedure. Extracts are then solvent exchanged to methanol for analysis. These target analytes produce chromatograms with single peaks. Identification is based on the comparison of a resulting sample chromatogram to that of a standard. Quantitation is performed relative to the initial calibration.

2.4.4.13 SW8330—Nitroaromatics and Nitroamines by HPLC

Method SW8330 is a HPLC method for the extraction and detection of explosives residues in waters, soils, and sediments. Aqueous samples suspected of containing high levels of explosive residues are filtered, and analyzed on the HPLC using direct aqueous injection. Aqueous samples suspected of containing low levels of explosives residues are extracted by "salting out" an aliquot of the sample, and extracting with acetonitrile. Soils and sediments are also extracted with acetonitrile prior to analysis by HPLC. If soils and sediments appear non-homogeneous they are air dried, ground, and sieved through a 30 mesh screen. A 2-gram sample aliquot is then extracted with acetonitrile, aliquoted, treated with calcium chloride solution, filtered, then analyzed by HPLC. All samples and extracts are analyzed on an HPLC fitted with a C-8 reverse phase column at an ultraviolet detection of 250 nm. Positive detections may be confirmed on a cyano-column. These target analytes produce chromatograms with single peaks. Identification is based on the comparison of a resulting sample chromatogram to that of a standard. Quantitation is performed relative to the initial calibration.

2.4.4.14 SW8332—Nitroglycerine by High Performance Liquid Chromatography

This method uses reverse phase high performance liquid chromatography to separate nitroglycerine from the sample matrix. Solid samples are extracted into acetonitrile, whereas liquid samples are diluted 1:1 with acetonitrile. The nitroglycerine concentration is determined by measuring the response on an ultraviolet detector and comparing the result to calibration standards.

2.4.4.15 SW8440—Total Recoverable Petroleum Hydrocarbons (TRPH) by Infrared Spectrophotometry

This method is applicable to the determination of TRPH in solid matrices. Samples are extracted using Method SW3560, supercritical fluid extraction for TRPH. The extracts are analyzed using infrared spectrophotometry. This method is used as a substitute for the more traditional Method E418.1, which uses a chlorofluorocarbon solvent.

2.4.5 Other Analytical Methods

The following sections describe analytical methods not covered in the previous sections.

2.4.5.1 ASTM D2216—Soil Moisture Content

Determining soil moisture involves transferring a weighed one or two gram sample to a tared container, then placing the sample and container in to dry in a preheated oven at $110^{\circ}\text{C} \pm 2^{\circ}\text{C}$. During the drying period, a current of dried air should flow through the oven. In most cases, drying a test specimen overnight (about 12 to 16 hours) is sufficient. In cases where there is doubt concerning the adequacy of drying, drying should continue until the change in mass after two successive periods (greater than 1 hour) of drying is an insignificant amount (less than about 0.1%). After the drying period, the sample will be removed and allowed to cool in a desiccator before weighing. The modified formula for calculating moisture, listed below, shall be used for the calculations:

$$w = [(W1-W2)/(w1-wc)] \times 100$$

Where

w = Moisture content, %

W1 = Weight of container and moist soil, grams

W2 = Weight of container and oven dried soil, grams

WC = Weight of container, grams

2.4.5.2 E160.1—Total Dissolved Solids

Total dissolved solids in water are measured by filtering a measured volume of sample through a glass fiber filter. The filtrate is transferred to a tared drying dish. The water is evaporated and dried at 180°C . The drying dish and residue are cooled in a desiccator and weighed. The drying cycle is repeated until constant weight is obtained. The total dissolved solids are equal to the final weight of the drying dish plus residue, minus the tared weight of the drying dish, divided by the volume of sample.

2.4.5.3 E300.0/SW9056—Common Anions (Chloride, Nitrite-N, Nitrate-N, and Sulfate)

This is an ion chromatographic (IC) method applicable to the determination of anions in water. A small volume of sample (0.2 to 0.5 mL) is introduced into an ion chromatograph, typically through a fixed loop. The anions of interest are separated on an anion separator column, eluted through the addition of a sodium carbonate / sodium bicarbonate solution, and measured by a conductivity detector. To determine the concentration of an analyte, the measured conductivity level is compared to the calibration curve. Samples containing particles larger than 0.45

microns require filtration prior to analysis. Soil samples must be extracted with deionized water prior to analysis.

2.4.5.4 SW1010—Pensky-Martens Closed-Cup Method for Determining Ignitability

This method is used to measure the flash point of a liquid waste. The sample is heated and stirred in a closed cup. A flame is directed into the cup at regular intervals. The temperature at which the vapor in the cup ignites is the flash point of the liquid.

2.4.5.5 SW1030—Ignitability of Solids

This method is used to evaluate the characteristic of ignitability of solid waste material. A propane flame is applied to one end of a strip or powder train of material 250 millimeters long. If the material does not ignite after a specified time period, it is considered inflammable. If the material ignites and at least 200 millimeters of the strip burns, then the material is considered capable of sustaining combustion and a burning rate test is performed.

2.4.5.6 Standard Methods 2320C/E310.1—Alkalinity

The sample pH is measured. The sample is then initially titrated with HCl to a pH of 8.3, the volume of titrant recorded, and then the titration is taken to a final pH of 4.5 to determine the total alkalinity. The contributions to the total alkalinity from carbonate, bicarbonate, and hydroxide ions are then calculated.

2.4.5.7 SW9012A/SW9014—Total and Amenable Cyanide

These methods use a reflux-distillation to separate cyanide from the sample matrix. Soil samples are prepared using Method SW9010/SW9013 when analysis is performed by SW9014. The preparation procedure for samples analyzed by SW9012A is described within the method. Hydrocyanic acid (HCN) is generated by refluxing the sample under acidic conditions. The HCN gas is absorbed in a sodium hydroxide scrubber, and the cyanide concentration in the scrubber solution is determined using automated ultraviolet colorimetry in SW9012A and manual colorimetry in SW9014. To test for cyanide amenable to chlorination, one aliquot of sample is pretreated with chlorine and the result is compared to a second, untreated aliquot.

2.4.5.8 SW9040B—pH Electrometric Measurement

This method uses a meter equipped with a pH electrode to measure the negative log of the hydrogen ion activity (pH) in an aqueous sample. The meter measures the electrical potential from a glass measuring electrode and compares it to a reference electrode potential. The measured value is temperature dependent and must be compensated if the sample is at a different temperature than the standard buffer solutions.

2.4.5.9 SW9045C—Soil and Waste pH

This method measures the pH of solid and waste samples. The sample is mixed with reagent water to form a slurry, and the pH of the slurry is measured with a meter as in Method SW9040B.

2.4.5.10 SW9060—Total Organic Carbon (TOC) in Water

The organic carbon in the sample is measured using a carbonaceous analyzer. The organic carbon of a liquid sample is converted to carbon dioxide (CO₂) by catalytic combustion or by persulfate oxidation. The CO₂ formed is then measured directly by an infrared detector. The amount of CO₂ produced by the sample is directly proportional to the concentration of carbonaceous material in the sample.

2.4.5.11 Walkley-Black—Total Organic Carbon (TOC) in Soil

Organic carbon in soil samples is analyzed by oxidizing the organic matter with hot potassium dichromate and acid, followed by titration with ferrous sulfate. The chromate reduced in this reaction is assumed to be equivalent to the organic carbon present in the sample.

2.4.5.12 Method TO-15—GC/MS Analysis of Air or Soil Gas Samples

The canister method follows the guidelines established in USEPA's Compendium of Methods for the Determination of Toxic Compounds in Ambient Air (1996). Air or soil gas samples are collected in evacuated stainless steel canisters or Tedlar bags for analysis by GC/MS. The TICs will be reported when requested for TO-15 analyses. The TICs will be compared to a NIST library of mass spectra. A fit factor will be reported with each TIC to assess the accuracy of analyte identification in the sample.

After a sample is received from the field and logged into the laboratory system, the canister pressure and temperature are measured and logged into a separate sample analysis notebook and then measured and recorded. Nitrogen is added to the canisters to provide positive pressure for removing the sample, and to minimize sample component reactions.

To achieve the desired detection levels, VOCs are separated from the vapor matrix and concentrated. The analytical procedure consists of:

- Collection of the VOCs through a drier or moisture trap onto a cryogenic trap;
- Flash thermal desorption onto a fused silica capillary GC column;
- Detection of VOCs by MS; and
- Computer-assisted data reduction.

An average RF or linear regression is used for quantitation. The system is tuned daily using 4-bromofluorobenzene (BFB); the method specified tuning criteria must be met before analysis can proceed. Although TO-15 includes a very large list of potential analytes, the target analyte list for air and soil gas analyses will adhere to the list specified for Method TO-15 in Appendix A unless otherwise specified in the site-specific FSIP.

2.5 ANALYTICAL QUALITY CONTROL REQUIREMENTS

The purpose of this section is to describe how analytical data quality will be assessed and the criteria used to define acceptable limits of uncertainty. The term "data quality" refers to the level of reliability associated with a particular data set or data point. The data quality associated with environmental measurement data is a function of the sampling plan rationale, the procedures

used to collect the samples, and the analytical methods and instrumentation used in making the measurements. Each component has its own potential sources of uncertainty and biases that may affect the overall data quality. Sources of uncertainty that can be traced to the sampling component of environmental data collection are poor sampling plan design, incorrect sample handling, faulty sample transportation, and inconsistent use of field procedures. The most common sources of uncertainty that can be traced to the analytical component of environmental data collection are problems associated with sample preparation, equipment calibration, and laboratory contamination. Although these major sources of potential uncertainty can be minimized by the proper execution of all QC mechanisms, uncertainty cannot be eliminated entirely from environmental data. The amount of uncertainty that is tolerable depends on the objective of the sampling program and the intended use of the data.

A variety of QC samples are used to quantitatively assess the quality of the data. Method blank and laboratory control samples uniquely measure the laboratory component of measurement performance. Matrix spikes, matrix spike duplicates, laboratory duplicates, and surrogate spikes measure the matrix component of measurement performance, but also reflect laboratory performance. The contract laboratory shall, as a minimum, analyze internal QC samples at the frequency specified by the analytical method and in this QAPP. In the field, additional quality control samples are used to assess field sampling techniques and environmental conditions during sample collection and transportation. Trip blanks, equipment rinsate blanks, filter blanks, source water samples, QC field duplicates and QA split samples are used to help evaluate field representativeness. These QC samples will be evaluated in terms of precision, accuracy, representativeness, completeness, and comparability (PARCC), as described later in this section, in order to determine overall data quality. Method-specific QC procedures, frequencies, acceptance criteria (control limits), and corrective actions are provided in Appendix B.

2.5.1 Quality Control Samples

QC samples are used to quantitatively assess the quality of the data. These samples are discussed in this section.

2.5.1.1 Method Blanks

Method blanks are used to monitor the laboratory preparation and analysis systems for interferences and contamination from glassware, reagents, sample manipulations, and the general laboratory environment. The method blank is an analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing, and which is taken through the entire sample preparation process. One method blank shall be prepared for each batch of samples (one per batch, up to a maximum of 20 samples). Some methods do not have a distinct preparation, and for these tests, the instrument blank, which contains all reagents used with samples is considered to be the method blank. The concentration found in the method blank should never be subtracted from sample or LCS concentrations when reporting final results/recoveries, respectively.

2.5.1.2 Instrument Blanks

Instrument blanks are used to monitor the cleanliness of the instrument portion of the sample analysis process. Instrument blanks consist of the solvent or acid solution of the standard used to calibrate the instrument. With the exception of metals analyses, instrument blanks are

routinely analyzed on each instrument at the beginning of each analytical batch, or once every 12 hours for GC/MS analyses. Routine metals analyses receive an instrument blank every ten samples. Instrument blanks are also analyzed on an as-needed basis for troubleshooting and should be analyzed after any sample which contains sufficient concentration of any analyte to require reanalysis at greater than a 1:5 dilution to prevent carryover to subsequent samples.

2.5.1.3 Laboratory Control Samples and Laboratory Control Sample Duplicates (LCS/LCSD)

Laboratory control samples are well characterized, laboratory generated samples of a known matrix (reagent grade water, reagent sand, or other USACE PM or his/her representative approved matrices) used to monitor the laboratory analytical process independent of matrix effects. LCS samples are spiked with a known quantity of all target analytes, and are taken through the entire sample preparation and analytical process. LCS samples are prepared and analyzed with each batch of environmental samples up to a maximum of 20 samples of a similar matrix. LCS samples measure laboratory performance regarding the accuracy of the preparation process by measuring spiked target analyte recoveries in a controlled matrix. LCS results, together with MS results, can also establish the presence of matrix effects.

For methods where there is no distinct preparation, a continuing calibration standard may be used as the LCS, if it meets all LCS and matrix-matching criteria. An LCSD is required in addition to the LCS for batches which do not have another measure of precision (e.g., when not enough sample is available to prepare a site-specific MS/MSD pair for a batch, for all batches for methods where matrix spiking is not possible, and for batches of low-level volatiles analysis which do not contain an MS/MSD pair). An LCSD is not required in other batches but is recommended. When samples from a preparation batch are reanalyzed in a separate analytical batch (e.g., when dilutions are required) the LCS/LCSD pair need not be re-analyzed.

2.5.1.4 Matrix Spikes and Matrix Spike Duplicates (MS/MSD)

Matrix spikes measure matrix-specific method performance. A MS sample is prepared by adding a known quantity of all target analytes (with the exceptions listed for Methods 6010A/6020, 8081A, and 8082 in this section) to a single field sample prior to sample preparation to determine how well the target analytes can be recovered from the sample matrix. The accuracy of the matrix-specific method may be determined by the recovery of the spiked analytes after native concentrations of the spike analytes are subtracted. When an MSD is analyzed, the matrix specific precision of the method may also be calculated.

For a minimum of every 20 samples that are sent to the laboratory, one sample shall be provided in sufficient quantity such that a MS and an MSD can be generated in addition to an aliquot reserved for actual sample analysis. If more than 20 samples are shipped at any time, one sample shall be provided in quantities sufficient to generate an MS/MSD for each set of 20 samples. This sample will include sufficient volume such that one re-preparation/reanalysis of the MS/MSD pair may be performed if necessary. Analytical batches will be required to contain an LCS/LCSD pair if they do not contain an MS/MSD pair. Re-preparation of partial batches due to internal standard and/or surrogate failures does not require the inclusion of an MS/MSD nor do batches that contain only field blank samples. When samples from a preparation batch are reanalyzed in a separate analytical batch (e.g., when dilutions are required), the MS/MSD pair need not be re-analyzed.

For large investigations, where samples are being collected at multiple sites, matrix spiking should reflect the sampling at specific investigation sites to the extent practical. Thus, the contractor will select the sample to be used for matrix spiking. Only samples from projects under this contract will be used for MS/MSD analyses.

MS data evaluation is more complex than blank or LCS data evaluation since matrix spikes measure matrix effects in addition to sample preparation and analysis effects. If available for a particular method, sample extract cleanup techniques will be considered if matrix interference is suspected. The options should be discussed with the client. If cleanup is inappropriate or ineffective, flag data as matrix interference. If cleanup is effective, consider reanalysis of entire batch using cleanup procedure(s). The heterogeneity of soil, grab samples, and sequentially collected water samples further complicates the evaluation of MS sample data since matrix specific accuracy and precision assume that the native concentration in the three sample analyses is constant. However, appropriately trained personnel aware of the data's end use may improve data quality by an evaluation of MS data.

Methods 6010B/6020. Unless superseded by project DQOs, it is not necessary to perform matrix spikes for Na, K, Ca, and Mg for aqueous samples; or Na, K, Ca, Mg, Fe, Mn, and Al for soil samples. The native concentrations of these low-toxicity metals are usually relatively high.

Method 8081A. The MS should be prepared with all single-component pesticides. Multi-component pesticides (e.g., Toxaphene) need not be included within the MS, unless required by project DQOs.

Method 8082. The MS should be prepared with a mixture of Aroclors 1016 and 1260 unless other specific PCBs are required by project DQOs.

2.5.1.5 Surrogate Spikes

GC, GC/MS, and HPLC analyses include the addition, subsequent quantitation, and recovery calculation of surrogate compounds. Surrogate compounds are:

- Compounds not requested for analysis (non-target analytes);
- Compounds that do not interfere with the determination of required analytes;
- Compounds that are chemically similar to the target analytes, yet are not naturally occurring; and
- Compounds exhibiting similar response behaviors to analytes under determination.

Surrogate spikes help to monitor both performance of the analytical system and the effectiveness of the method for each sample matrix. Surrogate compounds are added to every sample and QC sample at the beginning of the sample preparation, and the surrogate recovery calculation is used to monitor matrix effects and sample preparation. Typical surrogates are identified within the determinative methods and in Appendix C. Other compounds may be chosen and used as surrogates, depending on the analysis requirements, whether they are representative of the compounds being analyzed, and whether they cover the chromatographic range of interest. Surrogate control criteria are applied to all environmental samples, QC samples, and method blanks. Re-analysis and re-preparation will be performed for surrogate

criteria failures according to the guidelines provided in Appendix B unless clearly defined matrix effects can be documented. Surrogate limits for method blanks shall be the same as those listed for LCS/LCSD samples. Surrogate limits for normal environmental samples shall be the same as those listed for MS/MSD samples. Sample results shall not be corrected for surrogate excursions.

2.5.1.6 Laboratory Replicates

Laboratory replicates are defined as two aliquots obtained from the same sample which are prepared and analyzed for the purpose of determining matrix specific precision. Laboratory duplicates shall be performed for all analyses where matrix spiking cannot be performed at a rate of one for each batch, up to a maximum of 20 samples.

2.5.1.7 Internal Standards

Internal standards are compounds which analytically behave similarly to the target analytes. Internal standards are used to correct for injection variability when using mass spectrometry. Internal standards are compounds not found in the sample and are added at the time of instrumental analysis to quantitate results. Control limits on internal standard areas are specified in the analytical method.

2.5.1.8 Field Duplicate (QC) and Split (QA) Samples

Field duplicate QC samples are two samples collected at the same time from the same source at the same depth or sample location, and which are submitted to one laboratory as separate samples (i.e., "blind" duplicates). The purpose of duplicate samples is to assess the consistency of the overall sampling effort, including collection, shipping, and analysis; the purpose of submitting them "blind" is to assess the consistency or precision of the laboratory's analytical system. Soil duplicate samples, other than samples for volatile organic analyses, may be composited and homogenized in the field prior to submittal to the laboratory. Field duplicates for the same analysis will always be collected using adjacent sleeves for soil samples. The collection frequency of duplicate samples is 10 percent or one field duplicate for every 10 samples of the same matrix (i.e., 1-4 samples requires no field duplicates (FDs), 5-14 samples requires 1 FD, 15-24 samples requires 2 FDs, etc.). Field duplicate samples shall be analyzed for the same parameters as the corresponding primary sample.

A QA split sample is a sample that, after collection, is divided into two parts which are sent to different laboratories for the same analysis, thus serving as an external QA sample. For projects under this contract, the requirement for the use of QA split samples will be addressed in the project specific FSPs. When required, one sample will be sent to the contract laboratory for analysis, and the other will be sent to the QA laboratory. Soil QA split samples, other than samples for volatile organic analyses, will be composited and homogenized in the field prior to submittal to the two laboratories. QA split samples for the same analysis will always be collected using adjacent sleeves for soils. The collection frequency of split samples, when required, is 10 percent or one field duplicate for every 10 samples of the same matrix. Split sample analytical results will be submitted directly to the USACE TM or his/her representative by the QA laboratory for evaluation.

2.5.1.9 Trip Blanks

Trip blanks are used to evaluate representativeness by identifying any volatile organic compounds that may have been introduced to the environmental samples during shipment, handling, or storage on site and at the laboratory. Trip blanks are prepared in the laboratory by pouring deionized, distilled water into preserved volatile organic analysis (VOA) vials sample vials in the laboratory. The trip blanks are then shipped to the field, and then shipped with the sample containers back to the laboratory with each cooler containing volatile organic analyses. Trip blanks are never opened in the field. Trip blanks shall be collected at a frequency of one per cooler that contains water samples for VOCs or volatile TPH analysis, unless specified otherwise in the site-specific FSIP. Trip blank frequency may be reduced for large sampling efforts if no target analytes are detected in the trip blanks submitted at the beginning of the project. Trip blanks will be analyzed for volatile organic compounds only (including volatile TPH).

2.5.1.10 Equipment Rinsate Blanks

Equipment rinsate blanks are prepared in the field (after decontamination of sampling equipment is complete) by collecting the final rinse water. Equipment blanks are analyzed for all the parameters which are to be performed on the associated samples. The results of each equipment rinsate blank analysis will be reviewed for the presence of target analytes as an indication of potential contamination from field procedures or insufficient decontamination. Equipment rinsate blanks will generally be submitted at a frequency of at least one sample per sampling crew per day if non-dedicated equipment is used for aqueous samples or if the equipment used for sample collection comes in contact with the sample matrix for soil samples (e.g., surface scrapes trowels). Equipment rinsate blanks will not be collected for soil samples collected in stainless steel or brass sleeves or in Encore samplers.

2.5.1.11 Filter Blanks

Filter blanks are prepared by passing laboratory-grade water through the filter-type being used during field filtration for dissolved metals fractions, and collecting the filtrate. The samples are then analyzed for metals to evaluate the potential cause of metals contamination by the filter. Filter blanks should be analyzed at a rate of at least once per lot of filter media used.

2.5.1.12 Temperature Blanks

Appropriate measures shall be taken to ensure that storage requirements with respect to temperature are maintained in the field, during transport to the laboratory, and during storage at the laboratory. Temperature blanks shall be used for all coolers containing samples requiring preservation at reduced temperature. It is required that all coolers contain at least one temperature blank. The temperature blank should be a 40-mL VOA vial filled with water and placed in a representative position inside the cooler (e.g., directly adjacent to samples in the middle of the cooler). Multiple vials could be used, if needed. It will be opened upon receipt by the laboratory and used to measure the temperature of the cooler, rather than attempting to measure the ambient air temperature in the cooler. The laboratory should document when the temperature blank was positioned inappropriately or was not representative of the cooler temperature measurement.

2.5.1.13 Source Water Samples

Various types of source water may be used for equipment decontamination in the field. If a source other than laboratory furnished reagent water is used, source water samples will be collected and analyzed to evaluate whether target analytes detected in the environmental samples are representative of actual conditions or are attributable to the source water, prior to its use. Source water samples will be collected at a frequency of one per lot of rinsate water if an off-site source is used and once per field effort if an on-site source is used, and will be analyzed for each analytical method applicable to the project.

2.5.2 Analysis Sequence QC Samples

Certain inorganic analyses (metals by ICP and GFAA) incorporate the following additional QC samples to assess method performance without the influence of the preparatory procedures.

2.5.2.1 Post Digestion Spikes (PDS)

PDSs are incorporated into an analytical sequence to assess matrix effects based upon (1) the occurrence of new and unusual matrices included within the batch, or (2) contingency analysis based upon serial dilution (SD) or MS failures. Duplicate injections of each environmental sample may be avoided if a post-digestion spike (PDS) is performed for each sample. PDSs are prepared by the addition of the primary source standard to the digestate for the same metals and at approximately the same concentration as is used for the MS. Refer to Appendix B for corrective action scenarios for PDSs.

2.5.2.2 Serial Dilutions (SD)

A 5X (1+4) serial dilution test shall be performed for an analyte to evaluate matrix interference if the analyte concentration in the original (undiluted) sample is at least 50 times the MDL. Matrix effects are suspected if the RPD between the undiluted and diluted result is >10%. If this criterion is not met, further confirmation of the interference via implementation of PDS is necessary. Calculation of the result through the use of MSA when matrix interference is suspected/confirmed.

2.5.2.3 Laboratory Batch Quality Control Logic

Many analytical laboratory processes are batch processes, where a batch of samples is used as the frequency of the QC elements. Two types of batches are used in the laboratory: the preparation and instrument batch. A preparation batch (herein referred to as "batch") is defined as a group of twenty or less environmental samples of the same matrix which are prepared (e.g., extracted or digested) within the same time period (concurrently) or in limited continuous sequential time periods, which follow the same method, using the same type of equipment and same lots of reagents. Samples in each batch are of similar matrix (e.g., soil, sludge, liquid waste, water), are treated in a similar manner, and use the same reagents. Significant gaps (greater than two hours) in the preparation sequence will result in the termination of the previous batch and the initiation of a new preparation batch. Keeping batches "open" for more than two hours will not be permissible; samples and their associated QC samples must be prepared in a continuous process. The batch must be analyzed sequentially on a single instrument. For volatiles samples collected in Encore[®] samplers, the preservation step for low-level samples will not constitute a "preparation batch" and method QC samples (method blank, laboratory control

sample, and matrix spikes) need not be prepared until the samples are analyzed. However, it is preferable if each batch of samples preserved together has a representative preservation blank prepared alongside the samples to evaluate possible contamination during the preservation procedures. Placing volatile samples collected in Encore[®] samplers into methanol for mid-level analysis IS considered a preparation procedure. All method QC samples must be prepared at the time that samples are transferred into methanol.

The instrument batch is a group of twenty or less environmental samples, which are analyzed together within the same analytical run sequence or in continuous sequential time periods. In general, if an instrument is not used for periods of time or shut down (e.g., overnight) then a new instrumental batch must be started.

For VOC analyses by GC or GC/MS, the preparation and instrument batch definitions become less distinct since the sample preparation (purge and trap) is performed as part of the instrumental analysis, and sample preparation is more of a sequential rather than batch process. For the purpose of QC frequency, GC and GC/MS batches for VOCs are defined as twenty or less environmental samples analyzed within a calibration time period, or within sequential continuous calibration time periods. For either GC or GC/MS volatile organic analyses, a batch may extend over a calibration and tune.

In general, preparation batches should be analyzed together, as a unit, within the same instrument batch. If samples from the same preparation batch are not analyzed within the same instrument batch (e.g., because of laboratory choice or instrument capacity) the following is required:

- All samples from the preparation batch must be clearly associated with their corresponding preparation batch QC samples, and appropriate corrective actions must be performed on all samples in the batch, based on the results of the associated preparation batch QC.
- All instruments QC for each instrument batch (initial and continuing calibrations, instrument blank analyses, and tuning, etc.) must meet the established criteria for the method.
- Instrument cleanliness must be proven through the analysis of an instrument blank, the preparation batch blank, or a preparation blank from another batch.
- The preparation batch LCS/LCSD, MS/MSD and method blank need not be analyzed on all additional instrument batches.

2.5.3 Analytical/Statistical/Control Parameters

As part of the data verification/validation process, analytical results will be evaluated for accuracy, sensitivity and precision parameters. These are described below. The project limits for accuracy and precision are listed in Appendix C. If review of laboratory statistical limits (as compared to the QAPP limits) by the laboratory and contractor staff identify specific analytes with statistically significantly broader limits, the laboratory limits will be adopted for the project

through a QAPP addendum or a call-out in the appropriate FSIP/Workplan. Laboratory statistical limits submitted for review should include surrogates and should include data assembled during the previous 6 months. Outliers should have been removed using a valid statistical outlier test prior to calculating laboratory control limits. Appropriate corrective actions for control parameter failures are listed in Appendix B. Sample analysis is considered affected by matrix interference when recoveries or RPDs exceed those expected for a "clean" matrix (LCS/LCSDs).

2.5.3.1 Accuracy

Accuracy for organic and inorganic compounds and general chemistry are described in this section.

Accuracy- Organic Compounds. Accuracy for organic compounds analyses will be evaluated through the collection and analysis of MS/MSD samples, LCS/LCSD samples, and by spiking all samples with surrogate compounds where applicable. Only samples obtained from task order sites will be used for MS/MSD procedures. Trip blanks and rinsate samples will not knowingly be used for MS/MSD analyses.

Accuracy is expressed as percent recovery of each of the fortified components, and is determined using the following equation:

$$\%R = \frac{(\text{Spike Result} - \text{Sample Result}) \times 100}{\text{Concentration added}}$$

For each group of samples that is sent to the contract laboratory, one sample in 20 will be provided in sufficient quantity such that a MS and a MSD pair can be generated in addition to an aliquot reserved for actual sample analysis. This sample will include sufficient volume such that one re-preparation/reanalysis of the MS/MSD pair may be performed if necessary.

The MS and MSD samples will be fortified with all method target compounds (with the exceptions noted in Section 2.5.1.4), while a third aliquot of the sample will be analyzed unfortified. Accuracy will be measured in terms of percent recovery of each of the fortified components. MS/MSD analyses not meeting the laboratory QC criteria specified in Appendix C shall follow the corrective actions listed in Appendix B.

LCS analyses are matrix spikes on a blank matrix (such as deionized water or reagent sand) to assess contract laboratory accuracy independent of matrix effects. Batches which do not contain an MS/MSD pair shall also contain and LCSD. LCS/LCSD analyses not meeting the laboratory QC criteria specified in Appendix C shall follow the corrective actions listed in Appendix B. Sodium sulfate and/or other approved matrices may be used with the prior approval of the USACE PM or his designee. The FSIP will detail matrix, method, and analyte specific QC criteria for all sample analyses used to determine contract laboratory accuracy if they differ from those presented in this QAPP.

Accuracy - Inorganic and General Chemistry. Accuracy for inorganic analyses will be evaluated through the collection and analysis of MS samples and laboratory control samples. For each group of samples that is sent to the contract laboratory, one sample in 20 will be provided in sufficient quantity such that a MS/MSD pair can be generated in addition to an

aliquot reserved for actual sample analysis. This sample will include sufficient volume such that one re-preparation/reanalysis of the MS/MSD pair may be performed if necessary.

The MS samples will be fortified with all the method target compounds (with the exceptions noted in Section 2.5.1.4), while an aliquot of the sample will be analyzed unfortified. The matrix spike for inorganic analyses will be an analytical spike (i.e., a spike of the solution being prepared prior to the preparation procedure). Accuracy will be measured in terms of percent recovery of each of the fortified components. MS/MSD analyses not meeting the laboratory QC criteria specified in Appendix C shall follow the corrective actions listed in Appendix B.

LCS/LCSD analyses are matrix spikes on a blank matrix (such as DI water or reagent sand) to assess contract laboratory accuracy independent of matrix effects. LCS analyses will be performed for each batch of samples up to a maximum of 20. Batches which do not contain an MS/MSD pair shall contain an LCSD in addition to the LCS. LCS/LCSD analyses not meeting the laboratory QC criteria specified in Appendix C shall follow the corrective actions listed in Appendix B.

Any proposed changes to QC criteria are subject to approval by the USACE PM or his designee. If those changes would result in an increased cost for analysis and/or data review, the change must also be approved by the USACE CO.

2.5.3.2 Sensitivity

Four sensitivity limit terms are used:

- Instrument detection limit (IDL)
- Method detection limit (MDL)
- Method quantitation limit (MQL) [a.k.a. practical quantitation limit (PQL)]
- Method Reporting Limit (MRL).

The **IDL** is an empirically derived value that measures the sensitivity of an instrument (in contrast to a method) by repeatedly analyzing standards over several days and multiplying by a factor of three times the standard deviation of the instrument response. IDLs are used for metals methods, and do not take into account variation due to sample preparation procedures.

The **MDL** is an empirically derived value used to estimate the lowest concentration a method can detect in a matrix-free environment. SW-846 defines the MDL as the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. The MDL is determined from the analysis of replicate samples of a given matrix containing analytes that have been processed through the entire preparation procedure. MDLs are established by the laboratory following the guidance in Appendix B of 40 CFR 136. MDLs shall be preparation and analytical method specific and shall include any cleanup methods if used. MDLs are also instrument specific. When multiple instruments are used by the laboratory, the highest MDL may be used for reporting. The laboratory established MDL values shall be verified quarterly by analyzing an MDL check sample (~2 times the MDL). The sample used for the MDL check must undergo all sample preparation procedures. The concentration of the synthetic sample that is processed may be

adjusted upward to account for the typical analyte recovery (i.e., if the MDL for an analyte is 1 µg/L with an average extraction recovery of 67%, the sample to be processed should be 1 µg/L x 2/0.67 = 3 µg/L). The expected concentration of the extract would then be 2 µg/L, or 2 times the MDL. The acceptance criteria to be applied to this check sample is to verify that all target analytes are detectable. If any of the target analytes are not detected, the MDL study must be repeated. The MDL verification and/or MDL recalculation must also be performed whenever there are significant changes to the analytical system.

The **MQL** is the lowest concentration that can be reliably achieved within limits of precision and accuracy during routine operating conditions. The MQL must be verified during initial calibration by including a standard at the concentration of the MQL and typically should be no lower than ten times the standard deviation from the MDL study (~3 times the MDL) and should not be more than 20 times the MDL. Occasionally, it may be acceptable to set the MQL as low as 2 times the MDL. If the QAPP required maximum MQL is between 2 to 3 times the laboratory established MDL, the laboratory should contact the Project Chemist for approval to use a MQL that is less than 3 times the MDL. In the absence of project specific requirements, the lowest calibration standard used for initial calibration shall be set at or between three to ten times the MDL (at or slightly above the MQL) for each analyte. MQLs must never be less than 2 times the MDL, even if the low standard from the initial calibration is less than 2 times the MDL. Analyte values reported below the MQL must be flagged as an estimated quantity (i.e., J flagged). The MQLs listed in Appendix A are to be considered maximum allowable quantitation limits, and are not to be used as required reporting limits. Laboratories should report their actual MQL, based on the concentration of the low standard (corrected for sample preparation weights and volumes, dilution factors, and moisture corrections when applicable). The MQLs listed in Appendix A should not be exceeded solely due to moisture corrections, but may be exceeded due to required dilutions. Where possible, **nominal sample weights for soil samples should be increased by the anticipated moisture percentage whenever possible to ensure that required maximum MQLs are not exceeded.**

All sample results will be reported down to the MDL. Analytes found above the MDL, but below the MQL, are quantitated and flagged (J) as an estimated value. This qualifier indicates the decreased precision and accuracy the method delivers below the MQL for that analyte. If dilution of an environmental sample is performed to bring the reported concentration of a single compound of interest within the range of calibration, the results of the original run and the dilution will be reported with the appropriate notations in the narrative. When matrix effects require dilution of the sample, cleanup procedures will be considered and discussed with the project chemist before the sample holding time has expired. Cleanup and reanalysis is preferable to dilution, where quantitation limits are raised to a level that makes the data of little or no use.

Matrix effects (i.e., highly contaminated samples requiring dilution for analysis, dilution to bring detected levels within the range of calibration, and matrix interference requiring elevation of detection limits) will be considered in assessing the contract laboratory's compliance with the requirements for sensitivity. All sample concentrations which exceed the equivalent concentration of the high standard from the initial calibration must be diluted and reanalyzed. For multiple analyte methods, it may be necessary to analyze the sample at multiple (up to three) differing dilutions in order to quantitate all analytes within the dynamic range of the instrument. For analysis by ICP or ICP/MS, samples need to be diluted and re-analyzed when concentrations exceed the linear range check concentration for Na, K, Ca, and Mg in water and

Na, K, Ca, Mg, Fe, Al, and Mn for soils. All other ICP and ICP/MS analytes must be diluted to a concentration below the high standard. A detailed analysis of all failures to meet requirements for sensitivity will be included in the narrative section of the Certificate of Analysis as described in Section 1.6.3.

The **MRL** is a threshold value below which the laboratory reports a result as non-detected (U); and must be presented as a "less than concentration value". MRLs may be utilized on specific data sets based on the project objectives. If MRLs are to be used, they will be specified in the FSIP.

2.5.3.3 Precision

Precision will be evaluated through the collection and analysis of field and laboratory duplicate samples. Field duplicates (QC samples) will be collected at a frequency of one duplicate for each ten samples of a given matrix, unless specified otherwise in the appropriate FSIP/workplan. This will correspond to the following frequencies: 1-4 samples (no FDs required); 5-14 samples (1 FD required); 15-24 samples (2 FDs required); 25-34 samples (3 FDs required); etc. The identity of QC samples will be held blind to the contract laboratory until after analyses have been completed.

The relative percent difference for field and laboratory duplicates will be calculated and used as a measure of precision, however, only laboratory duplicates will be included in the quantitative assessment of completeness. Results of field duplicates will be described in qualitative assessment of completeness.

Laboratory duplicates will be performed for all analyses where matrix spiking cannot be performed at a rate of one in twenty (one for each batch up to a maximum of twenty). Precision for all other organic and inorganic compound analyses may be determined by the analysis of MS/MSD samples. For batches which do not include an MS/MSD pair, precision will be evaluated using a laboratory control sample / laboratory control sample duplicate (LCS/LCSD) pair. Contract laboratory quality control criteria for precision of laboratory duplicates, LCS/LCSDs, and MS/MSDs will follow the requirements listed in Appendix C. The qualitative comparison criteria for field duplicates shall be <40% RPD for water and gas samples and <50% RPD for soil samples. Any proposed changes to QC criteria are subject to approval by the USACE PM or his designee. If those changes would result in an increased cost for analysis and/or data review, the change must also be approved by the USACE CO. Appropriate corrective action for failed precision criteria are presented in Appendix B.

To minimize the possibility of incorrect identification (or false positives), second column confirmation shall be required for all chromatographic methods involving the analysis of single component target analytes. Quantitative confirmation of results above the MQL is required for GC and HPLC (second detector confirmation) and shall be completed within the method-required holding times. However, whenever simultaneous analysis on dual columns or detectors is in place, this information should be utilized for concentrations below the MQL as well as those above the MQL. If confirmation information is not available for concentrations below the MQL, the analyte detected by the primary system should be reported, but should be qualified as a presumptive identification with an estimated concentration (NJ flag). If confirmation information is available, data should be reported according to the guidelines presented in Table 2-3. After the target analyte has been identified, compare the primary and

confirmatory results for agreement according to a method prescribed criterion. Analytical results should be reported from the primary column when the RPD is less than 40%. When the RPD is greater than 40%, the greater of the two results shall be reported unless the higher result is associated with obvious chromatographic interference. Once a column has been designated as primary, the laboratory analyst will apply this designation consistently for all samples with RPD less than 40%.

**Table 2-3
Reporting from Multiple Columns or Detectors**

Scenario	Detector or Column A (most sensitive)	Detector or Column B (less sensitive)	Reported Result	Flag
Detected by both detectors, results are quantitative, and results agree within 40%.	>MQL	>MQL	"A" result	None
Detected by both detectors, results are quantitative, and results don't agree within 40%.	>MQL	>MQL	Higher result	J
Detected by both detectors, one result is quantitative, and results agree within 40%.	>MQL	<MQL but >MDL	"A" result	
	<MQL but >MDL	>MQL	"A" result	J
Detected by both detectors, one result is quantitative, and results don't agree within 40%.	>MQL	<MQL but >MDL	"A" result	J
	<MQL but >MDL	>MQL	"A" result	J
Detected by both detectors, but both are below the MQL.	<MQL but >MDL	<MQL but >MDL	"A" result	J
Result is detected by detector A but not detector B.	>MQL	<MDL	<MDL of detector A	U
	<MQL but >MDL of detector B	<MDL	<MDL of detector A	U
	<MQL and <MDL of detector B	<MDL	"A" result	NJ
Result is detected by Detector B but not detector A.	<MDL	Any conc.	<MDL of detector A	U
Result is not detected by either detector.	<MDL	<MDL	<MDL of detector A	U
Result detected by one detector, but it does not respond to the other detector.	>MQL	N/A	"A" result	N
	<MQL but >MDL	N/A	"A" result	NJ

2.5.3.4 Contract Laboratory Internal Quality Control Checks

Internal QC checks are performed on sample batches. Samples are batched together by matrix and analyses requested for efficient data production in the laboratory. Each batch of samples (20 or fewer samples of the same matrix type prepared using the same reagents, standards and procedures in the same time frame) is processed with a set of specific QC "samples" which are used to assess the performance of the entire measurement process (sample preparation, analysis and data reduction). The analytical batch shall be analyzed sequentially on a single instrument. Significant gaps (greater than two hours) in the analytical sequence will result in the termination of the previous sequence and the initiation of a new analytical sequence. The practice of "holding a batch open" for as much as two weeks and performing a single set of batch QC samples for all analyses performed during that period is unacceptable relative to the requirements of these specifications. If the batch size is found to exceed 20 samples the data will be considered non-compliant.

Each batch contains a method blank to assess contamination and prevent false positive results. The acceptance criteria for method blanks is that no target analytes should be detected above ½ the MQL. If analytes are detected above ½ the MQL and there are detections of these analytes in associated samples within 5 times the concentration found in the blank, the batch will be re-prepared and reanalyzed.

To assess performance with respect to precision and accuracy, the batch contains a laboratory control sample and matrix QC samples. A LCS is a reagent blank spiked with all of the target analytes and prepared and analyzed in exactly the same manner as the samples in the batch. This standard is free of any interference from sample matrix or similar problems and demonstrates the ability of the entire measurement system to recover the target analytes. Matrix QC consists of selecting one sample in the batch and analyzing a spike and spike duplicate of that sample. If matrix spiking cannot be performed due to method limitations, a laboratory replicate is analyzed. The purpose of the matrix QC samples is to obtain both precision and accuracy information. In the absence of sufficient sample to perform matrix QC, two laboratory control samples are prepared so that both precision and accuracy data are available.

Accuracy is expressed as percent recovery of the spike and is determined using the following equation:

$$\%R = \frac{(\text{Spike Result} - \text{Sample Result}) \times 100}{\text{Concentration added}}$$

Precision between two measurements is expressed as relative percent difference and is calculated as follows:

$$\text{Relative Percent Difference (RPD)} = \frac{(\text{Result A} - \text{Result B}) \times 100}{(\text{Result A} + \text{Result B})/2}$$

Where A and B can be duplicate sample results, duplicate MS results (concentrations, not percent recoveries), or two laboratory control sample results.

Acceptance criteria are established so that the analyst can rapidly assess the quality of the data. Results below the MQL often demonstrate high RPD that do not invalidate the data because error below the MQL of most analyses is greater than is expected for other measurements.

With as many measurements as the laboratory performs and because acceptance criteria are based on a 99 percent confidence interval and the wide variety of matrix types that the laboratory receives, QC parameters do at times fail to meet acceptance criteria. In the event that a particular limit is exceeded, the analyst must determine if the failure invalidates the entire batch. The QC data for the corresponding analytical batch are reviewed to determine the disposition of the batch. When batch failure is evidenced by low surrogate recoveries for sample analysis method blanks, MS/MSD or laboratory control sample for recoveries or RPD, corrective actions are taken.

2.6 OVERALL PROJECT QUALITY CONTROL REQUIREMENTS

In addition to the control parameters discussed above, this section includes a description of completeness requirements, representative samples, and data comparability.

2.6.1 Completeness

Completeness will be evaluated qualitatively and quantitatively. The qualitative evaluation of completeness will be determined as a function of all events contributing to the sampling event including items such as correct handling of COC forms, results of field duplicates, etc. The quantitative description of completeness will be defined as the percentage of contract laboratory controlled QC parameters that are acceptable.

The goals for completeness are as follows: contract (100%), analytical (90%), technical (95%), and field completeness (100%). The calculations used for each type of completeness are listed below.

$$\text{Contract Completeness} = \frac{\# \text{ results not associated with contract compliance failure}}{\# \text{ results reported}} \times 100$$

$$\text{Analytical Completeness} = \frac{\# \text{ unqualified results}}{\# \text{ results reported}} \times 100$$

$$\text{Technical Completeness} = \frac{\# \text{ usable results}^\dagger}{\# \text{ results reported}} \times 100$$

$$\text{Field Sampling Completeness} = \frac{\# \text{ samples collected}}{\# \text{ samples planned}} \times 100$$

[†] Estimated results considered as usable for project decision-making

QC parameters that will be assessed by method, by matrix, for quantitative determinations of completeness will include acceptable instrument and method blank levels, surrogate percent recovery for organic compounds analyses, analysis of laboratory duplicates for RPD, analysis of MS/MSD analyses for percent recovery and RPD, analysis of laboratory control samples for percent recovery, and holding times.

The requirement for holding times will be 100 percent. If any sample exceeds the holding time specified, resampling and reanalysis may be required.

Data will be screened for contract compliance by the USACE PM or his designee. Failure of the analytical data to meet the standards for completeness may result in rejection of data with re-sampling and re-preparation/reanalysis performed. Completeness requirements will be applied to data for the entire laboratory task order project.

Non-conforming data as a result of well substantiated matrix effects will not be considered in assessing contractor compliance with respect to completeness. In the event of significant occurrence of non-conforming data, the contractor will present a summary of data to substantiate an argument for matrix effects to the USACE PM or his designee. These data will be reviewed by the USACE. The USACE PM or his designee will determine the validity of an argument for matrix effects and instruct the contractor as to the necessity of re-sampling/re-preparation/re-analysis. If the resampling/repreparation/reanalysis is out of scope, the USACE CO must be contacted for approval prior to starting work.

2.6.2 Representativeness

The following sections address how representativeness of samples can be addressed through field and laboratory procedures.

2.6.2.1 Field Procedures

Representativeness criteria for the field portion of the sampling and analysis program are best satisfied by making certain that sampling locations are selected properly, that a sufficient number of samples are collected, and that the sampling QA/QC protocols and procedures are strictly adhered to. Each FSIP will be designed to address each of the representative sample criteria described above. The FSIP will provide detailed descriptions of sampling locations and the number of samples to be obtained. The sampling design will be based on directives provided in the task orders regarding sampling locations and number of samples.

During field investigations, unanticipated conditions may warrant the collection of additional samples. In these cases, recommendations will be made by the PjM to the USACE for approval, and will further be documented by the QCSM in the QCSR.

2.6.2.2 Laboratory Procedures

Representativeness criteria for the laboratory portion of the sampling and analysis program are best satisfied by making certain that the aliquots selected for analysis are representative of the sample submitted. Protocols for sample preparation detailed in Sections 2.4.1 and 2.4.3 provide methods which assure sample representativeness of the aliquots used in the analysis. For non-VOC parameters, the contract laboratory will shake water samples prior to removing aliquots for analysis. Further, laboratory duplicates provide an indication of the ability of the laboratory to select representative samples. Finally, representativeness of aliquot preparation is also evaluated by the use of QA samples, which are provided to the QA laboratory for independent analysis. The contract laboratory shall also employ a specific information management system to assist in tracking the progress of each sample through the analytical process.

Analysis of QA samples by an independent laboratory may be considered as an instrument of contract administration by USACE. Significant deviation between QA lab and contract laboratory results will result in direction from the USACE CO to the consultant/contract laboratory(s) to investigate the suspected data. If investigation reveals errors in analytical procedures the expense of the investigation will be charged to the contract laboratory.

2.6.3 Data Comparability

Comparability is the extent to which comparisons among different measurements of the same quantity or quality will yield valid conclusions. Comparability of laboratory data can be maximized by the use of standard approved methodologies, the use of standard units and report format, the use of calculations as referenced in the methodology for quantitation, and the use of standard measures of accuracy and precision for quality control samples.

Comparability of data generated at the contract laboratory will be controlled by the procedures described in the Analytical Procedures Sections 2.4.2, 2.4.4, and 2.4.5. Performance of these procedures will be monitored periodically by performance evaluation studies.

2.6.4 Preventive Maintenance

An instrument preventative maintenance program is an important step to ensure reliable operation of the instruments with minimum-downtime. Unscheduled instrument outages can impact sample holding times and validity. A program to ensure that preventative maintenance is conducted per the instrument manufacturer's requirements and frequency has been incorporated in the contract laboratory's quality assurance program.

A preventative maintenance program for all facility and instrumentation used for sampling and analyses will be employed. The contract laboratory(s) will maintain a bound log book for each analytical instrument as a permanent record documenting any routine preventative maintenance and/or service. The contract laboratory(s) will also be a participant in performance evaluation programs offered through agencies on the federal level, and/or mandated at the state level.

Maintenance schedules for each instrument will be maintained by the assigned instrument analyst and will be available for review by the laboratory QA Director, the contractor QA Officer, and appropriate USACE personnel. Where practical, instruments will be maintained through service contracts with original equipment suppliers.

2.7 INSTRUMENT CALIBRATION PROCEDURES AND FREQUENCY

The following describes instrument calibration procedures.

2.7.1 Field Instrumentation

A variety of field instrumentation will be utilized during this program. The FSIP will provide descriptions of the equipment anticipated to be used, along with general discussions regarding their operation and maintenance. Should equipment that is required for any project not be discussed herein, a detailed description of the operation, maintenance, and calibration will be included as a separate appendix to the FSIP.

Generally, all field equipment will be calibrated according to the procedures described in the appropriate SOPs. All calibration data will be recorded in the field logbook. Any data collected by field instrumentation which may be suspect due to failed calibration checks will be noted in the field logbook, and these data will be regenerated using newly collected samples. These

data are available at the request of the USACE PM or his designee. If reproduction of such records is outside of contractor scope, the USACE CO must be contacted before work begins.

2.7.2 Laboratory Instrumentation

A list of laboratory equipment available to the USACE will be provided in the contract laboratory(s) QAPP. This QAPP shall reference procedures and criteria for performing the analytical methods, including MQLs for each analytical method, and calibration of the associated laboratory equipment anticipated to be used for the analyses. The specific QC criteria for initial and continuing calibrations for each of the primary analytical methods anticipated to be used will be provided, and must be in compliance with the requirements of Appendix B. Analyses not meeting those requirements must follow the corrective actions also listed in Appendix B.

2.8 SAMPLE TYPES

Samples collected in the field will be either environmental samples or QA/QC samples. The following sections describe these types of samples. A description of sampling method requirements is presented above in Section 2.2 of this QAPP.

2.8.1 Environmental Samples

Data from environmental samples will be used to characterize a site condition. Sampled media may include surface water, groundwater, sediment, soil, soil gas or air or vapor, solid surfaces, wipe samples, and drum or barrel contents. Depending on the intended use of the analytical data, environmental samples of liquid and solid media will typically be grab or composite samples. Gaseous media sample collection techniques will include grab sampling and integrated samples collected over a longer period of time.

2.8.1.1 Grab Samples

Grab samples, whether from soil or ground water, are intended to represent the composition of a source media at a given time and place. Grab samples will be collected when the source media composition is assumed to be constant over a period of time; when the composition of the source media is not expected to vary with distance; or when it is necessary to define variability with time or distance. Every effort will be made to collect grab samples having relative proportions or concentrations of all pertinent components that are comparable to those in the sampled media. Every effort will also be made to avoid altering the sample's composition during the sampling process or any subsequent processes prior to laboratory analysis.

2.8.1.2 Composite Samples

Composite samples, whether from soil or ground water, typically are a mixture of equal quantities of grab samples collected at the same point at different times or collected at different points during the same sampling event. For example, a flow-weighted composite wastewater sample may be collected over a 24-hour period to provide daily average values of analytical data. A composite sample may consist of grab samples collected over a discrete interval, homogenized and combined prior to placement in the final sample collection container.

Composite samples will be collected when average concentrations are to be characterized. Compositing will not be employed for volatile samples, including purgeable hydrocarbons.

2.8.1.3 Other Environmental Samples

Other sample types may be collected when the types described above are not adequate for the required data use. For instance, multi-point sampling techniques may be used to provide a sample that is representative of the depth or width of a surface water body. Another sample type includes gas cartridges used for passive gas sampling. Gas cartridges may be buried in the ground for a discrete time interval to characterize some aspect of soil gas composition.

Bulk soil samples may be collected for screening purposes on rare occasions. These samples consist of a shovel-full or trowel-full of material taken from borehole cuttings. This sample type is rarely collected because of its inability to accurately characterize a site condition, particularly with regard to depth, but may be used for certain project-specific needs. Other sample types collected for specific projects will be described in detail in delivery order-specific addenda, when required.

2.8.2 QA/QC Samples

QA/QC samples will be collected along with environmental samples for each media sample and each sampling event, and will be included with each sample shipment. Additional QC samples will be added by the contract laboratory. Data from QA/QC samples will be used to measure the reliability of the data resulting from the environmental samples. QA/QC samples for the Benicia Arsenal investigation include method blanks, instrument blanks, laboratory control samples and sample duplicates, MS/MSDs, surrogate spikes, laboratory duplicates, field duplicates, field split samples, trip blanks, rinsate blanks, filter blanks, and source water samples. A discussion of each of the QA/QC sample type with respect to laboratory data and laboratory QA/QC procedures is included in Sections 2.5.1 and 2.5.2 of this QAPP.

2.9 FIELD DOCUMENTATION

This section provides procedures for the use of project field logbooks, forms, and photographs. Additional description of field documentation procedures is presented in SOP 1.0 (Field Logbook) and other SOPs describing specific field activities (for example SOP 2.0 Boring Log Development). Examples of field forms are included in Appendix G.

2.9.1 Field Logbooks

Field logbooks contain a written record of all major onsite activities for a given project, delivery order, or task. The field logbook will serve as a diary of the events of the day and a daily log of all activities carried out in the field that involve field personnel. Since the field logbook becomes part of the permanent file for the project, and because the information contained in the field logbook may be admitted as evidence in cost recovery or other legal proceedings, it is critical that this document be properly maintained. Although field activities will vary, the general information that should be recorded in each field logbook will remain similar, and is described below.

Each field logbook will be bound, weatherproof, and have consecutively numbered pages, and be given a sequential book number. The inside front cover of each field logbook will contain names, addresses, and phone numbers of important contractor and client contact personnel (Project Managers, Project Safety and Health Officer, medical emergency numbers, etc.).

The initial use of the logbook will coincide with the start of the first field activity (e.g., initial site reconnaissance survey). Although the content of daily entries in the logbook will vary with the site activity, the following minimum information shall be recorded each day:

- Date, start time, weather conditions;
- Arrival/departure of site visitors;
- Contractor field personnel;
- Type of activity;
- Equipment to be used;
- Calibration activities, with reference to appropriate calibration forms;
- Names of subcontractors on site and their activities;
- References to field documentation forms used;
- Deviations from the sampling plan;
- Record of communications, including the time, individuals involved, etc.;
- Health and safety issues discussed or anticipated;
- Problems encountered and related corrective actions; and
- Time leaving the site.

Logbook entries must be legible, factual, and free of personal opinion. Hypotheses for observed phenomena must be labeled as such. Corrections to erroneous data will be made by crossing a line through the entry with the date and initials of the person making the correction.

Skipped pages or blank sections at the end of a page will be crossed out with an "X" covering the entire page or blank section. After the day's last entry, the field team member responsible for written entries will write his/her signature, the date, and the time after the last entry. To further assist in the organization of the logbook, the date will be recorded on top of each page of the field logbook along with the activity description (i.e., boring or well number).

The Field Team Leader (FTL) is ultimately responsible for maintaining the field logbook. If the logbook is transferred to alternative personnel during the course of field work, the person relinquishing the logbook will sign and date the last page of entry at the time the book is transferred, and the person receiving the logbook will do likewise. It is the responsibility of this individual (or designee) to keep the field logbook current during possession and to return it to the FTL, or to another field team as directed by the FTL. Following the completion of all work for the project, the field logbook will be returned to the PjM for inclusion in the permanent project files.

2.9.2 Field Forms

A variety of field forms will be used during the Benicia Arsenal Investigation in order to conveniently log and trace work activities occurring at the site. These field documentation forms shall include:

- Daily Quality Control Reports (DQCRs);
- Safety Meeting Forms;
- Soil Boring Log Forms;
- Well Completion Forms
- Well Development Forms;
- Groundwater/Surface Water Sampling Forms;
- COC Records;
- Aquifer Test Data Forms;
- Subcontractor Daily Log;
- Equipment Calibration Forms; and
- Sample Register.

Examples of these forms are attached in Appendix G and are described below. Optional forms including Subcontractor Daily Logs, Equipment Calibration Forms and a Sample Register are also described below. Hard copies of all pertinent field-related documentation will be organized by category, and filed in a three-ring bound, tab-divided project notebook which will be included in the project files following completion of the project. Examples of project notebook contents include purchase order copies, invoices, correspondence, faxes, cost estimates, completed field documentation forms and copies of blank forms. Alternatively, completed and blank field forms may be placed in a forms notebook (also three-ring bound) with tabbed dividers.

2.9.2.1 Daily Quality Control Reports (DQCRs)

An example of DQCR is included in Appendix G. Each DQCR shall contain the following elements:

- Location of work;
- Weather conditions;
- Subcontractors onsite;
- Work performed;
- Quality control activities (including field calibrations);
- Health and safety levels and activities;
- Problems encountered and corrective actions taken; and
- Special notes, including communications with the client.

The preparation of DQCRs will be the responsibility of the field personnel and will supplement the information already recorded in the field logbooks. DQCRs will be completed daily regardless of the duration of the field effort. Copies of this report will be distributed to the USACE TM, the Project Manager (PM), and the project files.

2.9.2.2 Safety Meeting Forms

Tailgate safety meetings, as required by the SSHP, are held at the beginning of each day before the initiation of work. All personnel, subcontractors, and others who will be on the job site are required to attend. The meetings are usually conducted by the FTL, on-site safety officer, or other qualified team member. The topics discussed at the meeting will be logged on the Safety Meeting Form. Each form shall include at a minimum the following:

- Name of individual conducting the meeting
- Names of those in attendance
- Topics discussed
- Actions required
- Appropriate signatures.

All attendees are required to sign the Safety Meeting Form. The original form shall be kept in the project notebook, and later included in the project files upon completion of the project.

2.9.2.3 Soil Boring Log Form

The preparation of Soil Boring Log Forms will be the responsibility of the field geologist assigned to the drill rig. The Borehole/Well Construction Log form in Appendix G is an example of this form. At a minimum, the following information shall be recorded on the form:

- Project and site name;
- Name of the logger;
- Date drilled;
- Name of driller and drilling company;
- Soil boring identification and location (sketch);
- Survey coordinates and elevation;
- Use of drilling fluids;
- Organic vapor analyzer and/or flame ionization detector (OVA/FID) readings;
- Reference elevation for all depth measurements;
- Depth at which first ground water was encountered, depth to water at completion of drilling, and the stabilized depth to water. The absence of water in the boring shall also be noted;
- Description of unconsolidated materials (including Unified Soil Classification System [USCS] classification, color, size and angularity of each component, plasticity, sorting, density, moisture content, blow counts, determination of natural or man-made

occurrence, documentation of lithologic changes, odor or visible contamination and any additional lithologic description);

- Description of consolidated materials (geologic rock description including stratigraphic/lithologic changes and depths at which changes occur, rock type, relative hardness, density, texture, color, weathering, bedding, structures such as fractures, joints, bedding, etc., blow counts, miscellaneous information such as odor, visible contamination, etc.);
- Depth intervals at which sampling was attempted and amount of sample recovered;
- Drilling and sampling problems;
- Depth of boring;
- Depth of grouting, sealing, and grout mixes, if applicable; and
- Date completed.

2.9.2.4 Well Completion Form

The preparation of Well Completion Forms is the responsibility of the field geologist. The Borehole/Well Construction Log form in Appendix G is an example of this form. At a minimum, the following information shall be recorded and/or illustrated on the form:

- Project and site name;
- Dates of construction start and finish;
- Well identification number;
- Name of driller and drilling company;
- Depth and type of well casing;
- Description of well screen and blank casings, including type and diameter;
- Borehole diameter;
- Type and amount of annular materials used; depth measurements of annular materials;
- Other construction details (filter pack type and interval, location of centralizers, etc.);
- Surface elevation and reference elevation of all depth measurements;
- Description of wellhead protection; and
- Diagram of the well.

2.9.2.5 Well Development Form

The Sample Data Sheet will be used when a well is developed. An example of this form is provided in Appendix G. The following information shall be recorded on the form:

- Project name, location, weather conditions;
- Well identification number;
- The date and time of well development;
- The water level;

- Pertinent well construction information (total depth, well diameter, screened interval, etc.);
- Volume of water to be purged;
- Type of purging equipment used;
- Type and duration of development techniques used;
- Developer's initials;
- Description of purged water; and
- Equation used to calculate the well water volume.

2.9.2.6 Groundwater and Surface Water Sampling Forms

The Sample Data Sheet form will be used for all water samples. An example of this form is provided in Appendix G. The following information shall be recorded on the forms:

- Site location and name
- Sampling personnel
- Date and weather information
- For ground water samples, note reference measuring point depth to water
 - casing depth
 - purge volume
 - sampling method (pump or bailer type)
 - pump start and stop times
 - measurement of field parameters such as pH, turbidity, conductivity, and temperature, as well as the times at which the readings were taken and the total volume of water purged when each measurement was recorded,
 - total volume evacuated
- Instrumentation used
- Samples collected and time sample was collected.

2.9.2.7 Chain-of-Custody Record

COC procedures allow for the tracking of possession and handling of individual samples from the time of field collection to laboratory analysis. The concept of "custody" is a critical one since the COC record may be admitted as evidence in legal proceedings. A sample is considered in custody if it is:

- In a person's possession;
- In view after being in physical possession;
- Locked or sealed so that no one can tamper with it after it has been in an individual's physical custody; and
- In a secured area, restricted to authorized personnel.

The function of the COC record is to list each sample, the type, date and time of collection, the analytical requests, and the individuals relinquishing custody. To simplify sample tracking, a triplicate carbon-type COC Record will be used for all projects. An example COC form is provided in Appendix G. A COC Record shall contain:

- General information (sample collection location, site, date, project number);
- Location of sample, identification number assigned to sample, date and time of collection;
- Matrix description (soil, sediment, surface water, ground water, soil gas, wipe, etc.);
- Sample technique or type (grab, 24-hour composite, etc.);
- Method numbers for analyses requested (when not known by the field sampling team, method numbers will be verified with PjM prior to transfer to carrier or laboratory); and
- Relinquished by, received by, time, and date columns for use during custody transfer.

The date of sample collection and the time of shipment of the samples will be recorded on the COC and the COC will be properly signed by all parties participating in the transfer of custody. A copy of the COC will be retained by the sampler prior to release to a carrier or the Contract Laboratory. The sampler will supply a photocopy of that COC to the Project Chemist. The TM will also receive (via facsimile transmission) copies of the COC at the time of sample shipment to the laboratory. The sampler will file the retained copy in the project notebook. Shipping receipts will be signed and filed in the project notebook along with the COC as evidence of custody transfer between the sampler(s) and the courier and laboratory.

The Contract Laboratory will be required to acknowledge sample receipt within 48 hours either by fax or by telephone. At that time, the Contract Laboratory will be required to communicate any other sample identification numbers assigned to samples' upon arrival and will immediately notify the contractor of handling problems such as insufficient sample volume, broken sample containers, etc. The Contract Laboratory will also retain sample numbers assigned by the contractor throughout their entire in-house tracking process. Contractor personnel will be able, by telephone and at any time during business hours, to track the progress of each sample through the Contract Laboratory using the contractor's sample identification numbers.

2.9.2.8 Aquifer Test Data Forms

Two aquifer test data forms to record water levels at both the pumping well and the observation well will be used during pumping test activities. The Aquifer Test Data Form (Observation Well) will be used for recording water level readings at observation wells (water quality measurements typically are not recorded at the observation wells). An example of this form is provided in Appendix G. Important components of the Aquifer Test Data Form are listed below:

- Project name and date;
- Well number/identification (data logger identification);
- Data logger information/parameter setup;
- Pretest and static water level data (include date, time, and measurement reference point such as top of casing);

- Type of aquifer test (slug, step-drawdown, pumping test, etc.);
- Slug test data (include length and diameter of slug for volume calculations);
- Start time of test;
- Duration of test;
- Pumping test data (including time, drawdown, recovery, flow rate data and disposal/containment of water information);
- Field observations and problems (include factors affecting test data or data collection);
- Tester's name; and
- All water quality measurements, including pH, conductivity, temperature (for pumping well only).

2.9.2.9 Subcontractor Daily Log

Some delivery orders may require the use of subcontractors. When subcontractors are used, a subcontract will be executed prior to commencement of field activities to detail work to be completed and "payable line items" for which reimbursement will be made. The ability to track field expenditures to support claims made on this subcontract will be enhanced by the use of the Subcontractor Daily Log. A carbon-style triplicate form is preferred, but not required.

When the form is used, an appropriate subcontractor representative will be required to fill out the daily log and sign it; the FTL will acknowledge receipt of the form by signing it and will note any discrepancies that may require further investigation. These daily logs will be used to verify quantities claimed on subcontractor invoices. Specific elements to include in the daily log may differ for given activities but shall consist of the following general elements:

- General information (location, site, date, job number, inclusive pages, personnel onsite, including name of field supervisor);
- Inclusive times of the specific activity (i.e. from 8 a.m. to 12 p.m.);
- Activity description (e.g. CPT, Geoprobe sampling);
- Quantifiable measures of progress (e.g., for drilling activities, number of drilled feet, number of grouted feet, etc.; for trenching, number of vertical and horizontal feet completed, etc.);
- Quantity of materials used (e.g., number of bags of cement, gravel pack or sand, grout or bentonite, drill bits, soil liners, etc.);
- Quantity of services provided (e.g., number of CPT feet advanced, hours worked by each category of site personnel, hours on standby or decontamination, hours of equipment use, etc.; and
- Travel time (per diem for crews, when appropriate).

2.9.2.10 Equipment Calibration Forms

Equipment Calibration Forms are used to record the field calibration readings. The field notebook entry will always reference the use of the Equipment Calibration Form. Field equipment calibration procedures will be recorded on the form on a daily basis at a minimum,

and when there is instrument drift. The following information will be recorded on the equipment calibration form:

- Project name and number;
- Date and time of calibration;
- Personnel present;
- Weather conditions;
- Instrument calibrated (check the instrument type on the list provided on the form);
- Calibration method;
- Concentration or pH units of standard used for calibration;
- Instrument reading measured upon calibration;
- Any pertinent notes or problems encountered;
- Calibration readings performed to evaluate instrument drift (citing the same elements listed above); and
- Maintenance or repair log (date submitted, problem, destination, type of repair and result of repair, and any additional comments).

2.9.2.11 Sample Register

A sample register may be generated in-house by personnel responsible for sample tracking or may be field-generated depending on the size and/or length of the sampling event. The function of the sample register is to provide a comprehensive record of collected samples to be used for tracking receipt of analytical data and to provide a foundation for information management. At a minimum for all sampling activities, an informal "sample register" will be generated using the photocopied COCs. A field-generated sample register may not be required for all projects or delivery orders.

When used, the field-generated sample register will be a field logbook with pre-numbered pages and all information will be recorded in indelible ink. The field logbook described in SOP 1.0 and Section 2.9.1 will refer to the field-generated sample register and will contain a detailed summary of sample collection events. The sample register will not be used in place of the field logbook for sampling activities. Both logbooks will contain the elements itemized below:

- Sampled location and sample identification number;
- Date and time of collection;
- QA/QC sample numbers;
- Client and project number;
- Collection method;
- Number and size of bottles for each analysis;
- Destination of the sample;
- Type of analysis;

- Name of sampler; and
- Date of receipt of analytical results.

2.9.3 Photographs

Photographs will often be used to enhance written descriptions of the field sampling events described in field logbook entries and/or in field-generated sample registers. Photographs will be coupled to a field logbook entry that includes:

- Date and time of the photograph;
- Site identification;
- Name of the subject;
- Intent of the photograph;
- Pertinent weather conditions;
- Name of the photographer;
- Number of the photograph frame on the roll of film; and
- The film identification (ID) number.

Logbook entries will uniquely identify the associated photographs by using the photographic frame number and the film ID number. Photographs will be traceable to negatives using the film ID number.

Negative packets received with developed film will be labeled with inclusive dates, project number, activities recorded and a film ID number. The film ID number will be used to cross-reference negatives to the field logbook.

The film ID numbering system will consist of a recognizable and consistent acronym that refers to the building number, followed by a sequential number that will increase with each film roll (for example, B154-1). Additional acronym assignments will be left to the discretion of the photographer.

All acronyms used in film ID numbers will be recorded on a summary page that is kept up-to-date by all personnel taking photographs. This summary will be included in the negatives file, will be in the project notebook, and will be in the field-generated sample register (when used). Personnel taking photographs will be required to be familiar with the film ID procedure and with all acronyms currently in use for the given project.

Photographs will be stored in a protective cabinet or file available to all appropriate team members. All photographs will become part of the project file and subject to all standard document controls. Negatives packets will be stored separate from the photographs as backup documentation. Upon completion of the project, all photographs will be provided to the TM.

3.0

3.0 ASSESSMENT/OVERSIGHT

The effectiveness of the implementation of the project and associated QA/QC will be addressed through an assessment and oversight program. This section describes the assessment and oversight program including quality management, organization, response actions, reporting requirements, and data validation.

3.1 CONSULTANT QUALITY CONTROL

This section describes the contractor quality management organization responsible for documenting and overseeing that contract work is conducted in accordance with project quality objectives. In addition, the three phases of QC inspection to be called out by the management team are described.

3.1.1 Quality Management Organization

The PM or his/her representative is ultimately accountable to USACE for implementation of contractor QC and performing all contract work in accordance with the quality objectives established for this project. The PM or his/her representative and his/her staff will provide QA/QC oversight. The PM or his/her representative will delegate authority as appropriate to the PjM. The PjM will have the QCSM and the PC as his/her two primary assistants for QC.

Program and Project Management Organizational structures, lines of authority and communications, and position responsibilities are described in detail in Section 1, Program and Project Management, of this document. The organization establishes an independent chain-of-command so that quality issues can be identified and resolved effectively. The PjM will delegate authority to the QCSM with a Letter of Assignment. A sample Letter of Assignment is shown in Figure 3-1.

3.1.2 Three Phase Quality Control Inspections

The project quality management organization implements the three phase control system consisting of preparatory, initial, and follow-up phases. These three phases are described in more detail below.

3.1.2.1 Preparatory Phase

The preparatory phase will be performed prior to beginning work on each definable feature of work and will include:

- Review of each paragraph of applicable specifications from the FSIP/SSHP, and QAPP;
- Review of the site diagrams detailing locations where samples are expected to be obtained;
- A check to assure that all materials and/or equipment are acceptable for use;

Figure 3-1. Sample Letter of Assignment

SAMPLE LETTER OF ASSIGNMENT

To: Quality Control Systems Manager
From: PjM
Copies:
Subject:
Date:

You are hereby advised that you have been appointed as the Quality Control Systems Manager for the subject contract. In this capacity, you will be responsible for implementing the Quality Control Program and ensuring quality throughout the duration of contract. You will be responsible directly to me.

A detailed description of your responsibilities are outlined in the QAPP. In general, you have the responsibility, authority, and organizational freedom to identify quality problems, initiate action which results in solutions, verify implementation of solutions to those problems, and control further processing, delivery, or installation of a non-conforming item, deficiency or unsatisfactory condition until proper disposition has been made.

You have the authority to enforce the Quality Control Program, which includes both the Chemical Data Quality Control and Contractor Quality Control functions. In this capacity, you have authority to reject materials and work; to stop work until any deficiencies are satisfactorily corrected; and to require that tasks be redone until quality control objectives are fully satisfied.

- A check to assure that provisions have been made to provide required control inspection and testing;
- Examination of the work area to assure that any required preliminary work has been completed and complies with the FSIP/SSHP;
- A review of the appropriate activity hazard analysis or SSHP to assure safety requirements are met;
- Discussion of procedures for execution of work including repetitive deficiencies;
- Document performance standards for that phase of work;
- A meeting conducted by the QCSM and attended by the PjM, and other personnel, as applicable;
- Documentation of the preparatory phase actions by separate minutes prepared by the QCSM and attached to QCR. Minutes will be signed by all participants in the preparatory meeting;

- The PjM will instruct applicable workers as to the acceptable level of performance required in order to meet the requirements of the project; and
- The PjC will conduct preparatory meetings with the contract laboratory(s) at the beginning of each task order as discussed in his/her duties in Section 1.2.1.7. During that meeting, differences between the laboratory quality assurance manual and this QAPP shall be discussed. If there are any aspects of this QAPP that the laboratory cannot comply with, this must be brought to the attention of the USACE Project Chemist as early as possible prior to sampling.

3.1.2.2 Initial Phase Inspections

The initial phase inspections will be accomplished at the beginning of a definable feature of work and will include the following:

- A check of preliminary work to ensure that it is in compliance with FSIP/SSHP, and QAPP requirements and the agreements reached in the preparatory meeting;
- A pre-award systems audit of all new laboratories, which have not been used or audited by the contractor for previous USACE projects, to verify laboratory analytical capabilities and ability to meet project QA/QC requirements. These audits will be conducted by qualified auditors (representatives from the contractor's QA, chemistry and/or data management staff) and include verification of laboratory procedures for archiving/retrieving GC and GC/MS data stored on magnetic tapes;
- Establishment of the level of performance and verify compliance with minimum acceptable performance standards;
- Resolution of all differences;
- A check of safety to include compliance with and upgrading of the safety plan and activity hazard analysis;
- A check of equipment maintenance and calibration;
- A check of work documentation;
- Notification of the USACE PM or his/her representative in advance of all initial phase inspections;
- Preparation of separate minutes of this phase by the QCSM, signed by all participants, and attached to the QCR; and
- The initial phase should be repeated for each new crew to work onsite; any time acceptable specified quality standards are not being met; or when modifications to the FSIP/SSHP impact existing procedures.

3.1.2.3 Follow-up Phase Inspections

The follow-up phase will include the following:

- A project-specific audit of all participating laboratories during early sampling efforts to ensure that project QA/QC requirements are being met. These focused audits will be conducted by qualified auditors (representatives from the contractor's QA, chemistry and data management staff) and include verification of laboratory procedures for archiving/retrieving GC and GC/MS data stored on magnetic tapes;

- Daily checks to assure continuing compliance with contract requirements until completion of the particular feature of work. The checks will be made a matter of record in the QCR; and
- Final follow-up checks will be conducted and all deficiencies corrected prior to the start of additional features of work which may be affected by the deficient work.

As determined by the USACE PM or his designee, additional preparatory and initial phases may be conducted on the same definable features of work if the quality of ongoing work is unacceptable; if there are changes in the applicable staff, onsite supervision or work crew; if work on a definable feature is resumed after a substantial period of inactivity; or if other problems develop. If these additional preparatory and/or initial phase inspections are outside the contractor's scope, the USACE CO must be contacted for approval prior to starting work.

3.2 ASSESSMENT AND RESPONSE ACTIONS

The contractor will execute a number of assessments during performance of this project that will include but not be limited to surveillance, peer review, management systems review, readiness review, technical system audits, performance evaluations, audit of data quality, and data quality assessment. The contractor is expected to maintain data quality, project schedules, and personnel management while implementing these assessments. Success criteria will include goals, performance objectives, acceptance criteria specifications, and personnel feedback.

3.2.1 Routine and Annual Assessments

Routine and annual assessments will be conducted to assess the performance and effectiveness of the existing quality management systems in accordance with the QAPP. The intent of these assessments is to identify, correct and prevent management problems that hinder the achievement of project objectives.

Routine assessments will be performed by the PJM utilizing a combination of formal and informal evaluation activities as described below:

- Conducting project status meetings and site visits;
- Assessing data quality;
- Reviewing and approving project reports;
- Reviewing QCRs;
- Reviewing responses to Non-Routine Occurrence Reports;
- Reviewing responses to Non-Conformance Reports; and
- Reviewing performance evaluations or system audit reports.
- Reviewing results from QA split samples when available from the USACE.

Annual assessments will be performed by the QCSM through a review of quality-related activities and control mechanisms. This assessment will include reviews of performance evaluations and system audit reports, both of which will include a review of corrective actions.

In addition, discussions will be conducted to evaluate customer and employee perceptions relative to the following key issues:

- Adequacy of program management and implementation;
- Effectiveness of the quality management system controls that are established to achieve and ensure quality; and
- Adequacy of resources and personnel to achieve and ensure quality.

Areas recommended for improvement will be identified in their respective routine or annual assessments, and documented at a level consistent with that of the assessment. Resulting response actions will be identified by the QCSM and the PjM, and implemented through CARs as agreed upon between the QCSM and the PjM. The effectiveness of these response actions will be monitored through the routine assessment mechanisms discussed above. Either the PjM or the QCSM may suspend work if it is necessary to correct a significant non-conforming condition. Examples of significant non-conforming conditions may include, but are not limited to, erroneous data or incomplete data packages.

3.2.2 Performance Evaluation (PE) Samples

Where applicable PE samples may be submitted to each participating laboratory for primary analytical methods and sample matrices (all definitive analytical methods with at least 100 planned samples/matrix, pending the availability of PE samples). Wherever practical, PE samples will be submitted "double-blind" as part of the field shipment so that the laboratory is unable to distinguish between PE and project samples. "Single-blind" samples will be acceptable, especially for some soil samples, when preparation of double-blind samples is not possible.

Use of project-specific PE samples in demonstrating method proficiency by project laboratories will be implemented based on project data quality objectives (DQOs). The PE samples will then be used to quantitatively assess the data produced by a laboratory. Project-specific PE samples will be submitted based on previous experience with project laboratory, number and type of methods, number and matrices of samples, and other boundaries of the project scope of work. The need for data from PE samples will be determined for the project based upon the eventual decisions that need to be made; therefore, implementation of PE samples in each project will be a reflection of the DQO requirements. PE samples may be recommended for sites where the consultant does not have a long history of performance proficiency for the project laboratory, sites that have a potential for a majority of non-detects, or for sites where the contaminants of concern have already been identified. Each FSIP shall specifically address the requirements for PE samples. If required, PE samples will be submitted during initial phase of a project in order to correct any potential nonconformances in the beginning of the project execution. Currently, the complete range of organic and inorganic PE samples are available for water matrices only. Selected organic and inorganic PE samples are available for soil and none are available for vapor matrices. The PE sample supplier will have a documented QC system such as that required by ISO9001 or equivalent.

All laboratories shall participate in Water Supply and Water Pollution Studies PE programs offered through private vendors or an equivalent program (e.g., ELAP) for California state certification. Satisfactory performance in this PE program demonstrates proficiency in methods

used to analyze USACE project samples. The laboratory shall document the corrective actions taken in response to unacceptable PE results to demonstrate resolution of the problems. This information will be reviewed as part of the pre-screening of contract laboratories for use for this project.

The PE samples will be developed from standard reference materials, NIST traceable materials, EPA QC materials, or neat compounds of the highest purity available. The samples will be prepared in a clean matrix or medium that allows evaluation of the analytical success of the method assuming no matrix interference. The PE sample is submitted disguised as a field sample (double-blind) whenever possible to realistically assess the accuracy of the field samples with which they were submitted.

Laboratory results are evaluated against criteria provided by the vendor, taking into consideration the following critical items:

- Accurate identification of the analytes included in the PE samples;
- Quantitation within acceptable limits (%R) based on vendor supplied control limits or LCS control limits provided in this QAPP for referenced method whichever is tighter;
- Absence of false positive identifications;
- Accurate report of results and any problems identified; and
- Acceptable analytical batch QC sample results.

These items will be used to identify when a system is outside of acceptable control limits. Appropriate corrective action must be identified in conjunction with the results from a systems audit or data validation, or through subsequent follow-up and requests for additional information from the laboratory. Any problems identified with PE samples must be evaluated to determine the influence on field samples analyzed during the same time period.

Corrective action is required and must be documented for all incorrect results. Unacceptable PE sample performance and/or corrective action will trigger the following actions:

- Conduct Level III Data Validation Review of the associated sample delivery group (SDG) and assess data impacts with respect to DQOs;
- Pending outcome of Level III review, conduct Level IV data Validation Review of the associated SDG and assess data impacts with respect to DQOs;
- Pending results of previous two bullet actions, reanalyze project samples of the associated SDG and assess data impacts with respect to DQOs; and
- If DQOs are significantly impacted, for example a protocol or calibration problem that requires rejection of sample data for constituents of concern, recollect and reanalyze project samples.

Copies of the PE sample certificates, laboratory results/scores and corrective action responses will accompany the Site Investigation Report as part of the data quality assessment.

3.3 REPORTS TO MANAGEMENT

Specific reporting mechanisms have been developed to keep USACE management informed of the status of project quality. This will be accomplished in part by including the USACE PM or his/her representative on the distribution of various reports and CARs. This section describes the type, frequency, content, and distribution of reports issued to inform management of project status, performance evaluation and system audit results, data quality assessment results, quality assurance problems and recommended solutions.

3.3.1 Quality Control Reports

An informal QCR will be prepared for the USACE PM or his/her representative at appropriate project milestones. Project information contained in the report will include the following as a minimum:

- Location of work;
- Weather conditions;
- Work performed;
- Results of any inspections performed;
- Any instructions received from government personnel for re-testing;
- Types of tests performed, the individuals performing the tests and test results;
- General comments;
- Calibration procedures; and
- Contractor's certification.

The contract laboratory will provide QCRs of laboratory activities associated with a task order and which summarize the laboratory's QC activities. The laboratory reports may be limited to out-of-control data events and corrective action taken to resolve them. Note and minutes of three phase inspections and meetings will be attached to the QCRs. The minutes of the preparatory meeting and the initial inspection will be signed by all participants.

3.3.2 Non-Routine Occurrences Reports

Written reports of all significant non-routine occurrence events will be sent to the USACE PM or his designee within 48 hours for field and laboratory work. These reports will identify the problem, corrective action, and verbal/written instructions from the USACE CO personnel for sampling or reanalysis. Significant events are occurrences impacting cost of work, schedule of work, quality of work, and quality of environmental analytical data.

3.3.3 Certificates of Analysis

A summary certificate of analysis, as described in Section 1.6.3, will be prepared by the contract laboratory. Generally, analyses are to be performed on a normal turnaround basis (21 days) and the comprehensive report will be received by the USACE PM or his designee no later than 30 days after the last sample has been acquired for the project (date of last sampling), unless

specified otherwise by the USACE PM or his designee. Draft data reports will be provided by the laboratory as soon as they are available, (anticipated to be approximately 14 to 17 working days after the samples are received at the laboratory). For work that extends over a period greater than 30 days, one comprehensive report shall be delivered for each month of project activities involving sampling and analysis.

3.3.4 Quality Control Summary Report

A Quality Control Summary Report (QCSR) shall be prepared at the end of each phase of field work by the QCSM. Issues covered in this report shall include the QC practices employed in execution of the contract, and a discussion of all data points which may have been compromised and their impact on the data quality objectives or remedial decisions. The QCSR shall be submitted to the USACE PM or his/her representative. The QCSR shall be prepared by compiling information relative to the project according to the following outline:

- Project Scope;
- Project Description;
- Sampling Procedures;
- Summary of DQCR: A discussion of field and laboratory QC activities. This section should focus on any deviations from planned activities and a summary of the evaluation of data quality for each analysis and matrix as indicated by the laboratory QC data;
- Analytical Procedures;
- Data Presentation (including analysis and validation): A presentation and evaluation of the data to include an overall assessment of the quality of the data for each method and matrix. The discussion should include qualitative and quantitative assessments of completeness as described in this document. Results for field duplicates shall be discussed in the qualitative description of completeness. The statistical procedures used in the assessment of data shall be described. Any results reflecting significant deviations shall be discussed. All internal QC data (splits, if available; duplicates, etc.) generated during the course of the project must be included in the QCSR. The data presentation shall include tabular summaries correlating sample identifiers with all blank results, MS/MSD results, field duplicate results, LCS results, and batch identifiers. The quantitative description of completeness will be performed by considering aspects related to data quality and to contract compliance. The completeness summary will be provided in tabular format presenting the relevant analyses, the total number of samples analyzed for each method, the number of samples qualified for any reason, the number of samples associated with contract compliance failure, the determination of "analytical completeness" (determined relative to the number of samples qualified for any reason), and "contract compliance completeness" (determined relative to the number of samples qualified for contract compliance failure). Each metal is considered a separate analytical parameter rather than considering the group of all of the metals in a single analytical category. A single number for completeness in each category for each analysis will be presented to describe the overall data quality. A complete sample will be considered a sample for which all QC parameters are within acceptable limits. The aggregate of sample results for multi-analyte organic methods should be considered as a single sample result for the purpose of calculating completeness;

- QC Activities: A field and laboratory QC results summary shall be included that provides a discussion of the reliability of the data and any QC problems encountered; and
- Conclusions and Recommendations: A summary of field or analytical procedures that could be changed or enhanced to better characterize chemical contamination in future work efforts at sites covered by the contract.

3.3.5 Memorandum of Findings

The Memorandum of Findings will provide the results of the PC preparatory inspection at the beginning of each task order. Copies of the checklists used in the inspection will be included. This memorandum is due to USACE within 15 days after completion of the inspection.

3.3.6 COC Forms

Copies of the COC forms will be provided to the USACE PM or his/her representative whenever samples are delivered to the contract laboratory(s) unless requested otherwise by the USACE PM or his/her representative.

3.3.7 Cooler Receipt Forms

Each laboratory has its own cooler receipt form. An example of the selected laboratory's Cooler Receipt Form will be provided to the USACE PM or his/her representative for approval during the planning stage of each task order. An example is provided Figure 1-4.

3.3.8 Criteria or Supplies and Consumables

Supplies and consumables used or provided by the laboratory (e.g., bottles and standards) will be inspected prior to use to ensure that supplies and consumables meet acceptance criteria for this project. Documentation will record information that uniquely identify the supplies and consumables including date received, date tested (if applicable), lot number, and expiration date. In addition, whenever bottles are requested from the laboratory, copies of the manufacturer's Certificate of Analysis will be forwarded to contractor project staff.

3.4 DATA VALIDATION AND USABILITY

This section describes the contract laboratory internal data reduction and validation procedures and the documentation associated with these activities, and the data validation procedure to be executed prior to reporting data to USACE. Table 3-1 provides a summary of how chemical data quality control will be evaluated in terms of PARCC.

The contract laboratory is responsible for maintaining accurate, legible records and logs in accordance with SOPs and is required to review all data produced before submittal. Raw data and its reduction to final results are reviewed by the contract laboratory. All data are subject to second party review within the laboratory to prevent simple transcription or calculation errors. All parties reviewing must initial the data prior to sending it for reporting.

**Table 3-1
Chemical Data Quality Control Evaluation in Terms of PARCC**

PARCC	Quality Control Program	Applicable Methods	Collection Frequency	Evaluation Criteria
Precision	Field Duplicates QA Splits MS/MSD Pairs LCS/LCSD Pairs	Inorganic/Organic Inorganic/Organic Inorganic/Organic Inorganic/Organic	10% for all matrices 10% for all matrices One per 20 environmental samples One per batch of samples that does not include an MS/MSD pair	Relative Percent Difference (a) Relative Percent Difference Relative Percent Difference Relative Percent Difference
	Lab Replicates	Inorganic (Wet Chemistry) / Soilgas	One per batch of samples for methods that cannot include matrix spikes	Relative Percent Difference
Accuracy	Surrogate Spikes MSD MS LCS LCSD	Organic Inorganic/Organic Inorganic/Organic Inorganic/Organic Inorganic/Organic	As required by the analysis One per 20 environmental samples One per 20 environmental samples One per batch of samples One per batch of samples that does not include an MS/MSD pair.	Percent Recovery (b) Percent Recovery Percent Recovery Percent Recovery Percent Recovery
Representativeness	Method Blanks Trip Blanks Source Water Filter Blanks Field Duplicates QA Splits Holding Time	Inorganic/Organic Organic aqueous volatiles Inorganic/Organic Inorganic Inorganic/Organic Inorganic/Organic Inorganic/Organic	One per batch of samples One per cooler with VOAs One per lot of rinsate water One per lot of filters 10% for all matrices 10% for all matrices ---	Qualitative, Degree of Confidence Qualitative, Degree of Confidence Quantitative/Qualitative, Degree of Confidence
	Equipment Rinsate Blanks	Inorganic/Organic	One per sampling crew per day if non-dedicated equipment is used for aqueous samples	Qualitative, Degree of Confidence
Comparability	Standard Field Procedures	Inorganic/Organic	---	Qualitative, Degree of Confidence
	Standard Analytical Methods	Inorganic/Organic	---	Qualitative, Degree of Confidence
	Standard Units of Measure -	Inorganic/Organic	---	Qualitative, Degree of Confidence
Completeness	Valid Data	Inorganic/Organic	---	Percent Acceptable Data (c)

NOTES:

Data will be evaluated for contract compliance in a separate activity.

- LCS/LCSD Laboratory control sample/laboratory control sample duplicate
- MS/MSD Matrix spike/matrix spike duplicate
- PARCC Precision, Accuracy, Representativeness, Completeness, and Comparability
- QA Quality assurance
- VOAs Volatile organic analyses

(a) Relative Percent Difference = $\frac{\text{Sample Concentration} - \text{Duplicate Concentration}}{\text{Sample Concentration} + \text{Duplicate Concentration}} \times 100$

(b) Percent Recovery = $\frac{\text{Analyte Concentration in Spiked Sample} - \text{Analyte Concentration in Unspiked Sample}}{\text{Concentration of Analyte Used for Spiking}} \times 100$

(c) Percent Valid Data (See Section 2.6.1)

The contract laboratory shall provide analytical data packages to a contractor designated subcontractor for independent laboratory data validation. This subcontractor will submit data validation reports to USACE and the PjM with the QCSR. The subcontractor will report egregious or recurrent errors in analytical work by memorandum to the USACE and PjM as soon as they are discerned. A more detailed description of the independent laboratory data validation is presented in Section 4.0 of this QAPP.

4.0

4.0 DATA MANAGEMENT AND DATA QUALITY ASSESSMENT

This section describes the general procedures for managing field and laboratory analytical data. In addition, requirements for data verification and data validation are presented.

4.1 DATA MANAGEMENT

The field team will collect samples as described in the FSIP. After collection, the sample documentation (sample tags, COC records, etc.) will be completed as described in Section 2.3. QC checks will be conducted on the sample documentation. If the documentation is acceptable, the samples will be shipped to the off-site laboratory, given to the on-site mobile laboratory, or kept by the samplers for field tests.

The primary contractor selected contract laboratory(s) will use an integrated local area network of computer hardware. The system will collect, reduce, and distribute information and data within the laboratory. The laboratory information management system will utilize technology between several operating systems. The information management system will utilize a network which provides sample tracking, results database, custom electronic and hard copy reporting, and data management services.

4.1.1 Data Archive

The specific procedures involved in archiving laboratory data include hard copies, computer hardware and disk copies. The computer tape and hard copy for storage are maintained within a secured building. The contract laboratory stores the data and reports for a period of ten years. Hard copy data over a year old are stored in a secure off site location and are accessible by box number on a database within the contract laboratory management system. The contract laboratory retains the capability to reconstruct data information at some future time.

4.1.2 Data Reduction

Data reduction is the process of converting measurement system outputs into concentrations and other information formats from which conclusions about the site can be made. The specific formulas used by the laboratory will be specified in the appropriate laboratory SOPs.

Statistical techniques will be applied to laboratory QC samples (such as MS/MSD, method blanks, surrogate spikes, LCS, and LCSDs) to assess the accuracy and precision of the data. The formulas for calculating the accuracy (%R) and precision (RPD) are in Section 2.5.4.1. Accuracy and precision data will be used to determine analytical data errors introduced through analytical procedures. This information can be used to determine the probability that the concentration of each analyte in the sample will exceed the site action levels.

In addition, the QC field samples (such as trip blanks, equipment blanks, rinsate blanks, and duplicate or replicate samples) will be evaluated to determine any systematic or random errors introduced by field procedures.

4.2 DATA QUALITY ASSESSMENT AND DATA VALIDATION/VERIFICATION

Verification, data quality assessment, and data validation involve maintaining proper laboratory record-keeping and assessing laboratory data. These steps are discussed in the following subsections.

4.2.1 Laboratory Recordkeeping

The laboratory will maintain records sufficient to recreate each analytical event conducted. At a minimum, the records will contain the following:

- COC records;
- Initial and continuous calibration records, including preparation of standards traceable to the original material and lot number;
- Instrument tuning records, if applicable;
- Method blank analyses;
- Internal standard surrogate spiking results (if required);
- Spike and spike-duplicate records and results;
- Laboratory duplicate records and results (if done);
- Raw data, including instrument printouts, laboratory bench worksheets, or chromatograms with compound identification and quantitation reports;
- Corrective action reports (internal or external audits);
- QC samples and results (e.g., ICP interference check standard results and blank spiking results);
- Any electronic deliverable required by the project and submitted for the project; and
- Other method- and project-required QC samples and results.

The laboratory will submit written procedures for each analytical method performed along with specific QA/QC requirements for each required method.

4.2.2 Assessment of Laboratory Data

Laboratory data can be assessed through third-party validation or internal verification. Data validation is the process of assessing data and accepting, rejecting, or qualifying data on the basis of established QC criteria. Validation is typically performed by an independent third party. Data verification is the process of screening data and accepting, rejecting, or qualifying them on the basis of established criteria. Internal data verification is based on the same QA/QC parameters as data validation, except that raw data record reviews and recalculation of results from the raw data will not be included in verification. Verification will be performed internally on the total amount of data produced (field screening, mobile laboratory, off-site laboratory). Validation/verification will include the subsequent subject areas. Any trends or problems associated with the data will be noted and evaluated in the analytical data report and the data summary report provided by the data validation subcontractor or internal analytical data reviewer.

The components of data verification and data validation are presented in Table 4-1 to illustrate the differences between the electronic data verification, manual data verification, and data validation. Electronic data verification results are reviewed by the project chemist during the manual data verification process before data are finalized.

**Table 4-1
Data Verification/Validation Requirements (1 of 2)**

Review Item	Performed by Electronic Data Verification ¹	Performed for Data Verification ¹	Performed for Data Validation ²
ORGANIC ANALYSES			
Case Narrative		X	X
Chain-of-Custody Documentation		X	X
Summary of Results		X	X
Holding Times	X	X	X
Method Blank Analysis Results	X	X	X
Field Blank Analysis Results	X	X	X
Surrogate Standard Percent Recoveries (%R)	X	X	X
Laboratory Control Samples (LCS) - %R	X	X	X
LCS/LCS Duplicate (LCSD) - Relative Percent Difference (RPD)	X	X	X
Matrix Spike (MS) - %R	X	X	X
MS/MS Duplicate (MSD) - RPD	X	X	X
Laboratory Replicate Analyses (LR) - RPD	X	X	X
Field Duplicate (FD) - RPD	X	X	X
Quantitation Below Low Standard or Above High Standard	X	X	X
Analyte Identification:			
Chromatography Column Precision Between Primary and Confirmation Columns (1C and 2C) - Percent Difference (%D) Analyte Retention Time			X
Internal Standard Areas (IS) - %R		X	X
Initial Instrument Calibration:		Summary	
Standard Analyte Concentrations		X	X
Analyte Response Factors (RF)		X	X
Percent Relative Standard Deviation (%RSD)		X	X
Correlation Coefficient		X	X
Analyte Retention Time Windows Established			X
Mass Spectrometer Tuning/Mass Calibration			X
Second-Source Calibration Verification		X	X
Continuing Instrument Calibration:			
Standard Analyte Concentrations		X	X
Analyte Response Factors (RF) - %D		X	X
Analyte Retention Times		X	X
Mass Spectrometer Tuning/Mass Calibration		X	X
Instrument Analysis Logs (including standards and samples)			X
Preparation Logs			X
Raw Data (samples, blanks, standards, QC samples):			
Chromatograms			X
Mass Spectra of Target Analytes			X
Quantitation Reports - Recalculation			X
Method Detection Limit (MDL) Study Data			X

**Table 4-1
Data Verification/Validation Requirements (2 of 2)**

Review Item	Performed by Electronic Data Verification ¹	Performed for Data Verification ¹	Performed for Data Validation ²
INORGANIC/METALS ANALYSES			
Case Narrative		X	X
Chain-of-Custody Documentation		X	X
Summary of Results		X	X
Holding Times	X	X	X
Method Blank Analysis Results	X	X	X
Field Blank Analysis Results	X	X	X
Laboratory Control Samples (LCS) - %R	X	X	X
LCS/LCS Duplicate (LCSD) - Relative Percent Difference (RPD)	X	X	X
Matrix Spike (MS) - %R	X	X	X
MS/MS Duplicate (MSD) - RPD	X	X	X
Laboratory Replicate Analyses (LR) - RPD	X	X	X
Field Duplicate (FD) - RPD	X	X	X
Quantitation Below Low Standard or Above High Standard	X	X	X
Analyte Identification:			X
Analyte Retention Time (ion chromatography)			X
Daily Initial Instrument Calibration:		Summary	
Instrument Calibration Curve Correlation Coefficient		X	X
Interference Check Standard Results (Method SW6010B only)		X	X
Calibration Standard Check (SW6010B only)		X	X
Standard Analyte Concentrations		X	X
Initial Calibration Verification (ICV) - %R		X	X
Initial Calibration Blank (ICB) Results		X	X
Second-Source Calibration Verification		X	X
Continuing Instrument Calibration:			
Standard Analyte Concentrations		X	X
Continuing Calibration Verification (CCV) - %R		X	X
Continuing Calibration Blank (CCB) Results		X	X
Instrument Analysis Logs (including standards and samples)			X
Sample Preparation/Digestion Logs			X
Standard Preparation Logs			X
Serial Dilution Results - %D			X
Method of Standard Additions (MSA) Results			X
Raw Data (samples, blanks, standards, QC samples):			X
Chromatograms			X
Quantitation Reports			X
Calculations			X
Method Detection Limit (MDL) Study Data			X

Notes

¹Data verification performed for all project samples and associated laboratory QC batches (Level III Data Package) Electronic verification is reviewed and approved by the project chemist before data are finalized.

²Data validation performed on a minimum of 10 percent of project samples (Level IV Data Package).

4.2.2.1 Screening vs. Definitive Data Comparison

Results produced by screening methods must be confirmed by a definitive reference method. Confirmation samples shall be selected to positively identify the unknown analytes and to confirm both detected and non-detected results. The intent of the confirmation should be to identify any potential problems with the data (e.g., false positives, false negatives, high or low bias, or high variability). Guidelines for comparison are presented here; exact specifications and data qualification schemes may be developed for a specific project depending on the type of screening methods used and the data use objectives.

The following should be evaluated to compare screening and definitive results:

- Check that the same analytes were reported by both procedures.
- For pairs of results where the same analyte was detected by both methods, calculate a correlation coefficient to determine if the two methods trend together.
- Evaluate bias. Calculate the RPD between paired results and evaluate whether the concentrations agree within a factor that meets the DQOs. (Note: RPDs of 67%, 100%, and 133% represent a factors of 2,3, and 5 respectively.)
- Compare not-detected results in both analyses for agreement.

All screening results will initially be flagged with an "S" flag. If all evaluation steps indicate that the data produced by the screening method are of acceptable quality to meet the data quality objectives, the data will be considered definitive and the "S" flag will be removed. Currently, electronic verification is performed using the Automated Data Review (ADR) tool developed for the USACE (Sacramento District) by Laboratory Data Consultants. All subcontracted laboratories are required to submit EDDs in the prescribed project format (currently the Standard ADR tool format appended with a few additional appended fields) for proper loading into the ADR tool, and then into the project database where the data will undergo evaluation and verification. The EDD specification is included in Appendix E of this QAPP. The calibration information (Table A2 of the EDD specification) is optional, and will be implemented based on the DQOs of the specific project. Data verification, which consists of the evaluation checks listed in Table 5-1 under the column "Performed for Data Verification", typically uses the ADR tool to preliminarily qualify the results.

Electronic verification reports will be reviewed and initialed by the project chemist during the chemistry review of analytical laboratory reports. The chemist also reviews information that cannot be evaluated electronically (e.g., case narratives, calibration, and corrective action documentation). When appropriate, the entire verification process may be performed manually. The ADR may be replaced with another automated tool with the agreement of the USACE TM.

Prior to electronic data verification, the laboratory EDD will be evaluated for format and content check. This ensures that appropriate information is available for use during data verification. A more detailed description of some of the checks performed follows:

- **COC Records.** COC records will be reviewed to verify that the following were documented: ID number, collection date, preservation, matrix, analytical method, temperature, sample condition, signature of each person having possession of the

sample, and date the sample was in their possession. Sample preservations will be compared with requirements listed in Table 2-1.

- **Holding Times.** The time elapsed between the date of sampling and the date of preparation and/or analysis will be compared with the requirements shown in Table 2-1. Sample preparation time is defined as the time that the preparation process has been completed. Sample extraction time is defined at completion of the sample preparation process as described in the applicable method, including any necessary cleanup before volume reduction procedures. Sample analysis time is defined as completion of all analytical runs, including dilutions, second-column confirmations, and any required reanalysis. If holding times are exceeded, resampling and reanalysis may be required.
- **Method Calibration Limits.** Initial calibration, initial calibration verification (ICV), and CCV standard results will be reviewed for conformance to acceptance criteria. To validate results, selected ICVs and CCVs will be recalculated from the raw data. Data validation will also determine whether the calibration events can be recreated. In addition, using correlation coefficients or ion abundances, verification will be performed to determine whether the instrument was properly tuned and/or calibrated prior to sample analyses.
- **Method Blanks.** The review will verify there is no analyte result greater than the ½ MQL from any of the method blanks. The review will also verify that no analytical data were corrected for the presence of analytes in the method blanks.
- **Analytical Batch Control Records Including Laboratory Control Sample Results, Spike Recoveries, and Duplicate Results.** The results of analytical batch QC samples will be compared with QAPP-specified, laboratory-established acceptance criteria. Data not within control limits require corrective action. Reviewers will check that corrective action reports and the results of re-analyses are available. Samples associated with out-of-control QC data will be identified, and an assessment of the utility of such analytical results will be recorded. Corrective action reports will be referenced in this assessment.
- **Corrective Actions.** The review will verify that QAPP-specified corrective actions have been implemented whenever contamination is detected or QC sample results exceed control limits.
- **Surrogates.** The preparation and results of surrogate spikes will be reviewed, and selected surrogate concentrations will be recalculated.
- **Completeness of Data.** This check ensures: (1) all samples and required analyses have been processed; (2) complete records exist for each analysis and its associated QC samples; and (3) the procedures specified in the QAPP, FSIPs and SOPs have been implemented. The results of the completeness check will be documented in project reports.

4.2.3 Data Validation

All laboratory data will be verified according to guidelines presented in previous sections. Further review of selected laboratory data will be implemented for 10 percent of the field samples collected and analyzed for definitive methods. Besides confirming the results of verification, validation is also an in-depth review of raw data that includes checking the accuracy of calculations and internal consistency between reported results and bench-level documentation such as bench notes and run logs. To facilitate in-depth validation, 10 percent of the samples for each analytical method and matrix delivered by the laboratory will be requested

in the form of EPA Level IV equivalent full data packages, which include raw data and bench-level documentation, in addition to the summaries of sample and QC results that comprise the standard Level III package. Data will be independently validated according to the procedures given in Appendix D, which were developed based on those specified in "USEPA Contract Laboratory Program National Functional Guidelines for Organic/Inorganic Data Review" (most current versions). Reviewers are encouraged to use professional judgement when applying qualifications. If situations arise where the basic qualification scheme does not appropriately address the qualification of the data, the reviewer may change the qualification scheme as long as the rationale for the change is clearly documented.

As a general rule, validation will be performed on representative samples of the data associated with all critical analytical parameters, all matrices, each involved laboratory, all field efforts (if a phased approach is used), and all sites investigated. To satisfy these objectives, the following approach will be taken for critical activities:

- IDW samples will not be included in Level IV validation;
- A minimum of one sample per field event for critical methods will be validated; additional data packages will be validated as necessary to maintain a nominal goal of 10 percent (or higher, if warranted by evidence of deficient work).
- Additional data packages may be validated in the event that serious deficiencies in the quality of the data are discovered during the validation of previous reports from a particular laboratory.
- Level IV validation will not be required for analysis for pH, alkalinity, TDS, ignitability, and TOC.

If third-party validation identifies notable deficiencies, the remainder of the data for affected methods from the responsible laboratory will be reviewed in detail to determine if the problem was isolated or systematic throughout the entire data set.

4.2.4 Reporting

Analytical data will be reported in various formats, depending on the requirements of the specific delivery order. QC results and cross-references will be reported along with summaries of methods, detection limits, control limits, and holding time compliance. The report will include a QA/QC narrative, data qualifiers, and an overall data quality summary, as appropriate.

The following units of measure will be used for reporting analytical results for chemical analyses:

- Water samples—inorganics and metals in milligrams per liter (mg/L)
- Water samples—organics in micrograms per liter ($\mu\text{g/L}$)
- Water samples—radioactivity in picocuries per liter (pCi/L)
- Water samples—dioxin/furans by SW8280, micrograms per liter ($\mu\text{g/L}$)
- Water samples—dioxin/furans by SW8290, nanograms per liter (ng/L)
- Soil and sediment samples—organics, inorganics, and metals (mg/kg, dry basis)

- Soil samples—toxicity characteristic leaching procedure (TCLP) (mg/L for metals; µg/L for VOCs, SVOCs, pesticides and herbicides)
- Soil samples—radioactivity, picocuries per gram (pCi/g)
- Soil samples—dioxin/furans by SW8280, micrograms per kilogram (µg/kg)
- Soil samples—dioxin/furans by SW8290, nanograms per kilogram ng/kg)
- Soil gas, vapor, or air samples—organics in parts per billion by volume (ppbv) or µg/L
- Moisture content for each soil/sediment sample (percent moisture)

All results for soil samples must be reported on a dry weight basis.

Data qualifiers for organic and inorganic chemical data will be:

- U Compound was analyzed for but was not detected at or above the MDL.
- J Value is estimated because all QC criteria were not met or due to a trace concentration (less than MQL).
- J+ Value is estimated with a high bias because associated QC criteria were exceeded on the high end.
- J- Value is estimated with a low bias because associated QC criteria were exceeded on the low end.
- N Presumptive evidence of a compound.
- R Unusable (rejected) data. Analyte may or may not be present.
- NJ Analysis indicates presence of an analyte that is tentatively identified, the associated numerical value represents its approximate concentration.
- UJ Analyte not detected above the MDL; however, the reported detection limit is approximate and may or may not represent the actual limit of detection.
- S To be applied initially to all field screening data. If there is sufficient correlation with side-by-side definitive data, the S flag shall be removed.

The use of these qualifiers in assessing the quality of laboratory data is detailed in Appendix D.

4.3 RECONCILIATION WITH DATA QUALITY OBJECTIVES

Results obtained from the project will be identified and reconciled with DQOs throughout the data collection process by a variety of status reports to management, through data validation and validation summary reports, and through data evaluation and investigation reports. Status reports such as the Quality Control Reports (Section 3.3.1) and DQCRs (Section 2.9.2.1) will identify problems encountered during site activities. These status reports will also document corrective action taken, changes in scope of work relative to the FSIP, and potential effects on achieving project DQOs.

Upon completion of sample analyses, data deliverables will be checked to ensure that the deliverables are complete and that samples were analyzed as requested. The Certificates of

Analysis will be validated to evaluate the precision, accuracy, and representativeness according to the guidance outlined in Appendix D and as described in Sections 4.2.2 and 4.2.3 of this QAPP. The results of data validation will be documented in validation reports that summarize data usability, and with data qualifiers that are input into the project database. The validation reports will also discuss limitations, if any, of specific data. In general, only unqualified, estimated, and definitive field data will be used in Arsenal risk assessments and statistical analyses. Rejected data will not be used in the decision making process. Screening level data will not be used in risk or statistical analyses, but will be used for developing site conceptual models, and in advancing site investigations.

Once the data validation is finished, the PjM will review the data to evaluate investigation results for reasonableness, and overall accuracy and acceptability. The reasonableness of data will be reviewed as to whether the results reported on various analyses are internally consistent. Comparative analyses are made such as BOD and COD, and the amount of organic contamination reported; TDS and specific conductivity; and other chemical relationships. Data will also be compared to sample descriptive information (e.g. soil type) or known site history that may aid in evaluating data against project DQOs. Where appropriate, data may be evaluated in accordance with USEPA guidance using statistically and/or graphical methods to assess overall quality (Practical Methods for Data Analysis, EPA/QA-9).

The PjM will also review the overall accuracy and acceptability of QA/QC data. If a QC parameter is outside acceptance limits or if DQOs have not been met, the PjM will ensure that an appropriate explanation and potential corrective action are described in the investigation report.

5.0

5.0 REFERENCES

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